Managing Laboratory Work Through Skepticism: Processes of Evaluation and Control

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Abstract:
Laboratory ethnographies are the shop floor studies of the knowledge economy. I draw on observational data from 11 months of field-work in a multi-disciplinary neuroscience lab to argue that scientific skepticism, long understood as an evaluative mechanism, also serves social control and monitoring functions. Using insights from organization theory, social psychology, science studies, and the sociology of science, I demonstrate that skepticism is socially organized at the micro-level of laboratory interactions. This organization makes skepticism a solution the extreme problems of control, coordination, and evaluation raised by uncertain scientific work conducted in a physically dispersed multidisciplinary setting. The diverse roles skepticism plays in laboratory interactions resonate with examinations of work in a number of occupational settings while providing direct insight into mechanisms that may account for the patterning of rewards and status across knowledge intensive workplaces.

Introduction:

With the end of the Cold War, the primary rationale for science and technology policy shifted from national security to economic competitiveness (Slaughter 1993; Cohen & Noll 1994). This change was accompanied by increased academic concern with science and technology based work as important factors in the post-industrial economy (Barley & Bechky 1994; Barley 1996). Here material production is no longer thought to be the primary source of value added, instead, knowledge and information are the key to economic development (Gibbons et. al. 1994; Stehr 1994; Drucker 1994). This conviction is coming to fruition in organizational studies of learning districts, flexible specialization theories (Piore & Sable 1984; Saxenian 1994) and network forms of organization (Powell 1990; Powell et al. 1996).

Sophisticated efforts in science studies (Mukerji 1989; Clark & Fujimura 1992; Fujimura 1996; Star 1995; Knorr-Cetina 1999), organization theory, and the sociology of work (Vaughan 1996; Barley 1996; Dubinskas 1988) begin to examine science as work by focusing on technical decision making and error in organizations (Vaughan 1996), the creation and maintenance of 'social worlds' and "doable" problems (Fujimura 1987; Clark 1992; Star 1995), and technical work practices (Barley & Bechky 1994; Barley & Orr 1997, Orr 1996).[1] Increasingly, research and technical work are treated like production work on the shop floor. Scientists, then, are technically skilled professionals who manufacture knowledge in specific organizational and social contexts. Long a staple in Social Studies of Science (Knorr-Cetina 1995), laboratory ethnographies also examine strategic sites for studies of work and organization. Laboratory ethnographies, then, are the shop floor studies of the post-industrial era.

Scientific work is changing along with policy rationales. Since World War Two, the trend has been away from disciplinary, single investigator research toward 'big' science conducted by multi-disciplinary groups across organizational settings (Traweek 1988; Gibbons et. al. 1994; Powell & Owen-Smith 1998). Against this backdrop, I investigate workplace control and scientific evaluation in a multi-disciplinary life science research group by addressing four orienting questions:

1. What problems of control are raised by multi-disciplinary research work?
2. How do senior scientists exert authority and control over expert subordinates?
3. How do junior scientists legitimately resist their seniors' evaluations and control attempts?
4. How is the quality and veracity of scientific work monitored under conditions of uncertainty and structural differentiation?

I answer these questions with data drawn from 11 months of ethnographic field work in a neuroscience laboratory which I dub the H-lab.[2]

Constructivist approaches to science have focused on the technical details of scientific work to demonstrate the local, contingent, and constructed nature of scientific knowledge claims (Latour & Woolgar 1979; Knorr-Cetina 1981; Lynch 1984; Clarke and Fujimura 1992). Recently, work in Science Studies has turned to the organizational embeddedness of scientific practices (Galison, 1997; Knorr-Cetina 1999; Sims 1999;

[1] See also Whitley (1984) and Fuchs (1994) for more macro oriented, contingency based theories of the organization of scientific work.

[2] In order to maintain confidentiality I alter some characteristics of the H-lab. All names are pseudonyms.

Thorpe & Shapin, 2000; Vaughan 1999a). I extend that focus, paying specific attention to micro-level questions of monitoring, control, resistance, and evaluation consonant with industrial ethnographies (Buroway 1982; Gouldner 1954; Dalton 1959; Stark 1990) and examinations of high-tech work (Kunda 1992; Vaughan 1996; Barley & Zabusky 1997). I examine the local status orders and social control apparatuses constructed and maintained in focused gatherings (Goffman 1961) like laboratory meetings.

Four disparate literatures frame this ethnography. The Sociology of Science's traditional focus on reward and outcome stratification (Merton 1968; Cole & Cole 1973; Zuckerman & Cole 1975; Zuckerman 1977) supports my consideration of structural differentiation in the H-lab. Science Studies anchors my discussion of the control problems inherent in managing multi-disciplinary work. One key finding from the Science Studies literature is that there is an 'art' to doing science (Latour & Woolgar 1979; Lynch 1984; Traweek 1988; Fujimura 1996). Tacit knowledge can mean the difference between experimental success and failure. Such know-how problematizes replication (Collins 1974, 1975) and makes monitoring difficult in organizations like the H-lab.[3]

Following March and Simon (1958; Simon 1959), I treat the H-lab as a structure of attention that directs the information search and use efforts of its members. Under this conception, information flows rather than hierarchy and unobtrusive control rather than bureaucratic governance characterize the structure of authority. Finally, two social psychological approaches to group processes, Expectation States Theory (EST) (Meeker 1981; Ridgeway & Walker 1995) and Legitimation Theory (Ridgeway & Berger 1986, 1988; Berger et. al. 1998), underpin my empirical focus on evaluative, skeptical, interactions in H-lab meetings.

EST examines emergent power and prestige orders in task groups, examining their effects on group members' evaluations of others' performances. In contrast, Legitimation Theory links local status orders to macro-stratification systems in examinations of local task evaluations. These social psychological resources provide new purchase on questions of control and resistance in work driven by tacit knowledge.

I begin by describing the H-lab, focusing on the control problems raised by multi-disciplinary science and loosely coupled organization (Weick 1976). After highlighting key difficulties for management, I introduce the important organizational role meetings play for controlling and evaluating the H-lab's diverse science and scientists. Skeptical encounters in group meetings link social control and evaluation processes in a single class of interactions. A skeptical encounter is any public conversational exchange where critical or directive comments are made about the technical, substantive, or theoretical details of a scientific claim. By monitoring outcome quality such skepticism underpins decisions about what claims 'make it out' of the lab to the wider evaluative arena of peer review and public presentation. Junior researchers' differential abilities to resist seniors' control and to influence substantive evaluations of their work result in divergent success, prestige, and opportunities for advancement. As it is deployed in H-lab meetings, scientific skepticism is *simultaneously* a method of control, a path for resistance, and an evaluative mechanism.

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[3] Examinations of tacit knowledge in science preceded Science Studies (c.f. Polanyi 1974). The control problems know-how creates by empowering 'lower participants' in organizations (Mechanic 1962) and 'unskilled' and skilled workers (Kusterer 1978; Buroway 1982) has also been recognized by sociologists.

Introducing the H-lab.

This article draws on data collected during eleven months of field-work in the H-lab, a neuroscience laboratory located in a Research One university. Jim, the lab's director, founded the H-lab more than a decade ago. Twenty-six people work in the lab; eighteen are active researchers.[4] Seventeen H-lab researchers hold or are pursing doctorates. The eighteenth is a technician. The H-lab is externally funded to the tune of more than $1 million per year. Jim and Frank, who is "second in command," hold grants from three federal agencies. Along with shared training and instrumentation monies, these grants represent the group's primary funding sources.

While in the H-lab I collected archival, interview and observational data. I interviewed sixteen scientists and observed laboratory work, but the primary data for this analysis are drawn from observations of eight monthly "lab meetings" and fifteen weekly "Muffin Meetings." Both types of meetings are held early on Wednesday mornings and feature muffins from a local bakery and discussions of "laboratory business." Lab meetings center on group members' formal presentations of work in progress.[5] In contrast, the much more informal (though still mandatory) muffin meetings generally involve more relaxed presentations of very early stage scientific findings. Together, these meetings represent group's primary fora for evaluating science and managing H-lab work.[6]

H-lab science. The H-lab is multi-disciplinary. Its scientists hold or are pursuing advanced degrees in nine disciplines ranging from applied mathematics to field ecology. Despite diverse training, these researchers share an empirical focus on olfaction in *Manduca Sexta*, the "tobacco hornworm moth."[7] Harry, a post-doc whose field-work examines *Manduca's* feeding behavior, characterizes H-lab scientists as "nose-people." A variety of interrelated H-lab projects seek to understand the molecular, anatomical, physiological, and behavioral mechanisms that enable *Manduca* to smell.

Moths smell with their antennae, so H-lab scientists examine the structure and function of the antennal lobe of the brain. Despite a shared object of inquiry, their efforts are differentiated both by subjects of study and levels of analysis. One set of researchers seeks to understand how male *Manduca* apprehend and respond to female sex pheromone. Male moths reliably distinguish females of their own species from those of closely related species by discriminating among chemically similar pheromone scents. The ability to respond to the 'correct' olfactory stimulus enables male moths to locate viable mates.

Another group of scientists attempts to determine how gravid female moths locate appropriate 'host-plants.' After mating, female *Manduca* must find suitable locations to ovaposit (lay eggs). *Manduca* larvae require large amounts of specific foods (tobacco or tomato leaves), but appropriate host-plants smell very similar to less hospitable vegetation. The ability to distinguish among plant odors means life or death to larvae.

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[4] Active researchers include faculty, research staff, visiting scientists, post-doctoral associates, graduate students, and technicians.

[5] Two such presentations occur at each lab meeting. Each of these talks is generally an hour long.

[6] For ease of reference I use the terms "muffin meeting" and "lab meeting" interchangeably to denote both types of gathering.

[7] Though the term *Manduca* defines a genus, I use it to refer to the H-lab's model species. *Manduca's* common name comes from its propensity to eat tobacco and the small brown "horn" that grows on the head of larvae.

These inquiries span multiple levels of analysis. Two post-docs, Robert and Adam, work to isolate the proteins responsible for sexual dimorphism in *Manduca's* brain. The olfactory lobe is anatomically distinct across sexes. H-lab scientists believe this dimorphism underpins the sexes' distinct olfactory capabilities. More holistically inclined research focuses on linkages between olfaction and behavior. For example, Anne, a first year post-doc, examines upwind flight to host-plants. Using a wind tunnel, Anne seeks to learn how female moths locate host-plants by flying into the breezes that carry their scent. The largest group of H-lab researchers examine male and female olfaction using a common method, intra-cellular recording. The "physiologists" – Jill, Caitlin, Michael, Patrick, and Frank – explore cellular responses to odors to determine the functional organization of the antennal lobe.

On any given workday, three major laboratory groups work in cramped office and lab spaces spread across three floors of two different campus buildings. Scientists at work "in" the H-lab often do not communicate outside their projects though they share a common topic and belong to the same organization. Practically, then, the lab's major endeavors are only tenuously linked.

Though Jim, the lab's director, strives to integrate these tasks, such synthesis cannot be accomplished during routine daily work because of the group's intellectual and physical dispersion. Weekly meetings provide a venue for presentation and discussion of ongoing research and enable the group to weave coherent knowledge about *Manduca* from diverse project threads. Like gatherings observed in engineering firms (Kunda 1992) and academic research groups (Traweek, 1988; Galison 1997; Knorr-Cetina, 1999), muffin meetings are central to the H-lab's management and science.

Controlling and Monitoring Scientific Work.

Like all formal organizations, the H-lab has a degree of hierarchy and some procedures for monitoring work. Jim and Frank control the grants that pay salaries and research costs. Beth, the H-lab's technician, administers a complex accounting system that requires group members to requisition and track the use of everything from chairs to reagents. Jim and Frank sit on or chair graduate students' dissertation committees. Continued post-doctoral salaries and research support depend on yearly performance evaluations. Nevertheless, these formal control mechanisms are undercut by the difficulties inherent in monitoring scientific work.

Scientific research is characterized by worker autonomy, reliance on tacit knowledge, dependence upon trust, and, very rarely, direct replication (Collins 1974, 1985; Chubin & Hackett 1990; Kunda 1992; Dasgupta & David 1994; Barley & Bechky 1994). These factors contribute to a collegial control system that bases quality evaluations on reputation and the ability to defend novel claims. Oversight follows a craft based model (Stinchcombe 1959), further lessening the effectiveness of Jim's bureaucratic authority.

Jim needs to exert control over his workers to ensure their findings' quality. As lab director, Jim's name goes on every publication arising from H-lab research. Adding his name to manuscripts represents an "investment of credibility" (Latour & Woolgar 1979). By "signing-off" on a paper, Jim throws his scientific reputation behind its claims, furthering its chances in the life sciences' single blind review process (Merton 1968; Chubin & Hackett 1990).[8] That investment is also a gamble. Should a manuscript's

[8] Reviewers are anonymous, but authors are not.

claims be proven false, or worse, fabricated, both Jim's and the lab's reputation will suffer. Jim must also monitor the quantity of junior scientists' research. As PI on most H-lab grants, he is responsible to funding agencies for the timely completion of grant-supported work. These responsibilities require Jim to monitor the direction, timing, and quality of projects underway in his lab.

Nevertheless, Jim's administrative role is strategic, and his intellectual role is abstract. He organizes and synthesizes the lab's findings, gathers information on rival groups and scientific developments, raises capital, advertises success, develops projects, and recruits group members. The range of his responsibilities and the lab's physically dispersed, loosely coupled organization make monitoring the quantity of work problematic. Directly regulating scientific quality under such conditions is nearly impossible. Nevertheless, it is essential that Jim accomplish both.

The difficulties inherent in monitoring multi-disciplinary academic work represent a special case of general control problems found in many work settings. Like most managers Jim is responsible for his group's outputs despite the fact that he no longer does the bench work that supports them. Control problems common to all workplaces are magnified by the diversity, uncertainty, and technical difficulty of H-lab endeavors. In addition to these 'passive' control problems, H-lab researchers actively resist attempts to manage their days. Like other highly trained workers, these scientists value their autonomy, resent direct management, and enjoy the flexibility characteristic of professional (Dalton, 1959; Powell, 1985; Morrill 1994) and technical careers (Barley & Orr 1996; Orr 1996; Vaughan, 1996).

Michael, a graduate student, describes this flexibility while elucidating the formal bases of Jim's authority. He also emphasizes variations in levels of constraint across positions in the laboratory.

> On a day-to-day and month-to-month basis Jim doesn't exert very much control over what goes on at all. He gets grants. He hires people and he puts them on certain projects. Jill was hired to do physiology and intra-cellular recordings so there is a limit to what Jill is supposed to do. Generally she has to work in these areas, so her job is pretty focused. As a Ph.D. student you are often given more general topics. It is your problem to pare them down. So I have a lot of leeway. But if you have a lot of leeway you are also not getting a lot of supervision. I guess that is Jim's strategy, as long as people are productive and get something done it is better to let them go and not interfere. He is smart enough not to put us on things we really are not interested in or do not want to work on.

While acknowledging Jim's broad control over his work, Michael emphasizes the leeway afforded to him in his efforts to 'pare down' a scientific problem.[9]

In contrast, Harry, a post-doc, suggests that even diffuse workplace control is a constraint best avoided. He explains his reasons for seeking fellowship support independent of Jim's grants.

> I have my own money, you see? I have an XYZ post-doc . . . so I really get to choose my own thing. *They* don't pay *me* so it is sort of like "Fuck you, I don't want to work on that, I want to work on this." It is really very sink or swim. I get paid, but I do not really have to do anything. I could just stay home every day . . . I would stop getting a salary and have no job after two years, but I could stay home.

Harry's fellowship and intellectual focus make him an extreme case. Field observations of moth behavior remove Harry from the lab for weeks at a time. Where Harry sometimes

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[9] Roth (1966) notes that this is a general strategy to control and assure the work of hired-hand researchers in large-scale social science projects.

exits the lab to avoid Jim's control efforts, more dependent researchers, such as Michael, emphasize their autonomy within the constraints of Jim's general goals.

Such resistance to monitoring prompts Jim to joke that he schedules the group's only mandatory activities, muffin meetings, early in the morning to ensure that he gets a full day's work out of his researchers "at least once a week." While he is joking, the humor points to the very real difficulty of enforcing even relatively simple standards of attendance in the lab.

The control problems raised by scientific work are exacerbated by multi-disciplinarity. Beyond the difficulty of controlling resistant subordinates, Jim simply cannot maintain the knowledge necessary to directly monitor the range of work done in his lab. Even if he could remain abreast of developments in nine scientific fields, the effort would preclude his pursuit of the intellectual, administrative, and pedagogical duties required of an academic laboratory director. In practice, then, multi-disciplinarity creates a work setting where subordinates do work their superiors cannot do. In the specialized world of research science, expert subordinates may even undertake work whose details their supervisors cannot fully understand.

The problems of monitoring expert workers when knowledge bases are inconsistent are apparent, but similar troubles plague attempts to oversee bench work even when both superior and subordinate are similarly trained. Tacit knowledge problematizes replication (Collins 1974, 1975), making direct checking of bench work time consuming and difficult. Technical know-how makes every experimental scientist an expert in her own specialized domain. Even in cases where both superior and subordinate share disciplinary and methodological training, the local knowledge inherent in experimental protocols and equipment makes it impractical for superiors to directly check scientific work.

Similar monitoring difficulties attach to all skilled labor (Stinchcombe, 1959). Burawoy (1982) highlights the important role technical know-how plays in machinists' resistance to managerial control. Likewise, Barley (1996) and Orr (1996) demonstrate the extent to which tacit knowledge is essential to technical workers, emphasizing the strategies used to pass such know-how on to newcomers. Kusterer (1978) shows that 'unskilled' laborers also develop know-how that raises similar difficulties for managers of even the most straightforward work. Reliance on tacit knowledge does not make scientific laboratories unique. Rather, I suggest that multi-disciplinary research settings like the H-lab represent an extreme case of a common organizational phenomenon. Understanding the means by which workplace control is unobtrusively established and maintained in this setting may shed light on the dynamics of knowledge-based work places while providing new insights into more traditional settings.

The scientific skepticism Jim deploys in meetings solves H-lab control problems. Muffin meetings provide opportunities to evaluate scientific work. These meetings are the group's primary forum for monitoring, control, and collective sense-making (Weick 1995). In muffin meetings, skepticism establishes workplace control by setting the premises that govern daily decision-making.

Unobtrustive control in the H-lab.

Herbert Simon (1959) and James March (March & Simon 1958) viewed organizations as structures for gathering, processing, and using information. Under this conception, organizations are structures of attention that direct the information search and use efforts of members. The key construct here is decision making and the theoretical focus is on the information flows within organizations that shape, inform, and support it. This organizational theory differed drastically from those that preceded it and was predicated on the concept of bounded rationality (Simon 1959).

Simon's (1959) key insight is that individuals make decisions based on imperfect information. Rather than engaging in irrationally difficult and time consuming information searches to enable interest maximization, humans satisfice. Satisficing is accomplished by using rules of thumb, heuristics, habits, and schemas to make decisions (Kahneman, Slovic & Tversky 1982). In organizations, satisficing is often accomplished through rules, routines, and standard operating procedures that grow in the direction of key uncertainties (Nelson & Winter 1983) and instantiate the "logics of appropriateness" that bound and make sense of information flows for decision makers (March & Olsen 1976; Weick 1979, 1995). In and out of organizations, sastisficing is based in premises that direct information search and use.

Under uncertain conditions satisficing can streamline and standardize decision making (Powell 1985), but it also has a "dark side" (Vaughan 1999b). Dianne Vaughan (1996, 1999b) demonstrates that the routines, standard procedures, and decision heuristics characteristic of uncertain technical workplaces can lead to mistake and even disaster through "routine nonconformity." Bounded rationality and premise driven satisficing also enable unobtrusive control in organizations (Perrow 1986; Braverman 1974). Premise-based decision making, then, is a decidedly double edged sword.

Premises themselves are taken-for-granted assumptions that direct individual attention to particular stimuli and evoke specific sets of responses to those stimuli. Authority is unobtrusive to the extent that it governs work and workers by controlling the premises that structure attention rather than by directly managing choices. As long as a superior controls the premises, the choices can be left free because all possible outcomes are *already* constrained by the chooser's structured attention (Powell 1985:147). In the extreme case, alternatives counter to organizational premises will not even occur to employees as possibilities.

Muffin meetings are sites for developing premise-based control. Muffin meetings are the primary site for discussing the H-lab's key uncertainty (scientific work). These meetings are also the only place where group members routinely congregate. Thus, muffin meetings are a prime location for examining the development and maintenance of premise-based control.

Muffin meetings represent ritual opportunities for interaction among diverse and very loosely coupled H-lab members. Like similar meetings in high technology settings (Van Maanen & Barley 1985; Kunda 1992), the US park service (Bullis & Tompkins 1989; Bullis 1991), film schools (Mukerji 1976, 1978), community mediation centers (Morrill & Mckee 1993), publishing houses (Powell 1985), police stations (Van Maanen 1973), teaching hospitals (Becker, Geer, Hughes, & Strauss, 1961), and corporate board rooms (Morrill 1994) muffin meeting interactions serve as " . . . mechanisms through which certain organizational members influence how other members are to think and feel – what they want, what they fear, what they should regard as proper and possible" (Kunda 1992: 93). The meetings' ritual aspects and their unique role as focused gatherings contribute to unobtrusive control that extends far beyond its weekly enactment over muffins.

Muffin meetings are held on Wednesday mornings in a large, well-appointed conference room with an attached kitchen. H-lab members commonly arrive several minutes early, serve themselves coffee in one of the lab's eclectic collection of mugs and mill about swapping shop talk and social gossip. In Kunda's (1992) terms these activities help the group transition from a routine to a ritual frame. Jim generally arrives last bearing the 64 ounce coffee mug that is his signature. By that time H-lab members are usually seated at the large conference table, chatting quietly and noshing on muffins. Attention shifts to Jim as he sits, raps his knuckles once on the table, and asks the question that begins every Wednesday morning: "So, has anybody got any news?"[10] 'News' typically involves informal reports on the progress of experiments, professional gossip, reviews of recent publications, or the discussion of administrative changes affecting the lab. News of the first type often opens group members to scientific skepticism.

Skeptical encounters enforce premises. Skeptical interactions are fraught with consequences, especially for junior researchers. In scientific settings where rewards are reputational, monitoring is difficult, and outcomes are uncertain, quality is determined more by individual responses to questions than by direct oversight. Thus, the type of criticism leveled at a researcher's claims and her responses to it have important implications for success and access to laboratory resources. Skeptical encounters in muffin meetings serve scientific monitoring purposes while establishing and enforcing the information premises that support unobtrusive control in the H-lab.

Skepticism establishes premise-based control by emphasizing positive and negative features of work. Jim gives very few orders, instead he sets the priorities that direct group members' attention to specific problems and information. By doing so he channels their effort in the directions he wants it to go. Premise based control, exercised through skepticism, is critical to the management of work in diverse, uncertain, and loosely coupled organizations such as the H-lab.

Scientific skepticism enforces premises that guide group members' decisions about scientific behavior and certitude. The misgivings expressed by lab members, especially by the highest status researchers, teach junior scientists what counts as "good science," what characterizes "hot" topics, when data is sufficient to support claims, and how *scientists* should behave. In the H-lab, skeptical encounters also teach junior scientists that some findings are more likely to succeed when presented by higher status researchers, leading them to attempt to manipulate the group's status order in support of their own claims.

[10] There are striking similarities between H-lab meetings and similar gatherings in other organizations (Powell 1985; Kunda 1992; Van Maanen 1973; Mukerji 1978; Bullis 1991). But without examining a comparative case I cannot say how similar muffin meeting interactions are to gatherings in other academic laboratories. Jim and other H-lab scientists report that the H-lab is comparable to other life science labs. They also note that lab meetings are ubiquitous in both physical and life science research groups. Indeed visiting scientists from around the world fit easily into the pattern of H-lab meetings. Informants do caution that the H-lab is larger and better funded than most academic labs. Its size and diversity may contribute to different meeting dynamics than might be found in other disciplines or in smaller groups. Nevertheless, H-lab members assume that their lab is similar enough to other research groups to enable direct comparisons.

Dextrane or Cobalt? Consider a pair of interactions surrounding the use of different methods to "backfill glomeruli." A glomerulus is an anatomical structure in *Manduca's* olfactory lobe. "Backfilling" requires covering several sensilla (the hairlike sensory structures on a moth's antenna) with a blunt pipette and pushing a dye through them. The olfactory lobe is then dissected and microscopes are used to visualize the neurons that clusters of sensilla "project" to. This method informs scientists about the gross architecture of the brain by indicating whether different types of sensilla project to distinct areas of the olfactory lobe. Three H-lab scientists, Caitlin, a graduate student, Jill, a young post-doc, and Frank, Jim's "right hand man," use these methods. In two different muffin meetings Jim engaged Caitlin and Frank in discussions about their choice of dyes.

H-lab scientists use two dyes for backfilling, Cobalt and Dextrane. The former is an older substance whose properties are well known and whose use is "standard" but slow and difficult. There is no standard method for backfilling with Dextrane and less is know about its *in vivo* properties.

Frank describes the backfilling work Nicki (an undergraduate working with him) has done using Dextrane.

> Frank: "Something that Nicki has been doing needs to get pushed forward. She can put a large pipette over many hairs [sensilla] and stimulate all of them to fill them. Then we can see if they all project back to the same place." Jim looks up with sudden interest "Has anyone done that?" Frank waves at Nicki, "We have." Patrick jumps in "You did that with Dextrane, right?" Frank: "Yeah, but it hasn't worked yet." Jim: "Maybe we should get back to cobalt-lysine methods." Frank: "Those are a pain in the ass, it takes like six days for the cobalt to diffuse. Besides, there is some old work done with Nicki's method, but her work is pushing that now."

In this encounter, Jim expresses interest in a research project and suggests a new method to use. He frames the suggestion diffidently. Frank rejects it on two grounds: (1) Cobalt is difficult to use, and (2) other scientists have used Dextrane and Nicki's work expands on those findings. One or both of these reasons satisfies Jim. He makes no more comments and Nicki, under Frank's close direction, continues to backfill glomeruli with Dextrane. Here, a skeptical interaction between two seasoned scientists highlights the characteristics of a project that should be "pushed forward" while emphasizing some of the calculations that should go into a choice of methods.

Several weeks later Caitlin presents some "pictures," microscopic images of glomeruli she backfilled with Dextrane. The skeptical encounter that followed took a very different course.

> Jim leans over the image Caitlin has laid on the table, "So this is the same sort of thing you did with Dye-I[11] right? So this is complementary to that work, right? It answers different questions?" Caitlin is a bit flustered "Yes, oh yes, of course it answers different questions but I hope I will eventually be able to backfill with Dextrane." . . . Jim: "So what happened with the Cobalt? I mean we know the Cobalt will work . . . so if you couldn't get it to work then we have to figure out why." Caitlin: "Well, there were problems with the Cobalt, and I got much more promising results much more quickly with the Dextrane . . . " Jim interrupts: "But Caitlin, the Dextrane method is useful for answering different questions than the Cobalt method." . . . Caitlin: "But the Dextrane works so much more effectively, it saves days." Jim leans back and looks around the room "I only keep harping on the Cobalt because we know how it works and that it works. Dextrane could be OK if you work on the pipette so that you are sure it doesn't

[11] A third type of dye sometimes used to backfill glomeruli.

> leak, but we don't know if Dextrane diffuses out of the glomerulus. We are really interested in seeing what is associated with a single glomerulus, so since we know what the Cobalt does it might give us the answer. Since we don't know so much about the Dextrane we just have a bunch of new variables."

This interaction focuses on the same method discussed by Jim and Frank, but the outcome is very different. Jim directs much more pointed questions at Caitlin than he did at Frank.[12] Caitlin tries to justify her preference for Dextrane by appeal to one of Frank's reasons for preferring the method, Cobalt staining is difficult and time consuming. But her argument is rejected. Jim describes the benefits of a known method and the "fit" between the method and the questions "we are interested in." Soon after this meeting Caitlin begins using Cobalt to backfill glomeruli.

Like the encounter between Jim and Frank this discussion serves several functions. It highlights the 'proper' reasons to choose a method, emphasizes the general characteristics of a good method, and establishes control over the work conducted by Caitlin. The two passages together also send a distinct message about who is and is not qualified to break new methodological ground in the H-lab.

By watching skeptical interactions like these, audience members learn the group's critical norms, the acceptable strategies for defending novel claims and methods, and the premises that guide decisions about scientific work in the lab. Muffin meeting skepticism provides public rewards or punishments and, thus, teaches group members the standards of practice acceptable in the lab without ever explicitly stating them. Muffin meetings offer Jim opportunities to signal his approval of claims, methods, and behaviors, further hammering home the priorities he wishes to govern behavior in his lab.

Skepticism helps set the premises that guide key scientific decisions, unobtrusively controlling scientists and their work. Jim can be confident in the findings he signs off on for several reasons. First, the H-lab's culture of skepticism and tradition of muffin meeting presentations ensures that problems chosen by junior scientists will follow the group's priorities. Thus, problem choice can be left largely up to group members, allowing them a wide range of autonomy within the boundaries set by H-lab premises. Well-developed premises constrain the choice sets of younger researchers. If the priorities that structure decisions meet with Jim's approval, then it is highly likely that any choice made within the boundaries of those priorities will also.

The outcomes of skeptical interactions in lab meetings are critically important to the eventual success of new scientific claims and individual researchers. The two interactions presented above suggest that differently positioned scientists receive and respond to diverse levels of skepticism. I argue that this pattern holds systematically across muffin meeting encounters.

Skepticism and Social Differentiation.

The question of how scientific stratification orders are locally constituted and maintained through interaction has not been systematically addressed. Under conditions of high uncertainty and problematic monitoring, professional rewards and laboratory resources are allocated largely on the basis of individual performances. If muffin meeting skepticism varies with a scientist's position, then some H-lab scientists are more likely to succeed than others. If H-lab skepticism is socially organized, then evaluations of

[12] Differences here might also be colored by Caitlin's gender. I will return to the question of whether gender operates as an organizing principle for H-lab skepticism, for now, note that these interactions are very different in character despite the fact that in both cases the backfilling was actually done by women.

scientific quality *and* degrees of social control vary across positions in the group. Thus, the character of skeptical attacks and the strategies open to resist them will be conditioned by individual scientists' locations in the H-lab's status order.

Though often attacked, Merton's (1976) norms of open science provide a starting point for thinking about skepticism and social differentiation. Merton (1976:6) argued that four normative imperatives – (1) universalism, (2) communalism, (3) disinterestedness, and (4) organized skepticism – comprise the 'ethos' of modern science. The validity and relevance of these norms have been hotly contested in works stressing the importance of corporate or state interests to science (Aronowitz 1988; Noble 1977; Mukerji 1990), the impact of scientists' personal beliefs, biases, and agendas (Harding 1991; Epstein 1994; Martin 1991), global and scientific structures of inequality (Haraway 1996; Zuckerman, Cole, & Bruer 1991; Stephan & Levin 1992) and the contextual and historical nature of scientific skepticism (Kuhn 1962; Shapin 1994). Nevertheless, considering socially organized skepticism as a local mechanism for organizing and evaluating work rather than a global scientific norm has potential explanatory payoffs at the level of laboratory work.

Unlike Merton (1976) who focused on the institution of science, I argue that skepticism is socially organized at the level of focused group interactions in laboratories. By this I mean that the character and outcomes of skeptical encounters vary with positions in labs. Skeptical encounters in muffin meetings represent the intra-group political process by which Jim's decision premises come to be more or less dominant over the group's knowledge structures (Walsh & Fahey 1986; Walsh, Henderson & Deighton 1988). Skepticism serves control purposes by enabling Jim to set decision premises, but the substantive critique of novel scientific claims also encompasses evaluations of veracity. I turn to a brief overview of two threads of social psychological research to link skepticism's premise setting and evaluative functions to status differentiation in the group.

Linking skepticism to status differentiation. Scientific labs are task-oriented groups. Despite differences in training and focus, H-lab researchers share a general task. They are all "nose people," dedicated to answering questions about olfaction. Organized skepticism is the group's primary mechanism for deciding when its tasks have been accomplished. Skeptical encounters in muffin meetings amount to group member's evaluations of each other's task performances. These evaluations, I contend, vary systematically with scientists' positions in the group's status order. Expectation States Theory (EST) (Meeker 1981; Ridgeway & Walker 1995) and Legitimation Theory (Ridgeway & Berger 1986, 1988; Berger, Ridgeway, Fisek & Norman 1998) connect such evaluations to quality expectations generated by individuals' positions in emergent and external status orders.

Both theories resonate in surprising ways with social constructivism and with Mertonian stratification systems. In EST, cognitive consistency theories are fundamental for understanding outcomes in task groups. Once formed, stable status orders result in the differential performance expectations for high and low status group members. 'Diffuse,' characteristics, such as race and gender, which are external to the task group can also help create expectations when they are salient to group members.

In other words, position in local status hierarchies and individual characteristics affect performance evaluations through evaluator's expectations regardless of the ‘objective’ quality of a performance.[13] Group members will tend to distort their evaluations of others’ contributions so that perceptions of ‘quality’ conform to their prior expectations for the performer. In theory, then, EST would suggest that high status scientists are more likely to have projects judged a success than low status scientists even when the finding reported is *exactly* the same (Foschi 1989, 1991). This is exactly the prediction at the heart of the Matthew effect (Merton, 1968) and it is born out in examinations of simultaneous discoveries, “multiples,” that link social control to the ascription of prestige (Cozzens, 1989).

Legitimation theory examines how characteristics external to a group’s emergent status order become important for the development of expectations. On this view, there are three salient sources of expectations for the quality of scientific performances (Ridgeway & Berger 1986: 604). Such beliefs can be based upon diffuse characteristics, specific task competencies, or reputations derived from prior accomplishments. In all three cases, the expectations that underpin skeptical evaluations will be drawn from the larger collectivities (organizations, subcultures, and/or societies) in which H-lab scientists share membership (Berger et. al. 1998).

In interviews and informal discussions, H-lab scientists often explicitly ranked one another in terms of specific experimental or analytic abilities and prior achievements. The shared salience and apparent ordering effects of these two dimensions resonate with two of the key sources of expectations identified by Legitimation Theory. The tendency to rank order lab members by ability and accomplishment suggests that these two factors are important sources of social differentiation in the H-lab.

A typology of social differentiation in the H-lab. I conceptualize the H-lab’s internal status order in terms of two dimensions. While they are broadly consistent with differentiation based in perceived abilities and accomplishments, these dimensions also capture some effects of the H-lab’s formal organization. The first draws on perceptions of scientific competencies by capturing differences in *individual scientists’* degree of control over their daily work. In the H-lab, variation on this axis is largely a function of perceived scientific ability. While individual work autonomy does vary with formal organizational position, H-lab scientists argue that varying degrees of freedom from oversight represent estimations of individual competence. Scientists with extensive experience in their specific experimental craft are monitored less than those who are neophytes in particular experimental or analytic techniques.[14] Thus, work autonomy reflects levels of individual competency in the H-lab.

[13] Indeed, some social psychologists (Ridgeway & Walker, 1995: 294) have drawn on classical ethnographic vignettes, most notably Whyte’s (1943) description of a bowling competition among members of the Norton street gang, to suggest that expectations shape the quality of individual performances regardless of actual skill levels as group members tailor their levels of success to match the expectations others hold for them. Experimental attempts to untangle the relationship between stereotypes and performance levels (Steele & Aronson, 1995; Steele, 1997) have uncovered similar patterns, finding that the risk of confirming a negative stereotype of one’s group negatively effects individual performance on standardized tests.

[14] While levels of experimental seasoning often accompany higher prestige formal positions, this is not always the case. One of the most closely monitored experimental procedures I observed was conducted by a visiting scientist who is a full professor at another university. Brent spent a sabbatical in the H-lab in hopes of mastering a new experimental technique. His first experiments using the method were closely observed by Nathan, the H-lab scientist most familiar with the procedure.

The second dimension introduces some organizational bases of evaluation to the more informal sources of expectations highlighted by social psychological theory. Here I draw on differences among *formal organizational positions* in the lab regardless of the positions' occupants. In essence this dimension depicts characteristics of the formal 'offices' that are occupied by individual H-lab researchers. These scientists firmly believe that formal academic positions reflect actual differences in levels of individual performance.

The lab's three most highly regarded post-docs, Walter, Adam, and Robert, are often referred to as "professor level" scientists, a categorization which suggests that their post-doctoral positions are incongruous with their individual accomplishments. Clearly, the mapping between professional accomplishment and formal position is less than perfect.[15] Formal positions may have something to do with status ranking based on scientific outcomes, but the stable constellation of rights and responsibilities conferred by an organizational position have implications for evaluative interactions that reach beyond expectations based solely in prior accomplishments.

The organizational dimension is a continuum capturing formal positions' different degrees of criticality to the lab (Pfeffer & Salancik 1978). Positions are critical to the extent that they uniquely reduce an organization's key uncertainties. If left empty, critical positions can impair organizational functioning. Consider the difference between the *position* of Laboratory Director and the *position* of Research Technician.

The directorship, with its mandate to maintain funding, guide the lab's scientific work, and broadcast the group's findings reduces at least three key organizational uncertainties. If Jim were to vacate the directorship, the position would have to be filled in order for the H-lab to continue existing as an organizational unit. In contrast the formal position 'technician' might exist to prepare specimens for microscopic analysis. While individual technicians' tacit knowledge can make them powerful and irreplaceable members of specific laboratories (Shapin 1989), research groups can and do survive without formal positions for technicians in their table of organization. Indeed, for several months prior to my fieldwork, the H-lab functioned without a technician. When Beth became ill and left the lab for extended recuperation no effort was made to fill her position.

These examples can be generalized as follows. Critical positions tend to (1) exist near the top of formal hierarchies; (2) be permanent rather than temporary or contingent; (3) be supported by stable funding sources; and (4) span multiple formal projects. I call positions that do not have these characteristics nonessential to indicate that they do not need to be filled for the H-lab to continue functioning.

The autonomy dimension highlights linkages between specific task competencies and control over work. Individual scientists have varied levels of control over their daily work practices regardless of the formal positions they hold. Simply put, scientists are independent to the extent that they control their own work. Autonomous H-lab scientists tend to (1) control their own funding sources; (2) be experienced in the specific

[15] See the description of Nathan, a very accomplished scientist who occupies a completely non-essential position, that follows.

experimental techniques they use; and (3) possess scientific abilities that are not duplicated by other group members and are important to the group's scientific goals.[16]

When combined, the criticality and autonomy dimensions yield a four-part typology distinguishing among H-lab members. Figure 1 represents these distinctions. Each cell in the figure discretely combines attributes of positions and scientists. The combinations are (1) Nonessential Position – Dependent Scientist (ND), (2) Critical Position – Dependent Scientist (CD), (3) Critical Position – Autonomous Scientist (CA), and (4) Nonessential Position – Autonomous Scientist (NA). I placed H-lab scientists on the typology by appeal to characteristics of biography and position. Using interview and archival data I compiled short 'biographical vignettes' for each researcher and then coded those in terms of the characteristics of criticality and autonomy. A brief example will concretize the coding scheme.

[Insert Figure 1 Here]

Nathan, a chemist, occupies the position 'Visiting Scientist' in the H-lab. The position is nonessential. It exists purely to give Nathan organizational legitimacy. If he left the position, it would not be filled. Nevertheless, Nathan himself is a highly accomplished scientist, the veteran of 30 years of research and administrative work in a prestigious academic department. His acknowledged skills mean that his scientific abilities are rarely questioned. Jim makes no effort to control or direct Nathan's work. Nathan is an autonomous scientist in a nonessential position.[17]

Scientists occupying the same cell on Figure 1 are structurally equivalent in terms of laboratory interactions. In order to determine whether scientific skepticism in the H-lab is socially organized, I draw on skeptical encounters coded from field notes taken during muffin meetings. A skeptical encounter is any conversational exchange in the context of a muffin meeting where critical or directive comments are made about the technical, substantive, or theoretical details of a scientific claim. Textual coding of field notes yielded 249 such encounters. If skepticism is socially organized and if Figure 1 captures salient dimensions of status in the H-lab, then the amount and direction of those encounters will vary with scientists' relative positions on Figure 1.

Table 1 presents descriptive statistics for observed skeptical interactions by scientist position and interaction direction. The rows present the percentage of all observed skeptical encounters involving a given pair of cells. These interactions are further divided in terms of their direction. 'Downhill' skepticism occurs when higher status scientists direct skeptical comments to lower ranked researchers.[18] 'Uphill' skepticism is the reverse. The dotted arrows on Figure 1 indicate the direction of downhill skepticism.

[Insert table 1 here]

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[16] For instance Robert and Adam, the lab's biophysicist and molecular biologist, are more autonomous than Patrick, one of many physiologists, despite similar levels of general experience. This difference occurred because Robert and Adam possess experimental skills and craft knowledge that is unique in the lab. In contrast, Patrick's skills are closely replicated by other physiologists such as Michael, Caitlin, and Jill.

[17] Note that Nathan's prior scientific achievements are somewhat incongruous with the non-essential position he holds in the lab. This disjuncture suggests that there may be some benefit to considering the effects of organizational embeddedness on evaluations in addition to the less formal bases of expectations highlighted by social psychologists.

[18] The ambiguous case of NA-CD discussions were coded as downhill if they were initiated by the more autonomous NA scientists.

Two clear patterns are apparent in Table 1. First, the volume of skeptical encounters involving a given scientist varies with position in the H-lab's local status order.[19] With the exceptions of Jim[20] and Beth, every H-lab scientist formally presented work to muffin meetings at least once, but some presentations were much more critically received than others. The group's highest (CA) and lowest (ND) status scientists were involved in the majority of H-lab skeptical encounters. The concentration of skeptical interactions along Figure One's off diagonal makes sense if skepticism is the primary means of monitoring work and if the lab's lower status scientists are most in need of oversight.

The direction of H-lab skepticism varies with dyad composition. Jim and Frank initiate most of the lab's skeptical encounters. They also doubt much more often than they are doubted. In the H-lab, criticism generally flows downhill. An exception to this rule appears in ND-CD encounters. These scientists differ only on Figure One's organizational dimension. Where scientists have equivalent work autonomy, only about 50% of skepticism flows downhill. In contrast, downhill debates dominate where levels of autonomy vary but criticality is equivalent (as in NA-ND interactions).

Individual scientists' chances to produce and defend novel scientific findings are conditioned by position in the H-lab's status order. Skeptical encounters serve evaluation functions, but evaluations are based more in expectations for performance than in the performances themselves. Social control in the lab also follows these patterns with expectations for performance quality determining the degree of oversight to which scientists are subjected.

A scientist's ability to defend new claims against skeptical attacks establishes findings' quality and validity in the absence of direct monitoring. Jim's confidence in his researchers' findings is skeptically grounded in two ways: (1) problem choice is structured by premised-based control, and (2) quality is monitored interactively through skepticism. Claims that survive group vetting in muffin meetings are judged valid enough to submit, as manuscripts, to the larger scientific community for further skeptical evaluation. It should be no surprise, then, that H-lab researchers actively resist skeptical attacks on their work and attempt to manipulate the group's expectations for their performances by appeal to sources of status external to the H-lab's social control structure.

Capacities and strategies for resistance.

I argue that junior scientists' have two distinct but overlapping avenues to resist senior researchers' critical attacks. Baseline resistance capacities are a direct outcome of the social differentiation in the lab and hold across sets of scientific claims. Junior scientists' local status positions convey differential abilities to deflect muffin meeting skepticism. In this context, baseline capacities capture the different levels of regard junior researchers must demonstrate for their seniors' critical comments.

Jim and Frank dominate skepticism in the H-lab. But the group's relatively flat formal hierarchy masks important distinctions among junior scientists. Even the nine post-docs, who have titularly equivalent roles, are differentiated in the lab's informal

[19] By 'local status order' I mean to denote the four categories delimited by Figure 1. These reflect the confluence of characteristics that are largely internal to the group. The effects of other sources of status drawn from outside the H-lab (e.g. disciplinary affiliation or gender) are treated in a later section.

[20] Who no longer does bench work.

status order. These scientists (italicized) are spread across three cells in Figure 1. Such variations have important consequences for young H-lab scientists because skeptical encounters vary with social position.

The five post-docs funded solely by Jim's grants occupy the ND cell with most of the group's graduate students. Harry, by virtue of his fellowship and fieldwork is afforded greater autonomy but occupies a non-essential position because his work does not represent an established component of Jim's grant-based research program.[21] Thus, Harry occupies the NA cell with the much more experienced research scientists and visiting professors. Finally, Walter, Adam and Robert occupy the CD cell and are distinguished by their relatively high levels of experience and their critical scientific competencies. The nine post-docs occupy the same formal position, but my typology and H-lab scientists distinguish among them. In terms local to the H-lab, the ND post-docs are called "hired-hands," Harry is a "gambler," and Walter, Adam and Robert are "stars." These emic labels map nicely onto my more sociological parsing of the group's status order. I draw on these distinctions among post-docs to highlight variations in junior scientists' baseline capacities to resist skepticism.[22]

Baseline resistance capacities among post-docs. Recall that skeptical encounters in the lab vary systematically with social position. Gamblers and stars (like other scientists in the NA and CD cells of Figure 1) are much less likely to receive criticism than hired-hands. Different post-doctoral statuses also allow divergent opportunities to defend findings. In the Dextrane/Cobalt example presented above we saw scientists of different status responding distinctively to similar criticisms of the same methodology. I turn to the differentiated post-doctoral role to highlight variations in baseline capacities to resist skepticism across differently positioned scientists.

The three field note excerpts that follow exemplify systematic variations in the framing of critical attacks and responses. I present three skeptical encounters. All are directed downhill from Jim to a post-doc. The examples are arrayed in order of descending capacity for resistance. Note that both the tone of Jim's comments and the character of post-docs' responses varies with the junior scientists' position in the lab. These characteristic differences, I argue, represent the effects of local status on resistance capacity.

Jim & Harry (a gambler) –

Jim looks up and interrupts, "Harry, I have a technical question about the mass spectroscope. . . " he goes on to ask if something was wrong with the machine because spectral lines are not supposed to "tail" like the one Harry is using as an example. Harry responds, "If I were a really careful spectrometer then I would not do anything without adjusting the little helium knobs on the back of the machine. The interesting thing to notice here is that no tailing occurs after about eight minutes. I am not really good at chemistry. An organic chemist would probably just look at this and say 'go home boy,' but the data look good to me." Jim seems satisfied and Harry continues his presentation.

Jim & Walter (a star) –

[21] In the terms I use here, Harry's position in the H-lab's status order reflects the confluence of organizational position and individual accomplishments. His NA status, then, reflects the somewhat ambiguous effects of successfully pursuing independent fellowship support.

[22] For ease of reference I use the H-lab's terminology to distinguish among types of post-docs for the remainder of this discussion.

> Jim points to a section of a slide, "Does that happen to be a subset of the cells you are interested in? It looks like those are fasciculated. . . "
> Walter: "Well, here is a fascicle, but I can not say for sure if it is part of my group.."
> Jim: "Well it certainly looks like you hit a fascicle cluster."
> Walter: "Yes, you can see more fasciculated clusters here and here."
> **Jim & Jill (a hired-hand) –**
> Jim: "Well, that is a nice result, but you have to be really careful with a concentration that high. In fact, that is something we talked about a lot at this meeting I just got back from, what they called a mass effect, where a strong enough concentration of any scent could force all the cells to react strongly. . . ." He trails off and looks at Jill. Jill looks around the room for a second, she seems to be getting progressively more nervous. Her voice quavers a bit when she says "Oh, OK. That is certainly something to be careful of."

Jim's phrasing varies across the excerpts, as do the post-docs' responses to his criticism. With Harry, Jim sounds almost apologetic. Harry dismisses Jim's concerns because the data "look good to him," even though he admits they might not look good to a relevant expert, an organic chemist. With Walter, Jim's comment is framed as a question, albeit a less hesitant one. Walter attempts to dismiss the remark, but Jim presses the issue. Eventually, Walter accepts Jim's implied position. Jim's remarks to Jill are statements. She makes no attempt to dismiss them. Instead she accepts them without substantive reaction. In addition to receiving diverse types and amounts of criticism, differently positioned scientists have varying capacities to deflect doubt.

These interactions vary with the presenter's position in the H-lab's differentiated status order. The variation indicates differences in the extent to which senior scientists direct and control the bench work of post-docs. These examples also illuminate diversity in scientists' capacity to resist downhill skepticism. Throughout my time in the H-lab skeptical encounters followed the general pattern suggested above. Harry generally dismissed often diffident critiques. Robert, Adam, and Walter routinely argued but usually acquiesced to criticism, and the hired-hands[23] most often accepted strongly phrased skepticism. Variation within a single role, the post-doc, concretizes my argument that some junior scientists are better positioned to defend new claims than others. These same scientists may also be better positioned to defend radical claims than their less fortunate colleagues.

The strength of a junior researcher's claims influences their chances of getting new findings past the group, which in turn alters opportunities for publication and career advancement. In this fashion the contents of published scientific knowledge and junior researchers' career trajectories are both structured by laboratory interactions and micro-level status orders. By shaping the premises that guide problem choice and control work, and by differentially benefiting some junior researchers, organized skepticism constrains scientific outcomes.

Gender, position, and skeptical interactions. In all the examples I have presented, female H-lab scientists appear to fare less well than their male counterparts. In particular, the skeptical encounters involving Jill and Caitlin suggest that gender may determine the character of H-lab skepticism. I argue that this is not the case, suggesting instead that the similarities between Caitlin and Jill's interactions with Jim result more from their equivalent status positions and associated resistance capacities than from their gender.

In science, as in other occupations, women are disadvantaged relative to men (Reskin & Roos, 1990; Zuckerman, Cole & Bruer, 1991; England, 1992; Fox 1995).

[23] Jill, Adrienne, Patrick, Velma, and Anne.

Women's differential career attainments and access to rewards in academic science may partially result from the expectation-based evaluation processes I highlight here. Indeed, where standards are subjective and reputationally based, as in scientific research, women are more often negatively evaluated than men (Pheterson, Kiesler & Goldberg, 1971). Systematically untangling the general effects of gender from more sub-culturally based expectations is beyond the scope of this paper. Nevertheless, close examination of skeptical interactions involving similarly placed male and female H-lab researchers suggests that variations in skepticism are driven more by the confluence of ability, outcomes, and positions than by sexism on the part of more senior lab members.

Recall that Jill, a 'hired-hand' post-doc, simply accepted skepticism leveled at her work by Jim. Likewise, Caitlin, a graduate student, unsuccessfully defended a novel methodology using strategies similar to those successfully deployed by Frank. I have argued that Caitlin and Jill's positions on the autonomy and organizational dimensions captured by Figure 1 explain both the strong criticism they received and their relative inability to defend against it. A plausible alternative explanation might hold that these scientists suffer skeptical disabilities because of their gender. Given the limitations of my data, two responses to this alternative are possible.

First, consider the gross characteristics of the lab. Jim is one of the foremost experts in his field. His lab is respected around the globe, as evidenced by a stream of visiting faculty members from U.S. and international research groups. The lab's prestige and track record make its post-doctoral positions highly sought after. Yet nearly half of the lab's post-docs are women. Likewise, both male and female H-lab alumni have moved on to successfully pursue faculty positions. The gender distribution of post-docs and success is incongruous with a selection mechanism driven by conscious or unconscious sexism.

Consider also the fact that both male and female scientists are located in the group's lower status positions. If gender were a central organizing factor for skeptical interactions, then Patrick, a male hired-hand post-doc, should receive and react to skepticism in a fashion more similar to male stars or gamblers than to female hired hands. Likewise, all female hired-hands should receive similar critical treatment from senior lab members. This is not the case. Consider two skeptical interactions involving Velma, Patrick, and Jim.

> **Jim & Patrick**
>
> Patrick continues to present traces and fills. Jim begins to fidget, eventually interrupting to say " But look, the important thing for the structure and function of the glomeruli is not so much that some compound causes the reactions you are seeing [the trace data Patrick has been spending much time on], but that all those receptors arborize separately [an implication of the fill data Patrick that has slighted.]" Patrick pauses and looks at Jim for a moment and them smoothly redirects his presentation to a discussion of cell morphology.
>
> **Jim & Velma**
>
> As Velma wraps up her presentation Jim speaks up, "This is a real tour de force. It's amazing that the numbers came out that close. But this is also a disappointment. We've hit the wall with *Manduca*, finally, and found out what it is and is not good for. So Velma has been using every microscope made by the hands of man to try and figure out what's going on."

These interactions are notable for several reasons. First, Velma is the only hired-hand whose claims met with Jim's wholehearted approval.[24] Acceptance, or the absence of skepticism, was much more commonly accorded to more senior and autonomous researchers, most notably Nathan, Erin, and Brent. More interestingly, consider Patrick's reaction to Jim's criticism. Unlike Harry, the gambler, who simply dismissed Jim's comments, or Walter, the star, who acceded after argument, Patrick's reaction is very similar to Jill's. After a moment's pause he accepts Jim's declarative criticism without argument by redirecting his discussion of findings. The key difference between Patrick and Jill's reactions, then, lies not in their capacity to resist criticism, but in the smoothness with which they accepted 'correction.' Jill's less polished response may be a function of her relative inexperience. Patrick has worked as a post-doc for nearly six years. In contrast, Jill defended her dissertation six months before I began my fieldwork.

Taken together, these interactions suggest that gender and experience[25] are less important than position in the H-lab's prestige order for explaining the characteristics and outcomes of skeptical interactions. Categorical beliefs based on gender do not seem plausible as defining principles for H-lab skepticism. I will not argue that gender does not matter in the H-lab, instead, I suggest that stereotyped expectations based in disciplinary affiliation are more salient than gender and offer junior scientists an avenue for strategic resistance to skepticism.

Intentional resistance strategies.

Intentional resistance strategies are the means scientists use to defend specific claims beyond the baseline for resistance accorded by their local status. During my time in the H-lab, I noted three types of intentional strategies. Young H-lab researchers sometimes strategically reinforce novel claims by (1) drawing on status orders external to the lab (2) using group oriented rhetorics to emphasize collective motivations for individual projects (Ridgeway 1982), and (3) relying on non-conformist presentation styles to defuse skeptical attacks while drawing attention to original claims (Ridgeway 1981). Illustrate two of these strategies below.

In the 22 cases where downhill encounters involved strong resistance by junior scientists, 72% (16) were accompanied by at least one of the resistance strategies I describe. Few of these interactions represent 'pure' cases of a single resistance strategy. Instead, H-lab scientists attempt to influence evaluations of their performances in multiple ways. Nevertheless, appeals to sources of status external to the H-lab were by far the most common strategies for resistance. Nine of the sixteen 'resistance cases' I coded included some form of appeal to an external source of status.[26] In nearly every case, that appeal was based on disciplinary affiliation. While this small number of interactions cannot conclusively demonstrate that these strategies capture attempts to

[24] I will return to an explanation of Velma's success. In this excerpt, Jim's lack of skepticism seems incongruous with Velma's relatively low status as a hired hand. I argue that the success of Velma's claim is, at least in part, a result of the intentional resistance strategies she deployed during her presentation.

[25] Patrick is more experienced than all but two other H-lab post-docs (Walter and Robert). The similarity between his and Jill's encounters, then, suggests that experience in the absence of outcomes (grants and publications) or unique skills is also not determinant of the character of skeptical interactions.

[26] Because several of these resistance cases included more than one of the strategies I discuss, I do not provide explicit counts for each type. Instead, I note that nine cases involved some combination of either non-conformist presentation styles or rhetorical demonstrations of collectivist motivations with other strategies.

strategically deflect downhill skepticism, their common use by H-lab scientists is highly suggestive. Indeed the dominance of appeals to discipline based status follows from the group's intellectual diversity.

In a multi-disciplinary setting where scientists are aware of each other's specific abilities but not necessarily of general knowledge bases, stereotypical perceptions of different disciplines serve as markers of particular kinds of competencies. Disciplines occupy different statuses in the subculture of neuroscience; more holistic areas, like field ecology, are less prestigious than more reductionist disciplines, like molecular biology. If disciplinary affiliation does carry categorical referential beliefs, then group members trained in higher status disciplines may be more positively evaluated because of that training even when it is not related to the task at hand.[27] By the same token, scientists trained in lower status fields may be disadvantaged in attempts to pass novel claims by skeptical audiences.

Categorical beliefs about disciplinary affiliation may have another effect, as shared performance expectations based on them can be intentionally manipulated by researchers.[28] Strategically drawing on a shared status order external to the lab may provide concrete interaction benefits for junior researchers by altering audience expectations for the quality of their scientific claims.[29] Such altered expectations, in turn, help to mitigate the interaction disabilities that come with lower positions in the H-lab's local status order. For instance, claiming affiliation with a specific discipline may help to overcome skepticism based in an individual's lack of experience with certain experimental techniques. Consider an example of this resistance strategy drawn from an argument between Harry and Jim.

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[27] Consider a case where Beth defends the quality of a researcher's findings without knowing the details of her experiments. Here the interaction revolves around Blanca, whose work in a Scandinavian lab challenges H-lab findings about male moth olfaction.

> Beth: "You might also want to ask her about her method. Before she came here she worked on really small beetles. That is a really difficult animal. She is an expert with these methods and she has techniques that we do not. Also, she is really good with chemistry. She has a really strong background, stronger than anyone here. So the answer to your implication that she hasn't thought through her controls is that she probably has!"
> Jim: "There is no question about the chemistry. But she is working in Bill's lab and we know that Bill is a bit to flamboyant with his methods."

Beth's defense of Blanca's findings is not based in detailed knowledge of the project but in stereotyped beliefs about the professional competencies of chemists. In other words, Beth appeals to a categorical belief (e.g. chemists know more than biologists about structuring experimental controls) on Blanca's behalf. Jim rejects this appeal without questioning the belief. Instead he highlights a premise that guides project evaluation in the H-lab; always consider findings in the context of the lab where experiments were conducted. Here a skeptical encounter encompasses an appeal to an external status characteristic, elucidates an evaluation premise, and serves its explicit purpose by judging the validity of Blanca's finding. Note also that Jim expresses skepticism about Blanca's findings for reasons that have more to do with the PI of the lab where she works (Bill) than with Blanca herself. This further suggests that gender is not the dominant organizing principle for Jim's skepticism.

[28] The potential for strategic manipulation of performance expectations is implicitly assumed by EST theorists who hope to intervene in interactions shaped by such expectations (Cohen & Roper, 1972). I write as if the manipulation of performance expectations is conscious. EST does not deny that conscious manipulation of expectations is possible. Nevertheless, the theory assumes that expectation and evaluation processes can, and typically do, occur without conscious thought.

[29] In the terms used by legitimation theorists, this amounts to a strategic attempt to tap categorical referential structures.

During a lab meeting presentation Harry makes a radical claim, arguing that moths search flowers for nectar, their primary food, by "tapping" them with their tongues. His statement is based primarily on infrared video recordings of wild moths' feeding behavior. Harry's assertion is important because it suggests that a sense other than smell is responsible for moth-plant interactions, an argument that flies in the face of most H-lab research into male and female feeding behaviors. The claim's radical nature may account both for Jim's uncharacteristically strong skepticism and for Harry's use of two intentional resistance strategies: an appeal to disciplinary status, and a retreat to group-oriented rhetoric.[30]

> Harry argues that the texture of flowers is important to *Manduca's* feeding behavior: "It is obvious to me that this is what they [the moths] have been doing [tapping flowers with their tongues before feeding] and I HAVE been out there watching them all summer." Jim interrupts to ask Harry how he knows this: "That only happens when they are really close to the flower, right?" Harry fidgets, he seems exasperated. He replies "Right, that is right, in the field you are not doing distance effects." Jim: "So how do you know the behaviors are meaningful?" Harry: "We don't. I am just trying to break the behavior down into classes."

This encounter contains attempts to manipulate categorical expectations. Jim questions Harry's claim. Harry accepts Jim's point but attempts to influence his evaluation by appealing to methods specific to his discipline, field ecology. He says "In the field you are not doing distance effects." This reaction is an attempt to convince Jim that his interpretation of difficult to interpret moth behaviors is appropriate because of special expertise conferred by his disciplinary background.

Jim rejects Harry's move, reframing his question more negatively, "How do you know the behavior is meaningful?" Harry responds by shifting from an individualistic claim – "it is obvious to me" – to a more group oriented response – "we don't know." Harry's appeals are attempts to use general categorical beliefs about ecologists to his advantage. He eventually retreats, framing his acceptance of Jim's skepticism in group oriented terms in order to maintain his position while further justifying his problematic claim.

Ridgeway (1981) finds that non-conformity with group interaction norms exerts influence on performance expectations by providing an audience with clues to competency and motivation. In the H-lab, flouting established presentation standards may

[30] This latter strategy is the least common and hardest to isolate of the three I identify. Therefore, I pay little attention to Harry's use of the group-oriented pronoun in the text, focusing instead on his appeal to the discipline based competency. Note however, that rhetorical signals of collectivist motivations (Ridgeway, 1982) have been shown to mitigate some of the effects of low status. While Harry has, among post-docs, the greatest capacity for resistance, his responses to Jim's attacks reiterate the gambler's lower status relative to the H-lab's most prestigious member. Thus, Harry appeals to intentional resistance strategies to bolster his claims in the in face of uncharacteristically strong skepticism from Jim.

In this case, Harry met with intense criticism because his focus on touch as a key sensory mechanism for moths to locate food contradicts the H-lab's established emphasis on olfaction as the primary sensory basis for multiple moth behaviors. Harry's retreat from an individualist claim, (e.g. 'I found this') to a more collectivist framing (e.g. 'we don't know, I'm trying to help us figure it out') represents more than a simple rhetorical trick. Instead, the use of the plural pronoun here suggests not only Harry's retreat from a losing battle with Jim, but also a return to shared expectations for moth behavior based in the H-lab's ongoing olfactory research program. Note, however, that Harry's retreat does not involve the repudiation of his original claim, only its reframing as a component of the H-lab's collective research endeavor.

serve to emphasize particular areas of expertise or claims a researcher thinks are worthy of more than run-of-the-mill defense. Recall that Velma is the only hired-hand whose research claims met with Jim's explicit acceptance. Earlier in the same presentation, she relied on a non-conformist presentation style to quell group skepticism.

> Loud discussion breaks out in the room. The entire audience seems skeptical of Velma's claim that male and female moths have the same number of sensilla. For a moment the room dissolves into white noise as they fall over one another to ask her questions. Velma waits for a moment and then focuses attention on her presentation, preempting any questions by glaring at Harry and yelling "QUIET, I'M TALKING NUMBERS HERE!" She puts up a table with counts for various types of sensilla and says "You can make your own judgments, but there are obvious differences in the data." Jim asks "Velma, didn't you aggregate given that Lee and Strousfeld don't classify sensilla the same way you have?" Velma smiles and the room gets a little tense. Harry is leaning forward toward the screen. After a moment Velma replaces her slide with one showing an aggregate count.

In this interaction, Velma draws upon multiple strategies to influence performance evaluations. She yells at her audience when it gets loud, and while doing so emphasizes the quantitative bases of her claims. Both of these actions are non-conformist within the context of the H-lab. Yelling during presentations is contrary to observed patterns of behavior in the group and drew startled responses from audience members. Relying on statistical presentations of findings is also a non-normative, though potentially strong, rhetorical tactic. In 11 months of presentations, only two researchers relied on significance tests or exhaustive count data to make substantive points.[31] For Velma, whose graduate training had a strong statistical component, the emphasis on numbers draws attention to her specific skills with a valued argumentative device.

Velma's non-conformity works by drawing attention to a piece of research that Jim later describes as a 'tour de force.' Other attempts to influence evaluations using this strategy fared less well in the group. Ridgeway (1981) noted that non-conformist presentations represent dangerous influence strategies. By drawing attention to a researcher's competencies, non-normative behaviors may raise audience expectations, but they do so at the researcher's peril. In experimental settings, non-conformist attempts at influence tend to fail unless accompanied by a compelling demonstration of competency. Jim's positive reaction to Velma's research suggests that she managed just such a display.

These two examples highlight some of the ways that strategic manipulations of skeptical interactions can be used to influence evaluations. Where junior researchers are differently able to directly respond to their seniors' criticism, their common use of strategic resistance mechanisms suggests that skeptical interactions may provide savvy junior scientists with opportunities to forward their claims while remaining within boundaries set and enforced through organized skepticism. In this way, H-lab skepticism simultaneously serves to unobtrusively control work, evaluate findings, and provide avenues for scientists to resist control and influence critical judgements.

Conclusion.

The H-lab's multi-disciplinarity and physical dispersion exacerbate problems of monitoring raised by tacit knowledge. There is an art to doing science and even researchers who share general training and experimental skills may be unable to directly check each other's work. Where knowledge bases are inconsistent, as is the case in Jim's

[31] As Jim once noted when confronted with fills and traces from two nearly identical cells "Wow, a couple more of those and we'll almost be a real science, you know what they say, one, two, infinity."

attempts to supervise research in nine different disciplines, direct monitoring and evaluation is so difficult that another mechanism to establish work quality is necessary.

I contend that scientific skepticism solves the control problems facing intellectually diverse, uncertain, and reputationally based workplaces. Scientific skepticism is socially organized. In collegial but differentiated organizations like the H-lab, the amount and character of criticism directed at a claim varies systematically with the claimant's social position. This variation replaces formal governance in a setting where direct control is rendered problematic by the character and uncertainty of work and the resistance of highly trained 'employees.'

The problems associated with laboratory governance resonate with research in Science Studies, which focuses on the technical and negotiated details of scientific practice to establish the contingent and constructed nature of knowledge claims. Early investigations in this tradition emphasized the role of tacit knowledge (Collins 1974, 1985), scientific credibility (Latour & Woolgar, 1986), the details of shop-talk (Lynch 1985), experimental procedures (Galison, 1997), and even the flow of time (Traweek 1988) in constructing the outcomes of scientific research.

In recent years, Science Studies research has shifted toward a consideration of scientific practices embedded in organizations (Vaughan, 1999a). This article extends the organizational turn in Science Studies (Thorpe & Shapin, 2000; Hessenbruch, 2000; Sims, 2000) by addressing micro-level issues of control, coordination, and resistance in multi-disciplinary workplaces. These concerns have more commonly been addressed in classical industrial ethnographies (Gouldner 1954; Roy 1958; Dalton 1959; Burroway 1982) and contemporary examinations of organizational decision-making (Vaughan 1996, 1999b), technical (Kunda, 1992; Orr 1996) and professional (Powell 1985; Morrill 1994) work than in constructivist laboratory studies.

Considering science as work also offers a corrective to Mertonian Sociology of Science, which has focused more on institutional reward structures, norms of behavior (Merton 1968, 1976), and outcome stratification (Cole & Cole, 1973; Zuckerman 1977; Cozzens 1989) than on the details of daily practice. Focusing on structured interactions within laboratory groups can link these disparate approaches by suggesting that the processes that constitute and maintain behavioral inequities in laboratory groups provide insights into both workplace control and knowledge construction.

On this conception, control and evaluation are flipsides of the same coin. Skepticism is a mechanism for collectively establishing the veracity of novel findings, but its evaluative function is inextricably linked to unobtrusive control. Such control is based on bounded rationality (March & Simon, 1958; Simon 1959) and implies that an organization's primary purpose is to structure the attention and direct the efforts of its members. As it is deployed in H-lab meetings, organized skepticism sets the premises that guide scientific problem choice and evaluation. By setting boundaries on behavior and decision making, organized skepticism limits the range of problems H-lab researchers examine and the methods they use while subtly shaping the character of findings that eventually 'make it out' of the laboratory.

But scientific judgments are not pure, and workplace control is less than total. Cognitive processes illuminated by social psychological research (Ridgeway & Berger 1986; Berger et. al. 1998) link assessments to expectations that stem from interaction, emergent, and existing status orders. Paradoxically, however, separating evaluations from claims also opens avenues for junior scientists to resist their senior's evaluation and control attempts. Socially organized skepticism offers varied benefits to differently positioned scientists, but it also opens room to maneuver. Individual capacities to resist skepticism are constrained by local position, but intentional resistance strategies that reach outside the H-lab's status order enable junior researchers to forward their findings without endangering the professional benefits that accrue to membership in a prestigious research group.

Understanding skepticism as a means to unobtrusively solve control problems in scientific workplaces connects the institutional management of information flows and decision making with the interaction processes and local status orders that structure evaluation, resource allocation, and career chances in the H-lab. The multiple roles organized skepticism plays in muffin meetings link cognitive processes with institutional governance by framing organizations as structures of attention and evaluations as the outcome of negotiations within local status orders. This organizational view of the H-lab emphasizes the extent to which choices about how to manage and organize scientific work are inextricably related to decisions about what claims are taken seriously and which researchers will succeed.

Skepticism, then, provides answers to three of the questions that opened this article. It is simultaneously a vehicle for evaluating the quality and veracity of new scientific claims, a means to establish and maintain unobtrusive, premise-based, control over workers, and an avenue for resistance to control and evaluations. The control problems Jim faces in managing diverse workers and uncertain projects are extreme cases of difficulties common to almost every work organization. Understanding local control and evaluation in the H-lab makes analyses of laboratory work resonate with manual labor (Kusterer 1978) the shop floor (Burroway 1982), the boardroom (Dalton, 1959; Morrill 1994), the stationhouse (Van Maanen 1973) and the practice hall (Murnighan & Conlon 1991). While the H-lab is not representative of these diverse organizational settings, unobtrusive control, status-based evaluation, and skeptical verification of work quality may well be. Indeed, linking workplace control and evaluation to the more general dynamics of task groups through social psychological theory suggests this framework's applicability across a wide range of contexts. I expect control and evaluation mechanisms very similar to scientific skepticism to be most apparent in organizations and occupations where direct monitoring is problematic, objective quality measures are difficult, work is uncertain, and status drives rewards, but aspects of the processes at work in the H-lab may be found in all collective work settings.

More concretely, scientific work's growing organizational embeddedness and the increasingly multi-disciplinary character of both academic and industrial R&D suggests that this analysis of scientific work may provide direct insights into a growing number of organizational settings. Organized skepticism works to control and evaluate non-routine "brain-work" of the type found in technically driven workplaces. To the extent that more and more productive labor is located in such knowledge intensive settings, an analytic approach linking macro-institutional and micro-interactional levels of analysis should prove fruitful at accounting for the patterning of rewards and status orders across the 'new economy.'

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Figure 1. Social Differentiation in the H-lab

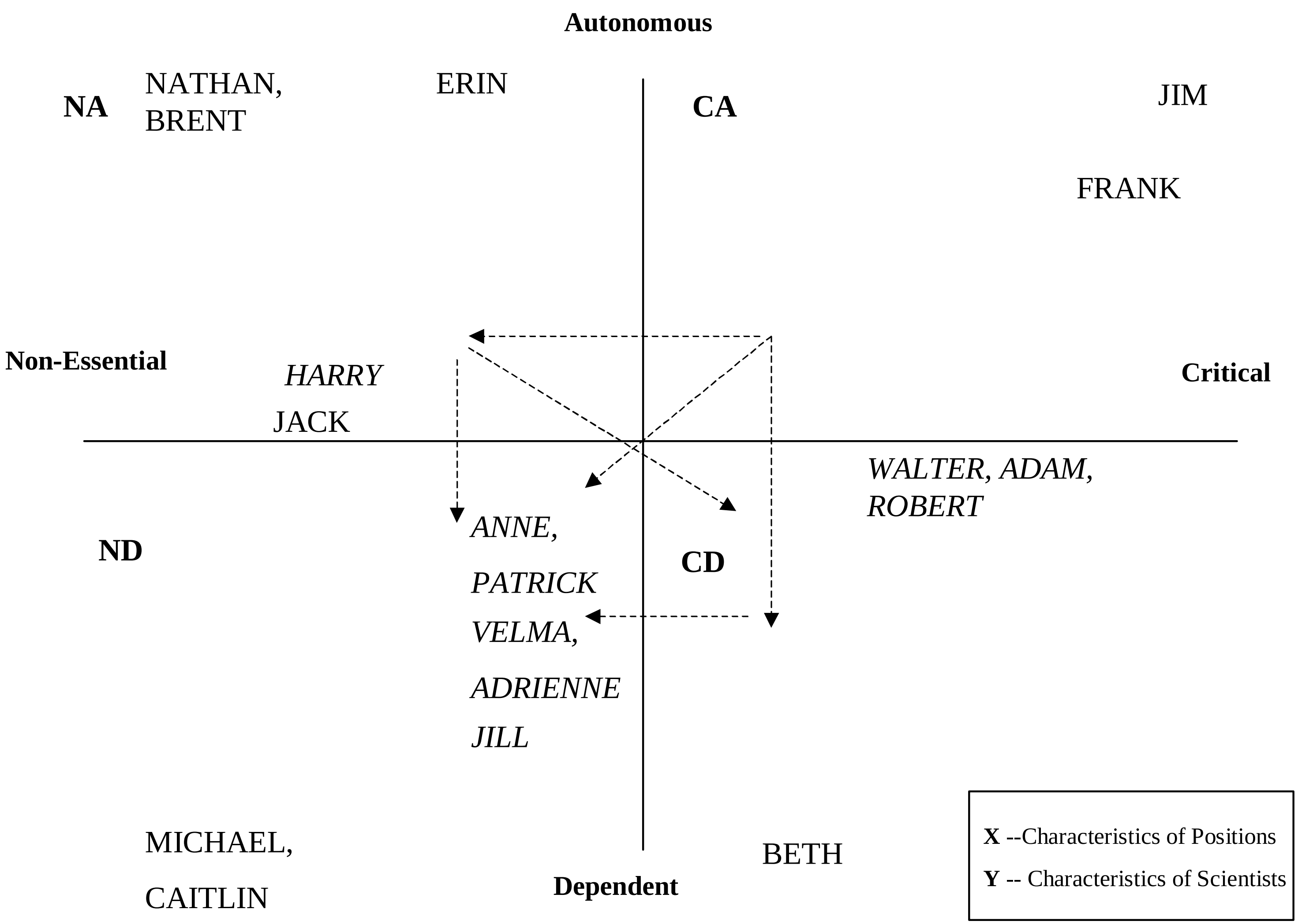

Table 1. Skeptical Encounters by Cell Pair and Direction

Cell Pairs (from Figure 1)	Total Encounters # (% total)	Downhill' Encounters # (% Pair Total)	Uphill' Encounters # (% Pair Total)
CD-ND	21 (8.4)	11 (52.4)	10 (47.6)
CA-ND	84 (33.7)	71 (84.5)	13 (15.5)
NA-ND	23 (9.2)	21 (91.3)	2 (8.7)
CA-CD	40 (16.1)	35 (87.5)	5(12.5)
NA-CD	6 (2.4)	4 (66.7)	2 (33.3)
CA-NA	27 (10.1)	20 (74.1)	7 (25.9)
Within Cell	48 (19.3)	-----	-----
N	249 (99.9)	-----	-----