Moral Frictions: Ethics, Creativity and Social Responsibility in Stem Cell Science

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ABSTRACT

Competing moral orders pervade markets and organizations. Previous studies of morals and markets show that organizational and occupational communities in contested areas promote one unique moral perspective in order to gain legitimacy and ensure organizational survival. In this perspective, change and innovation are only possible when distinct actors with a competing moral perspective enter a market. Yet communities do sometimes produce innovations at odds with the moral position they promote. How do they achieve this? Drawing on a 17-months ethnography of a stem cell laboratory, I explore the ways in which competing moral orders intersect in the workplace and how this collision shapes work and innovation practices. I examine two distinct moral conflicts: conflicts over safety and conflicts over bioethics.

These two different types of conflicts suggest together that, far from being ethical deserts where workers conform to their organization's perspective, workplaces dealing with contested objects and technologies are spaces of intense ethical questioning and negotiation. Local moral contests are rich with creative opportunities: organizational actors innovate and shape their organizations as they seek to couple the practices and goals of their organization with their avowed personal values. This dissertation contributes to unpacking the links between morals and organizations by showing that moral legitimacy is not just a post-hoc justification of organizational products or practices but is integral to the constitution of these products and practices. This work also contributes to studies of expert work by highlighting the role of moral heterogeneity, local contests, authority over tasks, and technological innovation on the definition of social responsibility in expert communities.

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INTRODUCTION

1. One day in Med Lab

Tuesday morning in Med Laboratory (Med Lab), Peter is completing the steps of a several-day-long experiment. Peter is a Postdoctoral Fellow in Med Lab and a pediatric instructor in a nearby hospital. He has completed five years of residency, three years of chief-residency specialized in Pediatrics and is finishing a three year sub-specialization in neonatology, two of them including research. He still shares his time between the hospital and the laboratory. He is on call at the hospital tonight and is trying to work as fast as possible so he can go home relatively early to rest. He is working simultaneously on five experiments that are lined up on his bench, a "Non-presidential" (NP) bench equipped with NP instruments and supplies.

"Non-Presidential" is the official label used by scientists across the stem cell community in the United-States to designate works that fall under the 2001 presidential order banning federal funding for human embryonic stem cell research. This presidential order signed by then President G.W. Bush in 2001 was part of a set of measures seeking to regulate the use of Human Embryonic Stem Cells (HESC) in the United-States. The order stipulated that no federal funding could be used to conduct research involving human embryos or HESC lines. A dozen lines that had been already derived from human embryos were eventually authorized for federal funding. These lines however were generally judged to be of relatively poor quality and did not meet the needs of most researchers. As a result, a number of laboratories – generally helped by larger institutions such as medical schools or hospitals – developed so-called "NP" facilities, facilities privately funded with deeded personnel that could conduct research not approved for federal

funding. Such research included amongst other things, the derivation of new HESC lines from human embryos, the use of HESC lines and nuclear transfer (that involves creating stem cells by inserting human DNA into a non-fertilized human egg). This highly visible ban and the adjoining controversy particularly aggravated the scientific community as it transformed a complex bioethical issue into a highly visible and controversial one. The "Non-presidential" label itself, with its transparent reference to the President who enacted the ban, clearly evokes the particular grudge the scientific community holds towards a President who fully placed the stem cell controversy as a core part of the "Culture Wars" in the early 2000.

Peter is in charge of the NP facility of Med Lab that employs, in addition to him, a doctoral student and 2 technicians. A number of other laboratory members also use the cell lines derived by this team. The facility itself is located in the broader space of the wet laboratory and includes one bench and one room equipped with two workstations, two microscopes with articulated arms that can perform "micro-injections" such as injecting an egg or a day-old embryo, two incubators and a fridge. One notice at the entrance of the room details the Massachusetts regulation regarding stem cells research, a long text that stipulates amongst other things that the law provides the right not to engage in research studies that involve "the creation or use of pre-implantation embryos" with a phone number to call to report non compliance with this rule. A second notice identifies the NP project, its content, the people in charge and the names of the non-presidential lines created. A third notice displays all the names and signatures of the laboratory members trained and entitled to work with these NP lines. All the equipment – machines, workstations, instruments, supplies, chemicals and biological agents – are labeled with a bright pink "NP" label.

All this NP infrastructure and work is not so much on Peter's mind however, except as a background annoyance. He is completing his final year as a postdoctoral student and has applied to a number of federal grants that would enable the establishment of his own laboratory. However, the complex funding and organization required to set up a NP facility renders such facility out of reach for a new Principal Investigator (PI) seeking to set up his laboratory. As a consequence Peter will have to give up on using the cell lines he has himself derived with the unique expertise he has developed as he moves to his next career level. He is carefully rethinking and shifting his areas of expertise in order to ready himself to make this transition. But utmost on his mind this Tuesday morning, is how to conduct the experiments as quickly as possible, generate the data for his next publication and go home to rest and see his wife and children before heading to the hospital for his night on call.

He began his experiments the day before. The first one involves staining cells with antibodies to detect the DNA. He has a set of mice embryonic stem cells in culture plates that he prepared the day before. He tells me he needs to insert three antibodies into these cells: one to detect the DNA, one to detect the first antibody, one to amplify the results. He transfers his cells to smaller plates so as not to waste antibodies. He takes from the fridge a white box with about 30 small vials of different antibodies. He tells me that each vial is worth between $200 and $300, "this is why I am stingy about it." Thrift with materials is often touted as a hallmark of good science by bench workers. It is a money-saving, waste-avoiding and order- and cleanliness-maintaining practice. Wasteful conduct is particularly frowned upon as part of the materials used come from living beings. Another reason cited for the importance of thrift with antibodies is that these substances are generated from animals that have incurred a specific biological stress in order to

produce them and are, as a result, precious. Order and cleanliness maintenance is also a paramount quality in a place where micro-quantities of materials are mixed in order to perform chemical and biological reactions and any infinitesimal amount of unwanted substance in a mix can either corrupt the result of day- or week-long effort or pose a threat to the experimenter's own personal safety. Peter sets up tubes in a NP tube holder and mixes the three antibodies with a pipette. He is working fast and chewing intensely on gum – an activity that is strictly forbidden from a safety standpoint as any food or beverage can be a vehicle for ingestion of "hazardous" materials.

A small crowd is building up at his bench where two heavily used QPCR machines (machines for detecting and analyzing DNA) are located. As he works in the NP area, Peter does not have to share his bench with one of the 40 members in the laboratory: a relative luxury balanced by the fact that the extra space is being used by two analysis machines. Three other laboratory members are now using or waiting to use one of these machines and discussing their experiments and results. Seven of us now have to negotiate the narrow space between two benches filled with machines, chairs, tools, waste bins and experimental mixes filled with chemical and biological materials.

"Popular bench" grumbles Peter. He gets up from his workstation and makes his way across the crowded area to pick up a kit for DNA identification. To use the kit, he needs to filter a cell preparation. The day before he had treated some cells with an agent that dissolved the cell walls so that their DNA can be identified (with the kit). He first needs to filter out the cell debris with the help of tubes that have an integrated filter. He looks for the tubes in a closet but the stock is

empty. He grumbles about the growing laboratory population using so many materials. This generates a "hoarding behavior" and sets out to roam the laboratory in search of tubes. Walking past the laboratory manager, he tells her they are out of the tubes. He goes back to his bench and checks his drawers unsuccessfully for leftover tubes. We then embark in a full speed walk across the laboratory. The chemical reaction Peter had started the day before with his cells is complete and he now needs to move on to the next step if he is to avoid wasting his carefully prepared materials. We walk past two sets of doors outside the wet laboratory space then down two floors to the 5th floor of the building where another Med Lab team is working on cancer research in a separate wet laboratory space. As we speed past an imaging center Peter decides to stop and check on some cells he has left for imaging. A large microscope is taking regular pictures of batches of mouse embryonic stem cells. Peter is trying to monitor the progression of cell division of these different batches. We watch the small film created by the pictures on a computer nearby. The initial cell masses look abnormal: some are lumpy and irregular. Gradually, as cells divide, the cell structure becomes more and more regular. Peter explains that he is trying to understand the mechanisms by which cells correct their development through cell division. He then slightly repositions the microscope focus to center more precisely on the different cell masses that have moved around in their medium.

We then go on to look for the tubes in the supply annex of the cancer team. No supply here either. He runs back up the stairs and, back in the main laboratory spaces, starts asking around for private supplies. A technician tells him that Rob might have some. Peter calls over to Rob across benches: "We're all out of tubes!" Rob, a post-doctoral fellow, walks calmly towards one of his bench drawers, "Again?" He pulls out and triumphantly brandishes a plastic bag with a

small supply of the precious tubes to the great relief of Peter. "He's a good guy," Peter comments to me, and then adds for good measure, "He's awesome."

To run out of a container or reagent is more than a mere inconvenience as it not only means losing time searching for one but it also entails the risk of not completing an experiment and potentially losing of all the materials prepared for the experiment. While supply shortages are endemic to biology laboratories that deal with many specialized supplies in often unplanned ways, this problem is particularly acute for Med Lab.

Following a major scientific breakthrough 2007, the laboratory has grown from a medium sized team of 14 people to a large laboratory of forty members (postdoctoral fellows, research technicians, PhD students and undergraduate students). This rapid growth has created many material issues, the complex management of supplies being one of them. While the laboratory members are constantly seeking ways to add laboratory space, they still need to operate within a space regarded by all members as too small for their needs. Workspace and storage space are particularly insufficient. The laboratory constantly lacks space to store incoming supplies. Deliveries have to be stored in prohibited areas such as corridors or close to safety equipment while the laboratory manager and the technicians seek to distribute them and store them away as fast as possible. Despite a bi-weekly inventory, shortages are recurrent and vocal incidents often erupt among frustrated laboratory members looking for supplies. Most times however, like Peter, workers will rely on collegial cooperation and an email exchange system has developed among laboratory members for the trading of specialized materials such as antibodies, cells, primers,

Rag2gc mice, fugene, collagene, cDNA clones, RNA samples, lipofectamine and other highly specific and hotly demanded items.

Back at his bench, Peter pipets his cell preparation into the tubes and then places the tubes into a centrifuge. While waiting for the centrifuge to complete its cycle, he moves over to another experiment. He tells me he is "hooking genes" to create a virus and needs to extract the DNA from cell debris. He watches the clock and sets his timer. As he sits at his desk to check his lab book, the centrifuge beeps. He gets back up and takes the tubes out. His beeper beeps. He then goes on to observe the tubes he had prepared for the virus creation and shows them to me. The liquid has become blue. He tells me that the liquid is blue because the "cells have popped", meaning the cell walls have burst. He shakes the liquid that becomes transparent again as proteins precipitate. "Ha" he exclaims with excitement pointing at the tubes and looking at me. "Ha" he exclaims again waving more forcefully at the tubes apparently seeking some reaction from me. As I look at him puzzled, he tries to explain: "it's all a little gimmick!" I realize he is sharing his enthusiasm for the cell's behavior just as he tried earlier, in the microscope room, to show his wonder at the observation of "live" cell division and development.

Peter next goes to the Tissue Culture Room to "passage" cells. When cells have reached a certain density, they need to be "passaged," or transferred into another dish so that they have more space.

"Cells are like pets," a postdoctoral fellow once observed. Goldfish would probably be an even better analogy. Plated cells need to be routinely - sometimes several times per week - fed, cleaned, "passaged," groomed, and even medicated with antibiotics. Without these crucial steps,

cells will die or differentiate into an unwanted state. Cells are fed daily, generally with Mouse Embryonic Fibroblasts (MEFs). Feeding takes about 1 minute per plate, multiplied by the number of plates used (about 20). The medium where they live and feed also needs to be changed daily to remove the waste they produce. This involves carefully pipeting the medium from the plate into another tube and replacing it with a new medium. The medium is then often enriched with antibodies to prevent bacteria growth. Since cells divide and come to occupy the full space of the plate, they occasionally need to be "passaged," partly transferred into another plate so they have more space to divide. This involves scraping the cells off the plate where they have attached and pipeting part of the medium and cells into another plate. Because cells, and in particular stem cells, differentiate into different types of cells, an important task when one wishes to maintain the same cell type is to take out the cells that have differentiated so that they do not contaminate the other cells or the results. This involves visually identifying the cells that have differentiated and then aspirating them out of the plate. Various enzymes and antibodies can be added to the cells depending on the experiment and their action on the cells must be monitored closely.

On average an active bench worker will spend two to three hours daily in the tissue culture room observing and taking care of her cells. She will take a stack of cell plates out from an incubator; take them to the microscope where she will examine the cells to see if they are in good health and if they have differentiated. She will then take them to a biosafety hood where she will perform the routine pipeting of medium, cells, MEFs and antibiotics. Plates are then taken back to their incubator and a new stack of plates is retrieved. Typically much additional time is spent doing less routine tasks such as virus preparation, medium preparation and various cell

manipulations that involve the same back and forth movement between incubators, hoods and microscopes.

The tissue culture room is the busiest place in an already hectic and crowded laboratory. Space shortage is more acutely felt here than anywhere else. About fifteen members need to share the four biosafety hoods between themselves. Since each of them will need between one and four hours of time at a workstation every day, demand is generally much larger than supply. A sign-up system was installed on the wall. Members need to sign-up for the day to use one of the four workstations. To prevent abuses, people can only sign-up in the morning when they arrive. It is not uncommon for the four workstations to be fully booked from 7am to 10pm. This system puts a strong constraint on the organization of people's days in addition to the rhythm of the machines and the biological rhythms of the experimental materials.

A piece of torn aluminum foil on the window of the tissue culture room door testifies to the scientists' ongoing efforts to close the tension between the need for safety and the needs of experimental work. The door was built with a window, possibly to allow for scientists to see each other and to avoid the possibility of banging the door into someone carrying precious and possibly hazardous experimental materials. Because cells thrive better in the dark, someone covered the window pane with a foil of aluminum. As laboratory members could no longer see one anther across the door, someone tore a piece out of the foil, thereby achieving a somewhat satisfying balance between the experimental and safety requirements. Knorr-Cetina (1999) famously observed that in order to conduct their experiments, scientists *tinker* with materials. Tinkering is a generalized feature of laboratory work and extends beyond the specific conduct of

experiments as scientists tinker with their equipment and their work practices as much as they tinker with the experimental materials.

The word laboratory comes from the Latin word *Laboratorium*, place of labor. While many studies of science have focused on the output of science, its scientific publications and abstracted scientific controversies, the larger part of science happens at the bench. It consists of bench*work*. Benchwork is the tedious, continuous, routine, highly regulated, poorly paid, potentially hazardous and sometimes morally tainted pursuit of small increments of knowledge. Med Lab scientists' assessment of benchwork ranges from "I hate it" to the somewhat less negative "I don't dislike it." More specific characterizations include "tedious and narrow," "gross," and "brainless activity." While scientists enjoy a comfortable autonomy with respect to their work organization both from society and their own hierarchy, their everyday world is populated by materials (machines, living cells and organisms, chemical or biological agents) that impose a rigorous structure upon their workdays. Cells and animals need to be fed, cared for and monitored, various materials need to be thawed, heated, mixed, incubated and variously transformed in cycles of different durations. The combined rhythms of the experimental materials such as cell life cycles, virus infection time and the rhythms of technology use impose a dense and often stressful schedule on the workers who are engaged in a constant struggle to fit the pace of nature with the pace of the laboratory. How scientists think of what constitutes good scientific practice is often derived from their close engagement with laboratory material during benchwork. Good science is inseparable from good benchwork. A good scientist is a scientist that engages with and masters the constraints of benchwork, that can plan his or her experiments well and not waste precious materials and that can provide for others through skills and

expertise. In Med Lab, scientists' sense of ethics is derived from their continuous involvement with the materials of the laboratory when doing experiments at the bench.

In the tissue culture room, Peter prepares his workstation. He sprays the whole work area with Etoh (a form of bleach) and puts the air vent on. He then walks out to the -80° c fridge located in the hallway to pick up some MEFs to feed the cells. He then goes to retrieve some cells from the -160°c liquid nitrogen fridge nearby. He puts on a large blue glove to manipulate the metal box holders in the fridge. "These guys need to come back to room temperature," he says as we walk briskly back to his bench to place the cells to thaw. Back at the bench, a smell akin to the smell of overused machinery floats in the air. I ask about the smell. He answers – slightly annoyed - that someone has been using phenol and should have been using a vented hood. After a moment of hesitation - seemingly thinking about what to do about it - he says that it is probably not worse than sitting in the middle of traffic for one hour. I ask if he gets paranoid about safety sometimes. He says that he is *always* paranoid, "the more you know, the worse it is". He always takes off all of his clothes and showers as soon as he gets home. He says that he tries not to think too much about it and concludes "you can drive yourself crazy." His beeper beeps. Time to go back to the tissue culture room.

All four workstations are busy. A new PhD student is observing a Postdoctoral Fellow doing cell culture. She is wearing a sleeveless shirt and some gloves. I ask Peter if I should be wearing gloves. He answers "Oh no, just don't touch anything!" Not fully reassured, I cross my arms tightly around me in the general attitude I am beginning to adopt with the rising awareness that I should keep my hands to myself. Many potentially hazardous materials - chemicals, viruses,

bacteria – become mostly invisible when outside containers. Any surface can potentially be contaminated with these invisible materials. Surface contact avoidance is the surest means to avoid contamination. Yet floors must be walked upon, doors opened, machines operated, air inhaled. The next best thing to rely upon – and consequently to try to enforce – are good segregation practices by co-workers.

In the room, two Laboratory members are wearing laboratory coats, a third person, at the station for retrovirus work, is putting on a disposable laboratory coat. Peter asks him if he is working with retrovirus. He answers "no." Satisfied by the answer, Peter starts working on his cells while explaining to me the different steps he is performing. As I stand behind him and hastily take notes, I hear a faint mumble behind me and then a louder "excuse me." Sandy, a postdoctoral fellow, is standing behind me with a pile of stacked culture plates she is transferring from her hood to the microscope station. Apologizing, I move out of the way as swiftly as I can. A few minutes later, Peter gets up to pick up more plates from the incubator behind him. At the same moment another laboratory member walks across his path from his hood to the microscope in a perfectly synchronized move with Sandy, herself making her way back from the microscope towards her workstation with a pile of culture plates. As I observe the whole carefully navigated exchange between the three workers all carrying stacks of plates with their precious cells and hazardous reagents, Peter looks at me and remarks with a laugh: "We call this the Tissue Culture Dance!"

As time goes by in the room, I try to be more alert to the cues of the co-workers, look for when they get up, move around. As I anticipate Sandy's next move and get out of the way, she gives

me a glance of approval. Body postures that minimize surface contact and "tissue culture dances" are part of the laboratory's embodied safety practices. Such practices have emerged and evolved as part of the adaptation to the particular material configuration of the laboratory. In this instance, the tissue culture dance emerged as the result of the need to protect oneself and one's experiment, the material configuration of the room and the high number of users. Embodied safety practices are also part of a broader situated safety system that co-exists with, builds upon and also conflicts with the official safety rules.

This system has its own rules, its own control and enforcement mechanisms. In this instance, the enforcement method – discouraging the wearing of personal protective equipment to enforce the embodied practice of minimizing surface contact – directly conflicted with the regulatory emphasis on using personal protective equipment - such as gloves. A parsimonious wearing of personal protective equipment also allows for a nuanced and adaptive system of signaling. In this case, Peter interpreted the co-workers' wearing of a laboratory coats as a signal that someone was about to work with a human-inducible retrovirus, a virus that can infect the workers and has the potential to reprogram some genes. This type of work triggers additional safety precautions from the co-workers. The signals are not perfect – in this case, the co-worker was not using retrovirus – but it is part of a broad system of cues to which workers pay attention and seek to clarify in cases of ambiguity.

Peter is working with HeLa cells. He tells me that these are cancer cell lines. They were retrieved from an African American woman who had cervical cancer. These cells are resistant and never become anything else. As a result they have been grown thousands and thousands of times, they

are well "characterized" (their characteristics are well-known and well-documented, a hallmark of a standardized experimental model) and they are widely used in most biology laboratories. He tells me that this woman probably never knew that her cells were taken to be used in research and reflects on the irony that this woman was illiterate and knew nothing about science and yet part of her has become so influential. HeLa cells are one of the reminders that biology deals with many materials to which broad cultural meanings are attached and which crystallize important ongoing ethical debates.

Many bioethical issues are attached to the use of human tissues: donor consent, commoditization of human materials, the status of human embryos (for stem cells) or the thorny question of ownership of one's DNA to name a few. Animal use and treatment for research purposes also constitute ongoing bioethical dilemmas and simmering social controversy. Finally ethical debates also extend to environmental and safety concerns with the growing public awareness and political gaze over the risks incurred by new discoveries and techniques such as genetic engineering. While acute controversy has mostly focused on the use of human embryos, many moral dilemmas and debates are still rampant. While spokespersons, such as highly regarded scientists, have made many efforts to safeguard science's claims to objectivity, workers in science and particularly in biology need to navigate between the competing moral frames offered by their profession and by the broader society.

Before leaving the laboratory, Peter needs to check on one of his mice. The animal facility is located on the second floor of the building. It is a separate facility that covers two floors of the building. Access is secured by a card check-in. All animal work must take place in the facility

and no live animal may be taken outside by the scientists although exceptions do occur. This regulation is mostly intended for secrecy and safety purposes. All animal work performed in the institute is approved; however the organization needs to protect itself and its members from potential activist threat. To enter the place itself we need to go through a lengthy routine to ensure an aseptic environment. All personal items need to be left in cubicles in the entrance. Each of us needs to then step into an individual air chamber that blows air over us for 30 seconds. When we exit on the other side of the chamber we put on gloves, shoe and hair covers as well as a disposable uniform. The whole routine takes about 10 minutes. Med Lab has a dedicated animal room with an adjacent dissection room. While the numbers vary, the laboratory keeps around 10,000 animals. Peter needed to check the evolution of cells graft on one of his mice. The verification performed, we head back to the wet lab. It is 3 pm; he can now go home to rest before his night shift as a pediatrician in a nearby hospital.

Peter was asked to lead the NP project because of his knowledge of hospitals and patient contact. To obtain the first human embryos needed to create human embryonic stem cells lines, rigorous informed consent from the families had to be obtained. The crafting and negotiation of the relation with donors in this sensitive context required the skills and experience of a physician.

Peter is in the process of transitioning to the next stage of his career as a laboratory Principal Investigator (PI). He wishes to orient himself towards basic research. When discussing his future career, the laboratory director insisted on the importance of having a "big" question in mind if only to give a "spiritual sense" to one's career. Peter feels however that, being a physician, he takes for granted the benefits of research for patients and already finds a "spiritual sense" to his

career from his work with patients. He would be comfortable generating small incremental changes that contribute to larger scientific programs. To him big leaps are made with big programs not necessarily with people asking big questions. He admits his wife does not understand his dedication to research in particular since he already has another – better paying and already demanding – profession, that of pediatrics. He says that, to him however, contributing to science is the more important activity.

2. Moral Frictions: Local ethical contests and the constitution of institutions

Should we trade body parts, human bodies or children? Can human embryos be used for instrumental purposes? What are the conditions for the proper exchange and use of chemicals, weapons or biomaterials? Can living organisms be treated as commodities? These questions have opposed economists, lawyers, policy analysts, ethicists, patient groups and scientists. Yet these debates have largely remained at a macro and ontological level. Studies of these contests are most often located at the macro-institutional level, with a focus on the actions and discourses of spokespersons. Scant attention is given to the ways in which organizations and institutions are also constructed as ethical through the ongoing contests and debates of their members besides the public sphere. Science, as central institution involved in the creation of many technologies and practices than come

This approach leaves us with a monolithic view of the scientific institution as fiercely defending its independence at the expense of broad social and cultural issues. Science however is an *inhabited institution* (Scully and Creed, 1997; Hallet and Ventresca 2006), a place inhabited by social, cultural and moral individuals who are both locally embedded in their working context

and "extra-locally" embedded in other institutions such as bureaucracies and religious communities. Scientists negotiate between the social and cultural assumptions stemming from their extra-local context and the local conditions of their work. While compliance to regulatory and social demands could remain at a symbolic level (Meyer and Rowan, 1977), the penetration of "extra-local" institutions such as religion or the law at the level of action ultimately depends on the workers, on their interpretation of and agreement with the values promoted by these institutions.

As institutions with competing norms such as science, law and religion overlap, the micro-level contests that arise at these overlaps can be intensely personal. Indeed, seemingly intractable debates have roots in the meanings different groups ascribe to objects at the heart of these contests (body-parts, children, women or embryos to name a few). These objects are socially contested. In the debate over whether to donate, sell or use human eggs, embryos or stem cells various communities (religious, political, scientific, medical) oppose different meanings about these "things" (embryos are construed differently as objects that can be used for research or as "sacred" future human being). At the center of these debates are deep seated convictions about one's personal ethic and preferences about what the ethic of one's group (community, society) should be.

While it is widely acknowledged that actors in the social and economic spheres have different ethical perspectives, little attention is given to ethical diversity within organizations. We take for granted organizational member's personal perspectives on their working materials. If we subscribe however to this view, we give undue weight to the rationality and freedom of actors as

they enter and remain in one organization. We depict organizational actors as passive recipients of organizational discourse and socialization processes. In sum, we leave scant room to understand how workers actively manage their ethical position in their organization and change their organization as they do so.

Organizational actors, as cultural members enter an organization with their personal values and perspective. They confront these values with that of their co-workers and their managers. In doing so, they must contend with organizational processes such as peer influence, socialization, collaboration, organizational control or career issues. Divergent ethical positions can be silenced by these processes. Empirically we know of many moral contests that lead to breakdown of dialogue, ambiguity and counterproductive practices. But moral divergence can also be an opportunity to problematize dominant norms and to create new practices. How are these opportunities translated into concrete practices?

In this dissertation, I explore how competing moral orders intersect in the workplace and how this collision, as it is mediated by organizational members, shapes work and innovation practices. Med Lab serves as an ideal case to explore this question. In this particular case, local moral frictions were generative, they led to the creation of new practices and technologies. Through a seventeen month ethnography, I observed two contests: a contest over safety and a contest over personal values in relation to bioethics. Frictions over safety were an occasion for the ongoing creation of new safety practices. The contest over bioethics led to the creation of a breakthrough technology. Through the analysis of these two cases, I sketch out some of the conditions that allow for moral contestation to be productive. I argue that the local negotiation among competing

moral orders is a core means by which institutions shape one another as institutional actors create new practices that build upon and blend competing institutional logics.

2.1 Science, Safety and Bioethics as competing moral orders in Med Lab

With the rise of bioethical concerns and the spread of accountability and governance demands and tools, laboratories in general and biology laboratories in particular have become increasingly sites of contestation. While bioethical debates might be better publicized, debates amongst scientists and other social constituents are equally intense and personal.

Bioethics. While biological laboratories, private or academic, are all sites of bioethical dilemmas, stem cell research is perhaps the site of most intense bioethical debate. Bioethical questions related to stem cell research have given content to thousands of newspaper articles as well as countless philosophical essays, public debates, guidelines and laws. As a brief introduction, we can name a few of the most salient questions – those that most occupy scientists in their day-to-day work:

- what is the social status of an early human embryo or of a "surplus" embryo[1]?
- when does human life begin?
- what is the of status of a stem cell itself[2]?

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[1] "Surplus" embryos are human embryos created through the in-vitro fertilization process which a procreating couple no longer wishes to use. These embryos are frozen in order to be conserved for a potential future use. It is estimated that IVF clinics host several thousand of frozen surplus embryos.

[2] Biologists have been able to develop animals from one single stem cell, thus posing the question of the ability of one human stem cell to generate a human being.

- are chimeras[3] socially acceptable and under which conditions?
- what constitutes donor consent? What are the rights of donors?

The debate over stem cell research has certainly generated much hype in the last decade (the *New York Times* alone published over 1500 articles on the topic of stem cells between 1998 and 2010). But beyond the constant media attention and, at times, overblown rhetoric, stem cell scientists agree that serious bioethical questions need to be considered. They also differ as to what the response to these questions should be. Peter, who heads the *Embryology* team and supervised the creation of human embryonic stem cells for Med Lab a few years ago, clearly views the use of human embryos for research as ethical under certain conditions. He must however collaborate with workers who believe human embryos should under no condition be used for research. Personal divergences abound in Med Lab and must be combined with the need to collaborate on common projects and towards a common goal. This particular tension, as we will see later, is however rich with creative opportunities for Med Lab.

Safety. Safety concerns emerged over the last century through controversies on the involvement of science with the military. Controversies over safety increased with growing public concern over potential health risks of science for experimental subjects, patients, surrounding communities and researchers themselves. Academic laboratories have been subject to growing federal regulation and local oversight over the use of health and environmental hazards. The

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[3] Chimera is a scientific term borrowed from the mythological literature. In the classic mythology, chimeras refer to creatures that are part animal, part human. In scientific practice, chimeras can refer to the result of varied procedures such as the implantation of human stem cells in the thigh of an animal or the implantation of human stem cells in chimpanzee brains or in animal eggs.

logic of increasing regulation and bureaucratic oversight has come to compete over the traditional ethos of science that privileged the autonomy of scientists and the specific demands of experimental work. Scientists have also become divided over how best to perform safety. To them, how navigate health and safety issues also takes the form of ethical dilemmas.

2.2. Socially contested objects

At the center of contested practices are socially contested objects: biohazards, chemicals, living organisms or body-parts. To study ethical contests at a micro-institutional level, we need to unpack how contested objects shape the everyday interactions of laboratory members.

Scholars of science have long highlighted how artifacts shape work practices. Experimental models are the reference materials that a community crafts and uses to study a set of questions. In biology, these models are biological organisms, primarily mice and cells, engineered to meet experimental requirements. Stem cell science is a field of inquiry organized around stem cell models, derived from mice or humans. Scientific communities are constituted around these models (Kohler, 1994; Rader, 2004). To borrow a term from Kohler (1994), scientific communities are material communities. Experimental models participate in the shaping of experimental practices (Pickering, 1993) and communication practices (Galison, 1997). Experimental models also shape the knowledge crafted by scientific communities (Rheinberger, 1997). In sum, scientific models are constitutive of science by shaping its practices, its occupational communities and the knowledge it produces.

Many other materials populate the world of scientists and shape their practices and culture (Knorr-Cetina, 1999). While scientists enjoy a comfortable autonomy with respect to their work

organization both from society and their own hierarchy, their everyday world is populated by materials (machines, living cells and organisms, chemical or biological agents) that impose a rigorous structure upon their workdays. At the same time working materials constitute essential opportunities: scientists tinker with their tools, create new technologies that redefine what is possible. Most laboratory materials whether machines or biological and chemical materials pose health and safety threats that scientists need to contend with. Laboratory materials are not just physically potent: they also gather powerful and contested social symbols. Many materials in biology are socially contested: stem cells, laboratory animals, patient cells or viruses all relate to a particular bioethical debate. Bacteria and viruses raise health and safety concerns for laboratory workers and societies at large. Laboratory animals embody both the possibility to improve science and medicine as well as science's disregard for animal suffering and use. Patient cells raise questions around patient rights.

Scholars of science and technology have explored the many ways in which materials are constitutive of sociotechnological communities. One area that has remained underexplored is how materials are constitutive of these communities' ethics. Indeed, objects can embody and represent contradictory ethical perspectives. In this sense, they give substance to abstract debates. It is one thing, for instance, to be in favor of animal testing or stem cell research, it is quite another to work every day with animals, embryos and their derived materials. Conversely, one might be against the instrumental use of such objects but what does it mean for a biologist to refuse to work with the core tools of his or her profession? Decisions to concretely engage with these materials raise deep questions about one's beliefs and one's identity.

In Med Lab, few scientists decide not to engage with some materials. The majority however constantly make decisions about *how* to engage with different materials. In doing so, scientists shape both their practices and their ethics. We will see in chapter 3 that scientists enter Med Lab with their personal ethical positions but ethics also emerge from their everyday engagement with contested objects. In Med lab, materials shape communities' understandings of what is ethical work.

Because ethical dilemmas stem from competing institutional logics, in this case, science, safety and bioethics, ethical contests in Med Lab are ultimately a contest between these logics. The temporary ethical settlements that Med Lab members reach are settlements among these logics. In chapters 4 and 5, I explore the local contests over safety and bioethics. While these contests are about how to work with different materials, the outcomes are the creation of practices and technologies attached to particular institutional logics.

Laboratories are complex sociomaterial systems where humans constantly interact with and through materials and technologies in order to achieve collective outcomes, be it research, safety or settlements over bioethical issues. In the crowded space of the laboratory, scientists like Peter and his co-workers constantly make micro-decisions about the best way to handle different materials. The result of these micro-decisions constitutes the sociomaterial assemblage (Latour, 2005) or configuration (Orlikowski, 2007) of the laboratory: constantly renegotiated settlements through which different institutions (science, religion and the law) interpenetrate and reinforce each other.

3. Fieldsite and Methods

3.1. Med Lab

Med Lab is a large stem cells laboratory in Eastern Medical Area (EMA). EMA is home to a major stem cell community in the United-States. When stem cell research was nascent and public funding restricted, several hospitals in EMA provided the initial funding and laboratory infrastructure necessary to develop stem cell research. The medical school provided a steady supply of medical students with a background in pediatrics and an interest in bridging research and medical innovation, a focus generally called "translational research" as opposed to "basic research," that focuses on the pursuit of scientific knowledge detached from immediate medical application. Hospitals also provide the human tissues necessary for research: fertility clinics provide the surplus embryos issued from in-vitro fertilization, other hospitals supply diseased tissues necessary for the study of disease-specific cells where stem cells are theorized to play a role (such as sickle-cell disease, leukemia, Alzheimer's disease or Parkinson's disease). While some stem cell research is conducted in independent academic centers, hospitals and medical schools have provided the main home for stem cell research. Some of the most preeminent stem cell centers in the United-States are located at the University of Wisconsin Regenerative medicine center, Yale School of Medicine, Harvard University Medical School, Boston University, Tufts University School of Medicine. This close working relationship between hospitals, medical centers and laboratories using stem cells as research models has shaped the ethical discourse centered on care and medicine and the structure of the stem cell community.

Under the supervision of Gary, the principal investigator (PI), Med Lab performs basic research in developmental biology and blood diseases as well as applied, translational research on several

genetic blood disorders such as leukemia or sickle-cell disease. The laboratory started as a small team performing research on blood related diseases. When the existence of hES cell lines became known, the laboratory sought to obtain these experimental models and generate or "derive" its own human stem cell lines from embryos. The laboratory began as a small community of cell biologists studying blood diseases. The founding identity of Med Lab was strongly associated with stem cell research. Scientists shared the ethos promoted by the stem cell community in the public sphere, in particular the close association between stem cell research and medicine. Following growing academic success and increasing funding, Med Lab constituted new teams with diverse expertise and background. The discovery by the laboratory of a gene involved in blood cell development and in cancer led to the creation of a team devoted to the study of this gene. Members of the new team were primarily molecular biologists, a sub-community of biologists using different methods and tools than cell biologists. Another phase of expansion followed the discovery of a new technique for obtaining "pluripotent" cells: cells engineered into behaving similarly to embryonic stem cells.

At the time of the study, Med Lab is composed of 4 different teams:

- *Embryology*: the embryology team, led by Peter, is specialized in work on embryos and human embryonic stem cells (hES cells). The team was initially constituted around the project to derive its own hES cells. The project's success has allowed Med lab to create its own experimental models and develop a deep knowledge of hES cells. The team is entirely funded through private funding. It operates with equipment purchased with private funds and operates in the NP area.

- *Reprogramming*: the reprogramming team emerged in 2007 when Roni, a postdoctoral fellow, invented a technique for reprogramming adult cells into a pluripotent state. By far the fastest growing team, it is populated primarily with cell biologists. Reprogramming scientists draw on the expertise of the embryology team.
- *Blood*: this team is constituted of two postdoctoral fellows and one technician. The scientists draw largely on molecular and cell biology knowledge.

Cancer: The cancer team has emerged when a PhD student discovered the implication of a cancer gene on blood development. The team is composed of Postdoctoral Fellows only. Their expertise is molecular biology and they rely mostly on mice models. Located in a different space than the other teams, cancer scientists have come to develop their own work practices and habits.

A separate facility, *TechCore*, provides the stem cell community in EMA with specialized knowledge and care related to stem cell research (procedures, training, cell banking and technical expertise on specific projects). TechCore is under the indirect supervision of Garyand another laboratory director and under the direct supervision of one postdoctoral fellow. The team is composed of technicians only.

Although Med Lab is under the authority of Gary, the Principal investigator or PI, the larger part of the day-to-day supervision and management is done by the senior scientist, Will. Med Lab also devotes a significant amount of time to bioethical debates. Gary is heavily involved in public debates and public policy discussions of bioethical issues related to stem cell research. The laboratory's senior scientist shares his time between the management of the laboratory and participation to bioethical debates and education.

Med Lab scientists are culturally diverse. Countries represented included Belgium, China, Germany, Israel, Japan, Korea, Turkey and the United-States. Some members also mentioned different religious affiliations including Buddhism, Catholicism and Judaism. Religious affiliation was volunteered during the interviews but was not the subject of a formal survey.

Table 1: Structure of Med Lab

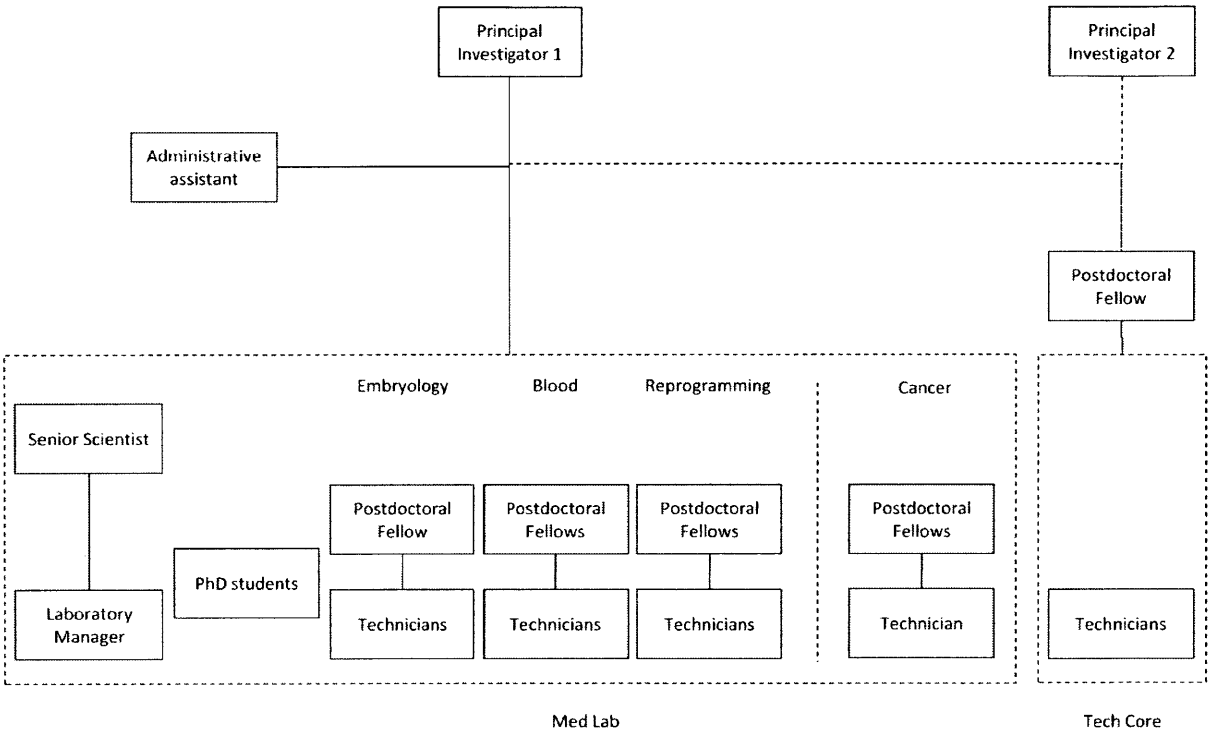

Table 2: Breakdown of laboratory members per role and gender in % (N=41)

	Female	*Male*	*Total*
Principal Investigator	0 % (0)	2% (1)	**2% (1)**
Postdoctoral Fellow	12% (5)	39% (16)	**51% (21)**
PhD student	2% (1)	7% (3)	**10% (4)**
Technician	22% (9)	15% (6)	**37% (15)**
Total	***37% (15)***	***63% (26)***	***100% (41)***

3.2. *Methods*

The stem cell community and Med Lab represent an ideal case appropriate for theory building (Eisenhardt, 1989). It is an extreme setting where everyday decisions and actions are shaped by radically different moral conceptions and therefore ideally suited for studying the role of contentious ethics on local decision-making and organizational and institutional change. Stem cell research is probably one of the most contentious areas of scientific inquiry. Raising deep moral questions about the status of human life and how human materials should be treated, stem cell research has also raised many hopes for social progress particularly in the medical area. In response to moral challenges to their activity, stem cell scientists have actively defended the ethics of their work and as a result have promoted a strong moral stance. Important questions that arise here include the following. How do scientists themselves make sense of moral dilemmas? How do they relate to the "official" position of their community and how does this shape their

activity? What role do moral understandings play in shaping collaborative practices and scientific production? How do these everyday contests shape the institution of science and the adjoining legal and religious institutions?

In order to trace and compare scientists' actions private space of the laboratory and their actions in the public sphere, I combine ethnographic fieldwork of stem cell scientists between 2009 and 2010 with textual analysis of press articles between 1998 and 2011.

I conducted fieldwork in Med Lab during 17 months. I collected participant, observational and interview data on internal laboratory interactions and work practices. I observed laboratory work, attended the weekly meetings and participated in informal events such as team lunches, breaks and celebratory events. I also collected all group emails during the observation period. When observing laboratory work, I took the role of a rotation student. Rotation students are new PhD students in biology who rotate in laboratories to learn the craft of experimentation. They typically shadow other laboratory members during their work. This position allowed me to extensively shadow researchers and technicians in a way that was habitual to them. Interview data was collected through informal discussions at the bench and through formal open-ended interviews of researchers and technicians in both laboratories.

In addition, I collected data about how scientists presented themselves to external audiences. I attended 27 talks on bioethics organized by the stem cell community and one talk organized by an opponent to the use of embryos for research. I selected 73 articles among the 1736 articles published on the topic of stem cells between 1988 and 2010 in two journals (New York Times and Christian Science Monitor) and analyzed them for content. I selected articles that related to

key events in the stem cell controversy acting as "scandals". Scandal arises when a group's sense of morality is offended. As a result scandals reveal the taken-for-granted assumptions about a given social order (Adut, 2005; Fine, 1996). In contested areas, each contending group generates events that are viewed as scandals by their opponents. When stem cell scientists created embryos for research, it was a scandal for religious groups. When religious activists launched a campaign to adopt an embryo, it was a scandal for proponents of stem cell research. Collected articles about scandalous episodes of the stem cells controversy crystallized the positions of the different groups and included quotes from both sides of the controversy. The topics of the articles included scientific breakthroughs (the first derivation of hES cells, the discovery of "reprogramming"), controversial pronouncements from stem cell opponents (excommunication recommendation by a religious leader), controversial scientific practices (such as the creation of embryos dedicated to the generation of stem cell lines, an instance of scientific fraud in South Korea) and key policy dates (2001 Presidential ban on stem cell research, 2008 lifting of ban).

All interviews were transcribed. I took extended fieldnotes of laboratory observations and of public conferences and talks. All interviews, observational and archival data were coded with Atlas TI. I coded inductively in two phases. First I noted when there were statement relating to a value judgment related to stem cell research (or part thereof). Then I used the codebook previously established to sort the ethical claims of the laboratory members, find patterns of ethical claims.

As it emerged during my fieldwork that scientists presented a different "face" towards external audiences (state officials, lay public, stem cell opponents or the media) and internal

audiences(co-workers, fellow scientists), I treated the claims, statements and actions towards the two audiences separately to understand how they differed from one another . In keeping with Goffman (1959) and the symbolic interactionist perspective more broadly, I make no pretense to uncovering private states of mind. The external/internal divide refers to different audiences.

Because the statements and claims directed towards an external audience were rich in symbolic content, I used a semiotics approach (Saussure, 1983) to map the claims of scientists and their opponents.

4. Dissertation plan

In Chapter 1, I review the different approaches to morals and organizations. The role of morals in shaping the emergence of markets and occupations has been well studied. Yet scholars are only beginning to explore how local moral divergences might shape organizational practices and organizations. These scholars differ as to whether local moral contests are productive or not for organizations. In chapter 2, I take a historical perspective to explore how biologists previously dealt with ethical dilemmas by studying key ethical controversies such as the relation between science and the military, science and safety and finally between science and bioethics. I argue here that the changes in the scientific institution were not just related to the coercive effect of law, regulation and public opinion but rather were led by dissenting voices within the scientific community itself. Ironically, scientists themselves, by settling their internal contests have built the bureaucratic apparatus that has increasingly come to regulate them. In chapter 3, I explore the differing conceptions of ethics in Med Lab. Chapter 4 explores internal contests over the performance of safety. I argue here that scientists allowed for alternative perspectives to safety

practices (led by bureaucratic approaches to safety) to penetrate the laboratory and in effect changed their profession's understanding of what constitutes safe practice. Chapter 5 focuses on the bioethical controversy related to stem cell research and looks at the duality of the ethics work performed by scientists: while they maintained a unified front in the public sphere, they negotiated their ethical differences internally and settled them by creating new scientific knowledge and materials aligned with societal concerns.

Ethics work or the ongoing negotiation among competing moral orders emerges as a central process by was scientific actors shape their institutions. This study provides an in-depth case to unpack how institutional arrangements are shaped and reinforced through the collective actions of institutional actors.

CHAPTER 1: COMPETING MORAL ORDERS AND THE CONSTITUTION OF INSTITUTIONS

> *[...] There is no such thing possible as an ethical philosophy dogmatically made up in advance. We all help determine the content of ethical philosophy so far as we contribute to the race's moral life. In other words, there can be no final truth in ethics any more than in physics, until the last man has had his experience and said his say. In the one case as in the other, however, the hypotheses which we now make while waiting, and the acts to which they prompt us, are among the indispensable conditions which determine what that 'say' shall be.*
>
> *William James – 1891:330-54*

> *So working in human embryonic stem cells didn't start the considerations of these moral things. They were always there. You know, there is always the question of how people are treated, and senses of fairness, and of needing to do things today as well as tomorrow -- this whole personal ethos.[...] And I think that the way that working in the field has changed my perception of ethics is it's forced me to really think about it more actively.*
>
> *Will – stem cell scientist*

Should we trade body parts, human bodies or children? What are the conditions for the proper exchange and use of chemicals, weapons or biomaterials? What does it mean to produce safe work and safe products? That diverse and conflicting moral understandings pervade economic activity is nothing new. As market activity has sometimes expanded by encompassing goods traditionally deemed off-limits to trade or monetary valuation such as body-parts, children, cadavers, life, safety or pollution (Zelizer, 1983, 1994; Almeling, 2007; Radin, 1996; Anteby, 2010), economists, lawyers, moral philosophers and policy analysts have sharply debated the conditions of use of such objects. Such debates remind us that innovations are not only disruptive

in a purely technological or economic sense but also in a social sense (Zelizer, 1983). For organizational scholars, this suggests a renewed need to understand what makes work moral. In particular, how is work defined as moral when competing moral orders intersect? Many approaches have taken an external perspective on moral legitimacy and looked at post-hoc justification practices, practices which aim at defining an existing organization or institution as moral. Yet the constitution of organizations and institutions that deal with contentious objects is inextricably linked to the variation in the social value attributed to these objects and to assumptions about the way they should be used (Almeling, 2007; Zelizer, 1983, 1994). To understand how organizations are constructed as moral, we need to understand how competing interpretations of morality are negotiated and translated into practice. In this dissertation, I build on the observation that local ethical concerns shaped the production of new practices and technologies to develop an analytical framework for explaining how ethical contests, or moral frictions, can be creative from the standpoint of the organization.

In this chapter, I review the literature that unpacks the role of morals in the production of knowledge and technologies. I first review external perspectives on organizations, occupations and morals. I argue that, while these perspectives allow us to understand the foundations of moral legitimacy, they overlook how organizational actors might differ locally over the ethics of their work and therefore fail to explore how local concerns are constitutive of work and organizations as moral. Next I turn to internal perspectives on morals and organizations. Internal perspectives explore the local constitution of moral orders within organizational and occupational communities. These perspectives highlight that local moral orders can be diverse. While some studies show that local moral divergences can be counterproductive, other studies

show that moral conflict is an opportunity for creativity. I build on the latter studies to suggest some conditions under which moral conflict can be productive.

1. External perspectives on organizations, occupations and morals

Morals refer to deep-seated beliefs and judgments about what is "the right thing to do." Moral judgment is the normative evaluation of an activity (action or practice), generally organized around sets of oppositions ("good" and "bad"). Moral or sociopolitical legitimacy reflects the "positive normative evaluation of an organization or an occupation and its activities" (Suchman, 1995; Aldrich & Fiol, 1994); it rests on judgments by a community about whether an activity is the right thing to do (Suchman, 1995). Scholars taking an external perspective on morals and organizations, view conformity with dominant moral understandings as a central way by which organizations or occupations gain legitimacy and ensure their survival (Meyer & Rowan, 1977; Aldrich & Fiol, 1994; Elsbach & Sutton, 1992) although they diverge on how organizational members respond to the need to gain legitimacy.

Institutionalists have long argued that legitimacy, including moral legitimacy, is central to organizational maintenance. In the institutionalist perspective on moral legitimacy, organizations seek to adopt formal structures aimed at displaying compliance with social expectations (Meyer & Rowan, 1977; Dobbin, Sutton, Meyer, & Scott, 1993; Edelman, 1992). In order to maintain congruence with their institutional environment, organizations sometimes decouple their formal structure from the demands of everyday work. In other words, when a conflict arises between social demands and organizational goals, organizations seek to maintain a "façade of

conformity" with social expectations while allowing their members to pursue the goals of the organization.

Researchers adopting a strategic view of moral legitimacy (Fligstein, 2001; Suchman, 1995) show that organizational actors in contested areas do not decouple their activity from the organizational structure but rather actively seek to define or redefine the moral status of their activity through involvement in the public sphere (Zelizer, 1983; Aldrich & Fiol, 1994; K. Weber, Heinze, & DeSoucey, 2008) or through impression management tactics directed towards important stakeholders (Elsbach & Sutton, 1992; Nelsen & Barley, 1997). In her study of life insurance, Zelizer (1983) shows that life insurance professionals had to overcome dominant understandings regarding death and money in order to ensure the acceptance of their product in the 19th century. To establish a monetary equivalent to human life initially represented a profanation of the sacred and was thought to contribute to "the sanctification of death" (1983, p47). In order to overcome this social resistance, life insurance professionals had to convince the public that theirs was not only a technically efficient business but also a morally superior system. They presented life insurance as an altruistic practice, both for one's family and for society and actively recruited religious agents to promote the moral standing of their activity.

Researchers in the strategic perspective have also shown that organizational and occupational actors mobilize and shape social understandings to establish moral legitimacy by establishing moral oppositions (Stephen R. Barley, 1983; Nelsen & Barley, 1997; K. Weber et al., 2008; Anteby, 2010). Moral narratives are generally organized around sets of oppositions which tend to devalue competing practices or understandings. For instance, in their study of the emergence of

paid Emergency Medical Services (EMS) as a new occupation, Nelsen and Barley (1997)find that paid EMS personnel constructed impressions of expertise, consistency and trustworthiness at the expense of voluntary EMS groups. Paid emergency medical technicians (EMTs) presented themselves as experts by depicting the caring and communal aspects of existing volunteer work as unprofessional and presenting their voluntary competitors as untrustworthy amateurs (Nelsen & Barley, 1997). Similarly, Weber, Heinze and DeSoucey (2008) show that workers in the grass-fed beef industry asserted their legitimacy by mobilizing codes of authenticity, sustainability and naturalness which resonated with ideals of affluent and urban customers. In doing so, they emphasized the negative aspects of industrial beef production such as its manipulative, exploitative and artificial nature (K. Weber et al., 2008). In the strategic perspective, the creation of new occupational mandates or market segments hinge on the mobilization and establishment of clear evaluative codes which establish the moral legitimacy of one group at the expense of the legitimacy of its competitors.

The strategic perspective sheds light on the micro-foundations of legitimacy. Yet by focusing mostly on public actions such as collective mobilization or impression management tactics, these studies present a uniform perspective on the moral views of organizational actors. Disagreements and oppositions are viewed as arising solely at the boundary between organizations, not within organizations themselves.

External perspectives on morals and organizations allow us to understand the role of morals in shaping public legitimacy and market emergence. Yet, they do not allow us to understand the role moral understandings play within organizations and in particular whether and how

organizational actors translate their moral understandings into organizational practice. A number of studies that adopt an internal perspective allow us to begin to unpack how morals shape organizational practices.

2. Internal perspectives on professions, occupations and morals

2.1. The emergence of local moral orders

Anthropological and sociological studies have shown that moral understandings arise within communities and help shape the contours of such communities, generally as group members establish moral distinctions between groups (Durkheim, 1976; Douglas, 2002; Lamont & Molnar, 2002; Lamont, 1992). Transposing this approach to the study of organizations, scholars using ethnographic fieldwork have explored the relationship between morals and organizations in practice. They have shown how shared understandings of morality emerge within occupational and organizational communities (Van Maanen & Barley, 1984; Lamont, 2000; Jackall, 1989; Barley, 1983; Kunda, 2006; Anteby, 2008; Besharov, 2011; Ho, 2009). These local moral orders are constitutive of situated practices (Jackall, 1989; Kunda, 2006). Studies have highlighted in particular how local moral orders emerge and constitute local imperatives for employees. For instance, Kunda (2006) showed how the workers of a computer company sought to live up to the values of hard work, professionalism and responsiveness crafted and communicated by the company's management. In his study of managers' behavior in a bureaucratic organization, Jackall (1989) argues that moral behavior in organizations is shaped by the specific structure and culture of an organization. In the company he studied, rules of conduct were the result of local political struggles. "Making the numbers," knowing the right person or forming the right alliance

are some of the elements of the moral ethos of Jackall's bureaucratic organization. Employees needed to conform to this ethos in order to remain or get ahead in the organization. In this Weberian perspective on bureaucracy, local values became disconnected from broader social values. In his study of the crafting and exchange of "homers" in a French bureaucratic organization, Anteby (2008) shows that employees crafted a positive sense of worth through the diversion of company time and tools. Both for employees who viewed it as an expression of their craft and for managers who accepted it as an informal and positive incentive, this practice took on a positive valence. Many such studies emphasize the uniformity of local orders, pressures to conform and as a result most often highlight a disconnect between local orders and broader social values.

Yet while there are important pressures to conform to local orders, examples abound of the coexistence of multiple moral frames within organizations. Works exploring the micro-foundations of institutional action emphasize that organizational actors locally interpret, negotiate and enact various frames (Ewick & Silbey, 1998; Orlikowski & Yates, 1994; Hallett & Ventresca, 2006a; Binder, 2007). These works show that organizations are central sites of contests among moral orders promoted by different institutions such as the law and professions (Huising & Silbey, 2011; Kellogg, 2009) or science and commerce (Powell & Colyvas, 2008; F. Murray, 2010). As organizations increasingly span multiple normative logics (for-profit, environmental, governmental for instance) and their products and practices encounter conflicting socio-political views, we need to better understand how employees deal with competing normative frames.

2.2. Local contests as counterproductive

Several studies have shown that the collision of multiple institutional logics within one setting can generate challenges for organizational members and can even be counterproductive. Competing institutions constitute conflicting interpretive frames which influence local decisions and actions (Heimer, 1999). This can raise issues of commensuration as organizational members must negotiate among competing frameworks to define the worth of their work (Espeland, 1998; Espeland & Stevens, 1998). Competing frames can create frictions within dominant occupational or organizational groups or between employees and management. Some studies found that when employees disagree with the ethos promoted by their organization, they can stymie the pursuit of these goals (Besharov, 2011; Turco, forthcoming). In her study of an environmentally-minded retail store, Besharov (2011) showed that employees holding strong environmental views acted in ways that conflicted with the for-profit norms of the company. Similarly, Turco (forthcoming) showed that employees of a for-profit provider of maternity services resisted performing actions that favored profitability over what they perceived as mothers interests such as selling expensive products.

2.3 Local contests as generative

Yet the coexistence of multiple orders of worth can also be an opportunity for creativity or "creative friction" (Stark, 2009; F. Murray, 2010). For Stark (2010), the coexistence of multiple orders of worth involve principled disagreement about what counts and can therefore drive the creative recombination of diverse knowledge. Creativity can arise out of a sense of "dissonance" or divergence with the accepted norms of a group. Hence, the collision between different moral

orders, as they are interpreted, negotiated and enacted by organizational members, can be a source of change and innovation:

> The coexistence of multiple, principled standpoints means that no standpoint can be taken for granted as the natural order of things [...] From this perspective, entrepreneurship, as an enabling capacity, proves productive not so much by encouraging the smooth flow of information or the confirmation of fixed identities as by fostering a productive friction that disrupts organizational taken-for-granteds, generates new knowledge, and makes possible the redefinition, redeployment and recombination of resources. In short, entrepreneurship occurs not at the gap but through the generative friction at the overlap of evaluative frameworks (Stark, 2010, p19)

Empirically, Murray (2010) shows that in response to commercial encroachment of their activity through the patenting of scientific materials by private actors, scientists skillfully adapted their practices by patenting materials themselves, not to extract private rents but rather to maintain the norms of communalism (free exchange) which undergird scientific exchange practices.

Institutional frames that come into conflict can also reveal dominant and taken-for-granted assumptions within communities. Scholars in the inhabited institutions perspective argue that when individuals in organizations are embedded in different meaning systems, they do not behave as institutional dopes but rather they actively negotiate among these competing frames or "logics" (Binder, 2007; Hallett & Ventresca, 2006a).

In addition, these differing repertoires allow individuals to deploy what Fligstein (2001) defines as social skill or "the ability to induce cooperation among others":

> Skilled social actors empathetically relate to the situations of other people and, in doing so, are able to provide those people with reasons to cooperate (Mead 1934; Goffman 1959, 1974). Skilled social actors must understand how the sets of actors in their group view their multiple conceptions of interest and identity and how those in external groups do as well. They use this understanding in particular situations to provide an interpretation of the situation and frame courses of action that appeal to existing interests and identities (Fligstein, 2001. p112).

Moral repertoires provided by different institutions constitute different discourses, different opportunities for actors to deploy social skills, to mobilize different institutional frames and to translate them into practices.

Taken together, these studies show that ethical conduct is not the systematic obedience to abstract moral rules but rather the ongoing interpretations, negotiations and practical applications of such rules in the context of a collective project. Practices aimed at gaining moral legitimacy do not begin at the boundary between organizations but rather within the organizational context as different moral frames are invoked to justify and motivate work. If we are to more clearly understand how contested moral orders shape institutional change, we need to attend to how divergent moral orders are negotiated internally, not just at the boundaries between organizations.

3. Objects and contested moral orders

Approaches to morals and markets have valuably shown that social assumptions about objects influence whether and how organizations might use and trade such objects. But these studies have primarily focused on the issue of commercialization (the monetary valuation and market trading of a good or activity) and explored how the fate of new products or activities depend on whether social constituencies view the insertion of these products and activities within a commercial endeavor as moral (Almeling, 2007; Zelizer, 1983). Commercialization is often socially contested because the monetary valuation of a good is viewed as leading to its instrumentalization or objectification (Radin, 1996). However in order to be commercialized, goods also need to be created or transformed. While many socially contested objects or activities are generally pre-existing (in the non-commercial realm), they still need to be sourced and transformed in order to be commercialized (see Anteby [2010] for a description of practices in the commerce of cadavers, as well as Almeling [2007] on the sourcing and transformation of reproductive cells). More complex technologies may also need to be invented and refined for some objects to be amenable to productive activity. For instance, in order to become useful technological or medical products, biological materials need to be engineered and tested: two steps which might be viewed as morally inappropriate or problematic. Hence, goods do not need to be subject to market trading (or commodification) in order to be instrumentalized: their sole inclusion into organized activity is instrumentalizing.

Objects are cultural goods (Mauss, 2002; Durkheim, 1976; Bourdieu, 1984). Within organizations, they represent or embed not just technical knowledge but also cultural and political understandings (Winner, 1980; Bowker, Timmermans, & Star, 1995; Bechky, 2003a).

Studies of scientific and technological settings have highlighted the role of artifacts in shaping knowledge production (Kohler, 1994; Callon, 1986; Star & Griesemer, 1989; Clarke & Fujimura, 1992). Objects embed the knowledge of their creators and users and as such help communities coalesce around particular knowledge and practices (Kohler, 1994; Rheinberger, 1997). Studies of artifacts have also highlighted that objects that embody multiple meanings can help represent, share and transform knowledge across communities (Carlile, 2002; Bechky, 2003b). Star and Griesemer, coining the term "boundary-object", famously showed in their study of museum conservation that objects such as maps or models were used commonly by the different communities in the museum but represented different types of knowledge to these communities. In this case, the objects' multivocality facilitated communication and coordination across communities.

But such multivocality can also involve incompatibilities or conflicts. For instance, biological materials (bodily materials, animals) in research laboratories can represent primarily scientific and medical progress for some or they can represent the exploitation of a living being for others. These objects are contested objects: objects which embody overlapping and competing modes of valuation (Boltanski & Thévenot, 2006; Stark, 2009). While boundary-objects facilitate agreement and coordination across boundaries, contested objects embody and represent social disagreements. In this case, objects can become strategic sites for the struggle among competing moral frameworks.

Materials, equipments, local interpretations, work practices and symbolic practices constitute a situated, complex and constantly changing socio-material assemblage or configuration (Latour,

2005; Orlikowski, 2007; Pickering, 1993). As organizational members constantly negotiate among the different meanings of their working materials, they change the socio-material arrangements of their organization. In short, contested objects create "moral frictions" that may — under certain conditions — create possibilities for organizational and institutional change.

4. Competing ethical frames in bioscience and the constitution of institutions

Stem cell science is an extreme case for studying how competing moral orders interact at the level of everyday practices. Scientists not only need to adjudicate between the norms promoted by science and religion but they also need to contend with social concerns over the safety of their practice. The materials they work with – biomaterials, chemicals and other biohazards – are also subject to competing interpretations of their worth. Science and religion have a history fraught with conflicts.

4.1. Science

In what became known as the normative position on science, Merton (1973) characterized the norms which he viewed as constituting the "scientific ethos": universalism, communism, disinterestedness and organized skepticism. These were seen to be the most commonly accepted norms of ethical conduct. In this secular and rational view, ethics is grounded in scientists' faithful representation of nature, untainted by personal, political or economic considerations. While science has not been immune to personal "strains" or to the encroachment of other interests or pressures whether political or economic, scientists do hold such norms as the standards by which they evaluate the ethics of their practice. Science professes to be universal, unconcerned with cultural differences. Empirical facts are what matter, not religious or cultural

ideologies. In this "enlightened" perspective, ideologies should not influence scientific practice, else the empirical validity of science would be threatened. Therefore, for scientists, religious encroachment on science not only constitutes a barrier to the pursuit of all possible avenues but also a moral threat to the purity of the scientific method.

Mulkay (1983) and Gieryn (1983), building on the notion of vocabularies of motives (Mills, 1940), argue that scientific norms constitute "vocabularies of justification which are used to evaluate, justify and describe the professional actions of scientists" (Mulkay, 1983. Pp 653-654). In this view, such norms constitute an "occupational ideology": the systematic presentation of a view of science which supports their collective interests. Gieryn (1983) further showed that these norms have been successfully used to defend the interests of science against external challenges. While both authors dispute the notion that scientific norms constitute moral imperatives for scientists, they agree that they are complex moral repertoires, mobilized in the pursuit of various ends, be it the defense of science in the public sphere or the pursuit of more local interests.

4.2. Religion and bioethics

Science and religion have a long history of confrontations on moral grounds (Biagioli, 1993; Gieryn, 1983) and this is particularly true for biology with its foray into human life. While most debates about bioethics are generally presented as a secular debate, they tend to oppose religious norms to scientific ideals. The stem cell controversy is only one of the latest of such conflicts which also cover issues of genetic engineering, end of life approaches, reproductive technologies or human-animal chimeras. Religions differ on these perspectives about the status of embryos and this divergence has shaped national policies. For instance, Buddhism and Judaism do not

grant human status to early embryos. As a result countries such as Israel have had more encouraging public policies towards research areas such as stem cell science and the research has thrived. Conversely for Christian religions, embryos are considered as sacred human beings from the moment of conception. For these religions, the destruction of human embryos for research purposes proves unacceptable no matter the developmental stage or the future prospects of these embryos. These frames have influenced public policy in many European countries – except the United Kingdom – where stem cell research is highly restricted.

It would be a simplification to say that religion is the only shaping factor of public policy regarding bioethics. Complex cultural and historical aspects of each nation also shape the public attitude and governmental regulation regarding bioethics. For instance, the use of embryos for research resonated with the use of vulnerable human being for research under Nazi Germany. As a result the public has strongly opposed the use of stem cells and German regulation has one of the most restrictive approaches to stem cell research (Sperling, 2008). Nonetheless, religious norms remain a major influence in the definition of regulation related to bioethical issues and many religious groups have been the fiercest opponents to stem cell science.

The United States is the only major country to have adopted a complex "middle-ground" position: rather than authorizing or forbidding the use of embryos and human embryonic stem cells, the federal government has only restricted the public funding for research involving such materials. Until 2010, science had free reign to use embryos and hES cells with private funding. This middle-ground position has set the stage for the continued stark confrontation of science and religion over conditions for the use of human embryos and human stem cells.

But while we might think of the opposition between science and religion as essentially playing out in the public sphere, there is also evidence that religious beliefs held by scientists also shape scientific practices. Through a broad survey of religion among scientists across natural and social sciences, sociologist Elaine Ecklund (2010) found that 47% of the elite scientists surveyed claimed a religious affiliation. While this rate is much lower than the 84% of believers among the general population, religious affiliation nonetheless remains high. Half of the scientists interviewed stated having some belief in the existence of God ranging from "I believe in God sometimes" to "I have no doubts about God's existence." In addition, 20 percent of scientists saw themselves as spiritual but not religious in a traditional sense. Many scientists who describe themselves as spiritual view their spirituality as flowing from science, from a deeper sense of appreciating the natural world. One scientist quoted explained: "Personally I believe in Nature, and I get my spirituality… from being in nature." Another noted "I am touched by the beauty of creation." This sense of spirituality flowing from nature relates to the close and meaningful relation scientists have with the objects of science which many scholars of science have described (see (Knorr Cetina, 1997; Keller, 1984). While this might be thought of as essentially an inner-state, many respondents mentioned that their spiritual perspectives influenced their choice of scientific investigation. Whether derived from their material world or from abstract principles, religion and spirituality has moral authority over many scientists in a way that can compete with scientific norms.

4.3. Safety

While contests between science and religion have been present since the emergence of experimental science as a distinct institution, the concern over safety is a more recent phenomenon which emerged in the second half of the 20th century through controversies over the role of science in the public interest (Fredrickson, 2001; Moore, 1996, 2008). Safety concerns emerged through controversies over the involvement of science with the military and growing public concern over the safety of experimental subjects, patients, the broader public and researchers themselves. As a result, the bureaucratic apparatus aiming at governing safety in academic laboratories has gradually increased over the last fifty years. The increase of safety rules and oversight has led to some resistance from scientists (Huising & Silbey, 2011) . Nonetheless, safety constitutes an additional moral rationale by which social and organizational actors can evaluate what constitutes good and ethical practice.

Science, bioethics and safety are hence three evaluative frameworks which scientists can mobilize in order to define what constitutes good, ethical work practice. From a practice perspective (Bourdieu, 1977; Giddens, 1984), ethical systems, as systems of practice, always constitute a dynamic, dialectical relationship between socially approved moral norms and individual moral behavior (Paxson, 2004). From this ethics-in-practice perspective, competing institutional logics (Heimer, 1999), modes of justification (Boltanski & Thévenot, 2006) or modes of evaluation (Stark, 2009) constitute different moral imperatives which individuals mobilize as they seek to justify or motivate organizational action. These everyday negotiations

over what constitutes good and ethical practice are an essential medium by which different institutions meet and change through the lived experiences of social actors.

In the remainder of the dissertation, I will discuss how scientists mobilized the three frameworks, science, safety and bioethics in order to define what they view as good, ethical work practice. This ongoing negotiation among competing frames is generative beyond the mere definition of temporary ethical agreements as it is also an occasion for the crafting of new practices and technologies. Local ethical contests are, in this case, constitutive of work and of science. In the following chapter, I review the major ethical contests that took place in bioscience over the last century and argue that these contests have both led to an increase in regulation and oversight of science and to a growing internal polarization among scientists about what constitutes ethical work practices. In the next three chapters, I delve into the ethnographic data to show empirically how scientists in Med Lab mobilized the three repertoires differently and how the ensuing contests led to the creation of new practices and technologies. In conclusion, I detail some of the conditions under which ethical contests can shape organizational and institutional change and discuss the implications of this work for our understanding of the social responsibility of organizations.

CHAPTER 2: THE POLITICAL AND LEGAL CONTEXT: REDEFINING SOCIAL RESPONSIBILITY IN BIOLOGY

A well-accepted feature of scientific life is that scientists engage in boundary-work to defend their professional autonomy and secure authority over the production of scientific knowledge. Boundary-work refers to the ongoing rhetorical activities and practices aimed at demarcating "pure" scientific activities and interests from non-scientific ones (political, ethical, religious) (Gieryn, 1983, 1999; Bruno Latour & Woolgar, 1979). These practices have allowed science to secure and maintain its position as a powerful institution and to shield itself from challenges arising from competing institutions such as religion or the law. However by focusing primarily on the public interventions of scientists, this view assumes the adhesion of scientists to the goals of their institution and overlooks the influence of cultural diversity on scientists' attitudes towards science. Moreover, this view fails to explain the rise of regulatory oversight of science that occurred throughout the last century. In this chapter, I will examine three contentious debates involving academic biology, the public and the state — Recombinant DNA, Animal Rights, and Stem Cells — to explore how diverging perspectives within the scientific community itself allowed for the penetration of "non-science" interests within science.

1. Boundary-work, morality and the crafting of a legitimate space for science

The emergence of modern science (empirical, experimental) as a powerful institution alongside the state and other knowledge producing institutions (religion, philosophy, engineering) has long been fraught with conflicts, generally fought on moral grounds (Biagioli, 1993; Gieryn, 1983;

Shapin & Schaffer, 1985). Early contests arose in the 17th century with experimental science seeking to carve a legitimate space independently from religion (Biagioli, 1993) and philosophy (Shapin & Schaffer, 1985). The interests driving the actions of such prominent actors as Galileo, Boyle and the Royal Society of London were twofold. First, they sought to define a space for a particular kind of knowledge production – experimental inquiry – over which the experimental scientist had full authority. Second, they sought to assert both the legitimacy and superiority of scientific knowledge over other modes of knowledge production. Contests were partly fought on material grounds: emerging scientists displayed or distributed their newly crafted tools such as telescopes (Galileo) or air-pumps (Boyle and his followers) to show and publicize the workings of nature. Through these contests, a common set of norms came to define and support the nascent experimental community (Shapin & Shaffer, 1985):

> The experimental polity was said to be composed of free men, freely acting, faithfully delivering what they witnessed and sincerely believed to be the case. It was a community whose freedom was responsibly used and which publicly displayed its capacity for self-discipline. Such freedom was safe. Even disputes within the community could be pointed to as models for innocuous and managed conflict. Moreover, such free action was said to be the requisite for the production and protection of objective knowledge. Interfere with this form of life and you will interfere with the capacity of knowledge to mirror reality (Shapin & Schaffer, 1985).

Through these early debates, scientists sought to carve a space of legitimacy by defining their institution through a strong moral ethos: a mission to further knowledge grounded in autonomy from legal and religious institutions.

2. The creation of public interest organizations led by scientists

While disputes between science, other disciplines, and social institutions also erupted during the 18th and 19th century, the strongest challenge to experimental science emerged during the 20th century with the growing use of scientific knowledge for warfare (Gieryn, 1983; Moore, 1996). By that time scientists had established a legitimacy that converted into public-supported research programs. The challenge was then "to retain control over the use of these material resources by keeping science autonomous from controls by government or industry (Gieryn, 1983, p. 789)." Just as the emergence of modern science depended on gaining moral legitimacy at the expense of competing institutions such as religion, philosophy or engineering, the maintenance of science's position came to depend upon the continuing legitimacy and social acceptance of its activities and values. Yet scientists became divided over how best to defend the interests of science. In her study of the creation of public interest organizations by scientists from 1955 to 1975, Moore (1996, 2008) shows that scientists' defenses in the face of public controversy were grounded in a contradictory act: the creation of public interest groups that bridged the interests of science and non-science. During this period, scientists (mostly biologists and physicists) formed politically engaged groups such as the Union of Concerned Scientists (UCS), Scientists' Institute for Public Information (SIPI) and Science for the People (SftP). They advocated for more transparency in the presentation of scientific findings, against government intervention in science, and for the

responsible use of science. While these organizations promoted and defended the core values of science, scientists became more politically engaged. Rather than demarcating science from non-science, these groups effectively argued for a compatibility between scientific and nonscientific interests. As a result of these efforts, the notion of "socially responsible" science came to the forefront of the debate. With public grants becoming a prevalent source of funding and the public exerting a growing oversight over scientific activity, the question of scientists' social mandates became a salient issue both for scientists and non-scientists.

The controversy over science's involvement with warfare thus led to the creation of a new institution: social movements led by scientists aiming at challenging the moral legitimacy of certain scientific practices. During this period however, debates centered on the applications of science, not on the materials and practices themselves. The symbolic notion of an "inside" of science, shielded from public and political oversight could still hold. In the subsequent debates, this differentiation became untenable. Indeed the main controversies that punctuated the later part of the 20th century were directed to the "inside" of science: its experimental materials and practices. The terms of the contest also shifted. While the earlier contests involved rhetorical actions and social mobilization, these later contests, involving recombinant DNA, animal rights and stem cell research, became increasingly to involve the defining and redefining of the rules of scientific practice and the creating of regulatory committees.

3. The recombinant DNA controversy: from self-regulation to external oversight

While the controversy over recombinant DNA is better-known as a public controversy, much of the early debate was actually and sustained by biologists themselves and led to the definition of

internal guidelines. It is only after these guidelines were defined that oversight became externalized and managed by the NIH (National Institutes of Health) and other research institutes.

The controversy over recombinant DNA – or genetic reprogramming - arose in 1974 when a group of scientists planned to conduct experiments involving the injection of viral DNA into bacteria. Microbiologists expressed concern about the potential for human contamination. As a result, a group of scientists led by Paul Berg and Maxine Singer (located at .....?) called for a worldwide moratorium on genetic engineering experiments until safety and ethics issues could be addressed. The moratorium was intended to leave time for the scientific community to organize a conference, which became known as the Asilomar conference, and issue some guidelines for the safe practice of molecular biology (Berg, Baltimore, Brenner, Roblin, & Singer, 1975; Berg & Singer, 1995). In these early steps towards defining the governance of scientific practice, tensions between the will to self-regulate and the desire for external oversight was readily apparent. During the Asilomar conference, some scientists circulated an open letter from Science for the People calling for public participation and noting that the signers did "not believe that the molecular biology community ... is capable of wisely regulating this development alone (Fredrickson, 2001)." A number of other scientists were strongly opposed to the guidelines and to public involvement for fear of crippling promising research. The conference issued a number of recommendations, in particular regarding physical (P1 to 4) and biological (EK 1 to 4) containment. Physical containment related to the physical and architectural barriers to be installed in the laboratory space. Biological containment related to safety barriers integrated within the biological materials (segmentation of viral DNA for

instance). Of particular concerns for many scientists (microbiologists in particular) was the use of some strands of *e-coli* bacteria, a common human pathogen, as a vector for the reproduction of viral DNA. Another concern was that so little was known at the time about genetic engineering that the effects on the biological environment were difficult to anticipate. Nonetheless, scientists at the Asilomar conference agreed on a number of guidelines which would allow recombinant DNA research to move forward.

Asilomar marked an important milestone in the relation between scientists and public policy. It was the first time that the scientific community agreed voluntarily to a moratorium on important research on the grounds of safety and social responsibility (Berg and Singer, 1995). Yet the Asilomar conference was only one part of the process through which research guidelines were to be established. Indeed, once the recommended guidelines were agreed upon, the issue became how to administer these guidelines within an institution that had no centralized governance. The solution adopted was to transmit the recommendations to NIH, which would become the authority competent to translate the recommendations into guidelines and then administer them. The outcome of the conference was the creation of the NIH *Recombinant DNA Molecule Program Advisory Committee* (RAC) and the issuance, in 1976, of interim rules for federally supported laboratories in the United-States (Fredrickson, 2001). Such interim rules however proved both too constraining and too open-ended. The guidelines were constraining because they had been established as the most conservative response in the face of much uncertainty. As little was known about the biological consequences of recombinant DNA, all experiments had to be performed under the most stringent containment conditions — P4 laboratories. Requests for such establishments instantly met strong resistance from a public weary of living near facilities that

would handle infectious diseases. The increase in visibility generated by the new regulation, in effect stalled early attempts to foster new knowledge that could help qualify the threats. The guidelines were also too open-ended: they gave no recommendation for making modifications or regarding implementation and administration. The RAC at NIH became faced with two major challenges: how to ease the guidelines so that research could go on and how to administer such guidelines uniformly without translating them into statutory regulation. Indeed if the recommendations remained guidelines administered by NIH, there could be no enforcement possible by NIH beyond the voluntary compliance of scientists. If the guidelines were to become federal statutory rules, scientists would lose control over the administration of the rules and lose the tight coupling between experimental rules and scientific knowledge. Meeting these challenges proved to be a multi-year involvement for the NIH, which had no precedent or relevant structure to administer such guidelines. This also meant that NIH had to take a more central role in enacting and governing the application of standard research guidelines (Fredrickson, 2001).

The transmission of these guidelines to NIH marked the end of the control and authority of biologists over these experimental practices. Indeed, NIH's first step, as a public agency, was to hold public hearings about the guidelines. This was the first attempt at communicating the debate to the public and it marked the beginning of a public involvement which would only grow over the following six years until the publication of the final guidelines. NIH also became increasingly involved in direct discussions with governmental units, in particular with Congress and the *Department of Health, Education and Welfare* (DHEW, now Department of Human and Health Services). The larger challenge for the NIH RAC was to negotiate with the government

parties who desired to translate these guidelines into statutory regulations. NIH's position was to maintain the guidelines and rely on scientists' voluntary compliance. This position however became difficult to maintain in the face of growing public concern. It is noteworthy to mention that public resistance was largely led by individual scientists who opposed recombinant DNA research and activist groups such as *Scientists' Institute for Public Information* (SIPI) and *Science for the People* (SftP) which had been created in the previous period of public unrest. The NIH position was also undermined by the impatience of molecular biologists with the restrictions imposed on research which led many of them to publicly oppose the guidelines and pushed some laboratories to bypass the restrictions in order to move their research forward.

As a result of public concerns and scientists bypassing the authority of NIH, the US Congress, under the leadership of senator Edward Kennedy who served as chair of the Subcommittee on Health and Science Research, held a number of congressional hearings and sought to pass legislation translating the guidelines into statutory rules under the authority of DHEW. After six years of back and forth negotiations between NIH, Congress and DHEW and in the face of growing evidence of the lack of hazards imputable to extant recombinant DNA research, NIH succeeded in shielding Recombinant DNA guidelines from becoming federally regulated. Oversight was given to the existing *Institutional Biohazard Committees* which were renamed *Institutional Bio*safety *Committees(IBC)* in a move to allay public and scientific fears. In 1981, the new NIH Guidelines for Recombinant DNA Research were published, six years after the Asilomar conference. These guidelines were significantly less constraining than their original version and allowed the larger part of recombinant DNA research to be performed into the low P1 and P2 containment requirements (now Biosafety Levels 1 and 2 on a scale from 1 to 4).

As the concerns over safety were winding down, the terrain began to move towards ethical and legal conerns. In August 1980 as the guidelines were close to be adopted and published, a researcher from UCLA, Martin J. Cline, bypassed approval from the university's Institutional Review Board to attempt injecting a gene into patients' bone marrow. This first attempt at gene therapy marked the transformation of the controversy over genetic engineering from a safety issue to an ethical question. The episode precipitated the formation of a *President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research* to examine moral issues in molecular biology. This commission was to replace the *National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research*, the first bioethical governmental commission which was instituted as a response to a nascent debate over the rights of research subjects, both born and unborn. Recombinant DNA research, by now more often described as genetic engineering, rejoined the nascent debate over the ethical and legal issues of biological and medical research (Berg & Singer, 1995; T. H. Murray, 1990). The publication of the Guidelines marked a partial victory for the molecular biology community: they had avoided the transformation of research guidelines into statutory rules and had as such partly kept the authority over the conduct of science. However this contentious episode became part of an important process implicated in the constitution of a legal, material and political infrastructure that would build bridges between science and public interest: the NIH and IBCs had taken new and important oversight roles, Congress and DHEW had ventured into scientific regulation, the regulatory discussion had extended to the nascent infrastructure related to biomedical issues (the presidential ethical advisory boards) and scientists had become accustomed to the public discussion of issues they believed to be best served when left to the

expert knowledge of scientists. Scientists had learned to better use the tools of public policy to serve their interests but at the same time the public and the government took an important step into the thorny question of scientific governance. These new roles, committees and practices would be ready to be activated for the next controversy.

4. The animal rights controversy and the birth of animal rights oversight

Animal care regulation emerged during the same period as regulation on Recombinant DNA although the public controversy came to the fore much later, in the 1980's. Animal regulation was also initiated "inside" science. In 1963, a group of veterinarians came together and published the "Guide for the Care and Use of Laboratory Animals." This guide was supported by NIH and NAS, the latter being the publisher of subsequent issues. At the same time, public concern over animal welfare grew, catalyzed by several articles in the press on poor animal welfare in the United States. This prompted Congress to pass the Animal Welfare Act in 1966. In 1971, a revision of the Welfare act required compliance to be achieved through either the use of an institutional animal care committee or accreditation.

In the early 1980's, controversy over the treatment of animals in laboratories grew, led by a rising number of animal rights movements such as the Animal Liberation Front (ALS) and People for the Ethical Treatment of Animals (PETA). While such movements targeted a number of organizations and institutions (the cosmetic industry, slaughterhouses), a major part of the contestation focused on animal testing in laboratories. In response to public concerns, the government sought to increase laboratory regulation. In 1985, Senator Robert Dole sponsored amendments to the Animal Welfare Act, which tightened the standards for animal care. The

amendment also provided for the creation of *Institutional Animal Care and Use Committees* (IACUC) in facilities performing research and required the inspection of animal use facilities twice per year. NIH also required that, to be eligible for funding, scientific protocols had to be reviewed by IACUCs and evaluated on the necessity of the proposed experiments and the "humaneness" of the research design. IACUCs now also monitor the treatment of animals once the project has been funded and provide training and advice on animal handling.

Similarly to the Recombinant DNA controversy, the animal rights controversy was initially instigated as a self-regulatory effort aimed at maintaining autonomy of scientific practices. Yet the effort also ended in externalization of oversight through bureaucratic rules and committee mandates. As the notion of the social responsibility of scientists grew (and came to include variously the rights of surrounding communities, patient and experimental subjects rights, and animal rights), the efforts at self-regulation became more and more externalized and bureaucratized.

5. The stem cells controversy: Delving further into the public arena

5.1. The rise of stem cell regulation and oversight

> *"I have a firm conviction that science exist in a social context and is in part responsive to the constraints of that social context. But I also feel it should be leading, as a leading voice in defining issues of truth and knowledge, and to some extent, the distinctions between sort of morality and morality" (Principal Investigator, Med Laboratory).*

The stem cell issue is the most recent controversy to erupt between science and the public. Although early ripples could be felt as early as 1973, as a fallout from Roe v Wade, the controversy reached its apex between 1998 when human embryonic stem cells were discovered and 2007 when a technical alternative ("reprogramming") enabled the generation of embryonic-like stem cells from adult cells. At this point regulatory agencies were extant and federal knowledge about legal, safety and ethical issues related to scientific research was broader than during the earlier controversies. While the guidelines for recombinant DNA were largely initiated by the scientific community, regulation of stem cell research was initiated by the government with scientists' attempts at self-regulation being reactionary. The stem cell controversy was also characterized by important regulatory back-and-forth. As early as in the 1970's ethics and regulatory committees were created and dismantled, regulations, amendments, bans or moratoriums were passed or decreed in rapid succession. While it might be tempting to see each of these regulatory episodes as a negotiation between regulation and deregulation, the process rather consisted of alternating moves involving different types of regulations, with an increase of regulatory oversight over the practice of biology at each move.

The Stem Cell controversy marked new milestones in the relations between science and the public and political spheres. Scientists lost a large part of their authority over the definition of research to the government but at the same time became more organized and empowered as a social movement. As early as 1973, when Roe vs Wade galvanized public attention over abortion, part of this attention became directed towards the use of fetal tissues in research. In response to public concerns, DHEW issued a moratorium on the use of fetal tissues for research. Congress also created the *National Commission for the Protection of Human Subjects for*

Biomedical and Behavioral Research in order to study these issues and allow the moratorium to be lifted. (Public law 93-348, National research Act, Title 2; Berg, 2009; Kelly 2007).[4] The first report of the commission, *Research on the Fetus*, defined guidelines and recommendations for such research and proposed the creation of the *Ethics advisory board* (1975) to regulate fetal tissue research. The board however was to be dismantled in 1981 by President Reagan who banned any federal funding for research involving fetal tissue. Controversy and ambivalence related to fetal and embryonic research would only grow again in 1988 with the discovery and derivation of embryonic stem cells from mice models. In 1988, Reagan formed a new committee to study issues related to the newly emerging field of stem cell research. The committee authorized anew the use of fetal tissue for research, only to face a moratorium by the incoming President Bush. When taking office, President Clinton removed the moratorium, only to reinstate it one year later. In order to settle the issue, Congress passed the Dickey-Wicker amendment in 1995, banning the use of federal funds for research using human embryos. The same year, President Clinton created the *National Bioethics Advisory Commission* (NBAC) in order to study ethical issues related to the use of biological materials.

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[4] While the public uproar over the syphilis experiments performed on African-Americans is more widely known as spurring the creation of this commission that would ultimately issue the Belmont Report, the initial mandate of the commission was to set guidelines for fetal tissue and embryonic tissue research. The first report of the commission in 1975 defined guidelines for research on the fetus (http://bioethics.georgetown.edu/pcbe/reports/past_commissions/research_fetus.pdf).

In 1998, a team of scientists at the University of Wisconsin, led by James Thomson and Joseph Itskowitz-Eldor, announced that they had derived stem cells from human embryos using private funding. Such cells had the potential to grow in petri-dish and be sent to other scientific teams as a research tool. This research area immediately fell into a legal gray zone: should embryonic stem cells be considered as fetal tissue and fall under Dickey-Wicker or should they be considered separately from embryos? NBAC became tasked with providing guidelines for proceeding forward. The NBAC guidelines, issued in 1999, recommended the use of federal funding for research involving the use of surplus embryos and stem cell lines derived from surplus embryos. They became then translated into a proposed regulation for publicly funding stem cell research using surplus embryos.

On taking office in 2001, President Bush vetoed the proposed bill and restricted federal funding to the use of about 60 existing stem cell lines. He also dissolved the NBAC and replaced it with the Council on Bioethics whose mandate was to continue investigating the ethics of biomedical science and technology.

While much of these early attempts at defining the ethics of stem cell research were enmeshed with abortion politics, a rising part of the debate came from the confrontation with novel ethical dilemmas spurred by new biological knowledge and technologies. Indeed the debate was no longer centered on the status of aborted fetal tissue or surplus embryos but focused on the creation of human embryos, cloning as well as human-animal chimeras. Such issues, which had previously belonged to the realm of science fiction, had become material possibilities. The debate also touched on one of science's main claim for autonomy: non-normative commitment to issues "beyond" the science, considered as belonging to the realm of religion and law.

In this context of limited funding, political uncertainty and public and scientific concerns over the ethics of a growing and promising scientific area, the National Academy of science (NAS) begun holding regular meetings in order to discuss the possibility of forging its own guidelines. A panel co-chaired by Richard O. Hynes from MIT and J.D. Moreno from the University of Virginia was constituted. In 2005, the committee issued its own guidelines for Human Embryonic Stem Cell research.[5] The NAS recommendations devised guidelines for creating hESC including: 1/ guidelines regarding donor consent for gametes, blastocysts, and cells as well as guidelines for reimbursement and compensation; 2/ guidelines for the derivation and culture of early embryos (limited to 14 days); 3/ guidelines on banking and distribution of stem cell lines; and 4/ guidelines for the use of stem cell lines, including the limitation of human-animal chimeras (implantation of hES cells into animal bodies or embryos), and the request for a review by the local IACUC. The NAS recommendations also included the creation of an institutional oversight committee, the Embryonic Stem Cell Research Oversight Committee (ESCROC), whose role would be to review the compliance of the research protocols (privately or publicly funded) with the NAS guidelines.

The NAS's attempts at defining guidelines were in many ways defensive: they were an attempt to regain authority over the definition of experimental work. For Richard Hynes, defining

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[5] Source: Guidelines for Human Embryonic Stem Cell research (2005), National Research Council and institute of medicine of the National Academies, The National Academies Press. http://www.nap.edu/catalog/11278.html

research guidelines was about allowing science to proceed without the restrictions or uncertainties related to governmental regulation and reclaiming an autonomous "inside" of science: "We wanted to set up a mechanism so that science could proceed.[...] we thought of it then as building a ring fence around stem cell research and within this ring fence, then research should proceed as usual" (R. Hynes, Conference on the Ethics and Public Policy of Stem Cell Research). But, as in the previous controversies, the solution adopted by scientists was paradoxical: defining more guidelines and creating more local oversight in order to regain autonomy and control over the experimental process. In so doing, however, scientists have expanded the regulatory and oversight apparatus over their work. Indeed, experimental guidelines and institutional committees reach deep into the internal, expert practice of science by seeking to define each step to be performed by scientists rather than leaving this area under the purview of expert knowledge.

5.2. The effects of the NAS guidelines for stem cell research

Academic institutions began implementing and following the NAS guidelines, particularly for privately funded research. Institutional ESCROCs were constituted and began reviewing the research protocols. At the federal level however the established regulation did not change. The federal administration did not reverse its ban nor did it approve new lines despite continuous calls and lobbyism by the stem cell community. For some laboratories and institutes that could rely on private funding, following the NAS guidelines was a way of asserting their professional ethics and promoting a mode of regulation through scientific guidelines over federal law.

5.3 The discovery of reprogramming

In 2007, four teams of researchers announced that they had discovered a technique for "reprogramming" adult cells into a state similar to stem cells. The cells, called "induced pluripotent cells" (IPS cells)[6] were seen as a major innovation for the stem-cell community; however they renewed the internal divisions over stem cell research. For opponents to the use of human embryos, reprogramming was thought to enable research to bypass the use of embryos and embryonic stem cells. The stem cell community was divided. Many scientists claimed that crucial differences between the two types of cells did not make them substitutes for one another. Many also felt that the ethics of earlier use of embryos still needed to be defended since the reprogramming techniques would not have been made possible without earlier research in embryonic stem cells. Yet the new discoveries opened up research avenues that were still limited with respect to ethical concerns such as the creation of disease specific stem cell lines. These discoveries also severed the tight bond between stem cell research and medical promises: to perform stem cell research for the sake of pursuing knowledge became more socially acceptable.

When President Obama was elected in 2008, the scientific community renewed its push for changing the regulation. This push was as much practical (opening up previously restricted areas of research) as ideological (overturning the stigma attached to the use of embryos in research). In 2009, the ban was indeed lifted. However this did not mean free reign for the scientific

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[6] Early stem cells can become any tissue in the human body and are considered "totipotent". After early phases of differentiation, they are called "pluriptent" as they can only differentiate into a select number of different tissues.

community. The decision included forming a committee at NIH to define new eligibility criteria for funding approval and to review individual lines on a case-by-case basis. This committee largely used the NAS guidelines and primarily focused on the issue of donor consent. With this new criteria, new stem cell lines were approved but the use of some formerly approved lines was banned. A related move on the federal front was to dissolve the presidential council on bioethics founded by President G. Bush which had come under criticism for adopting partisan views on bioethical issues. A new council, *The Presidential Commission for the Study of Bioethical Issues* was created as a replacement, in effect making the existence of bioethics committees a stable feature of the government.

This most recent major episode in the stem cell controversy has several implications. The regulation sought to redefine what was to be considered "ethical": a definition centered on donor consent and aligned with the NAS recommendations rather than based on religious principles. This change marked a material and ideological victory for many scientists who had advocated for the NAS guidelines and for ethical criteria to be based on donor consent. While the guidelines were closer to the wishes of the scientific community and were hailed as a victory, the definition of ethical experimental practices and models remained the prerogative of the federal government. New and more detailed regulation had replaced old regulation.

6. Implications for the boundaries between science, ethics and the law

Ewick and Silbey (2003) note that science can be a threat to other institutions and to society because its norms and practices are indecipherable and hence not easily amenable to external control:

> *Science is dangerous because, being indecipherable, it may incapacitate the law's, the religion's or the economy's routinized ways of operating and construing the world. However an important aspect of this indecipherability, especially from the point of view of law and religion is science's claim to operate without normative commitments. Thus, by abdicating responsibility for the social terrain occupied by law and religion, it turns out science secures a measure of autonomy for its most serious dangers.* (Ewick & Silbey, 1993)

The emergence of science as a powerful and autonomous institution largely relied upon the carving of a cultural space of knowledge production devoid of ethical and social concerns, leaving the questioning of ethics to religion and to the law. This position could be maintained as long as the ethical controversies were only attached to science's products and their use by non-scientists.

However, during the 20th century, science's answer to controversies was less to maintain strong boundaries but rather to seek to bridge scientific and public interests, first by making internal controversies public, and then by abdicating the administration of self-regulatory guidelines to external bodies. Scientific committees, federal commissions and institutional oversight committees constituted the building block of an infrastructure linking scientists to legal and political institutions. Scientists sought to appropriate policy-making tools: guidelines, regulations and oversight committees in order to defend their autonomy through self-regulation. But in doing so, they in effect constructed the political, legal and administrative apparatus that would increasingly mediate the settlement of disputes. Scientists largely crafted their own bureaucratic

iron cage in their effort to maintain autonomy and authority over their experimental practices. At the same time the social responsibility of science – in biology at least – became gradually redefined as part of a larger social debate rather than at a remove from other institutions' effort to define social good.

Bureaucratic and professional ethics. While the controversies have not stifled research, they have resulted in added regulation. New rules and oversight committees have brought the debate into the core of science: the laboratory space and its internal practices. The laboratory space which was previously entirely ruled by the norms of science has become penetrated by legality (Ewick and Silbey, 1993). Each episode precipitated the creation of institutional boards: nascent ethical concerns spurred the creation of IRBs, the recombinant DNA controversy led to the expansion of IBCs, the animal rights controversies led to the creation of IACUCs, and the stem cell controversy was addressed in part by creating ESCROCs. While compliance with the guidelines promoted by these boards is voluntary, it is a prerequisite for obtaining federal funds. These rules touch the heart of experimental research: they define which research models and which tools are to be used and how they are to be used. At the level of everyday work, scientists have become effectively torn between two competing moral orders: the professional, scientific ethic and the bureaucratic ethic.

This process has led to the establishment of an infrastructure (interest groups, regulatory committees and roles, institutional oversight committees, scientific and legislative knowledge) that bridges political and scientific interests. It has also allowed debates previously located in the public sphere to penetrate the laboratory space. Experimental practices and materials have

become contested grounds for the workers. But as regulatory institutions became more adept at regulating science, scientists also became knowledgeable and skilled actors in navigating social controversies[7].

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[7] The New York Times published an article about the Guatemalan trials on Aug 30 2011 after this chapter was written. These medical trials were conducted before the Tusgekee trials and involved injecting Gatemalan prisoners and mentally-retarded patients with Syphillis. The trials were conducted by US physicians under the supervision of the same physician who conducted the Tuskegee trials. The presidential bioethics committee is currently investigating this episode. This latest investigation does seem to be part of the overall trend to keep scientists more legally accountable over bioethical issues. A member of the bioethics committee cast the investigation in this continuity: "The problem in 1946," Dr. Gutmann said, "was that ethical rules were treated as obstacles to overcome, not as fundamental bedrock of human dignity. That can still apply today. That's why our panel is doing our report." (NYT, Aug 30 2001, Panel Hears Grim Details of Venereal Disease Tests)

Appendix 1: A short chronology of stem cell public policy and research

1973 - Roe vs Wade galvanized public discourse in arenas other than just abortion issues. Public revelation that fetal tissues are being used for medical research. A newspaper released a front page with a picture of a fetus and the title: "the fetus as a guinea pig"

1974 - Congress creates the national commission for the protection of human subjects for biomedical and behavioral research. Congress also issues a ban on the use of all fetal tissues until the national commission established guidelines

1975 - Creation of the Ethics Advisory Board to regulate the use of fetal tissue in research. This committee will issue the first bioethical recommendations and guidelines, including the Belmont report and the creation of the Institutional Review Board

1979 - Department of health, education and welfare allows embryo research and its funding but requires consent from the Ethics Advisory Board.

1980 - President Reagan dismantles the Ethics Advisory Board which prevents any possibility for federal funding.

1981 - Discovery of animal stem cells (in mouse models)

1988 – President Reagan creates a committee to study these issues. The committee approves the use of fetal tissue in research.

1990 – President Bush places a moratorium on this approval

1998 – Isolation of Human Embryonic Stem Cells by James Thompson. The discovery renews the ethical debate on the use of embryos as they are now used to generate stem cells.

1998 – Clinton launches a reflection committee within NBAC to think about stem cells research in particular. The committee issues the NBAC guidelines in 1999, recommending the use of federal funding for research involving the use of surplus embryos and stem cell lines derived from surplus embryos.

2001 – Proposed regulation for hESC funding along the lines of the NBAC guidelines. President Bush issues an executive order ruling that research could only use SC lines already in existence and derived from IVF embryos

2005 – NAS issues guidelines for stem cell research. The guidelines recommend the authorization of the use of embryos but not the creation of embryos for research. The main focus is on individual consent and the limits to human-animal chimeras. The guidelines recommend the Creation of institutional Embryonic Stem Cells Research Oversight Committees (ESCROC) to provide legal oversight of all issues related to derivation and research use of hES cell lines.

2007 – Discovery of techniques for reprogramming adult cells into "induced pluripotent cells" (IPS cells)

2009 – President Obama overturns the executive order but does not repeal Dickey-Wicker. A committee is created to review and approve stem cell lines for federal funding, based on donor consent

Appendix 2: Bioethics commissions in the U.S. since 1974[8]

Years	Bioethics commission	Founder
1974	National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research	Congress
1978 - 1983	President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research	Congress
1988 – 1990	Biomedical Ethical Advisory Committee	Congress
1994 – 1995	Advisory Committee on Human Radiation Experiments	President Clinton
1996 – 2001	National Bioethics Advisory Commission (NBAC)	President Clinton
2001 – 2009	President's Council on Bioethics	President Bush
2009 -	The Presidential Commission for the Study of Bioethical issues	President Obama

[8] Source: The Presidential Commission for the Study of Bioethical Issues. http://www.bioethics.gov/commissions

Appendix 3: Salient bioethical debates since 1974

Controversy	Main Actors involved	Timeline	Guidelines definition	Administration and oversight
Recombinant DNA and Biorisk	Environmental movements Biologists NIH	1974-1981	Scientific	NIH Institutional Biosafety committees (IBCs) Institutional Review Boards (IRBs)
Animal rights	Animal rights movements	1980-2000	Federal State NAS NIH	IRBs Institutional Animal Care and Use Committees (IACUCs) NIH
Embryos / Stem Cells	Pro-life and religious movements	1990-2010	Federal (Presidential Bioethics councils) NAS	NIH IRBs Embryonic Stem Cell Research Oversight Committees (ESCROCs)

Acronyms:

DHEW: Department of Health, Education and Welfare

ESCROC: Embryonic Stem Cell Research Oversight Committee

IACUC: Institutional Animals Care and Use Committee

IBC: Institutional Biosafety Committee

NAS: National Academy of Science

NIH: National Institute of Health

RAC: Recombinant DNA Advisory Committee

CHAPTER 3: THE SOCIAL ORDER OF MED LAB

"We do whatever it takes to do research; this is how we do world-class research!" {Laboratory director}

"Yes I would do it if I had to do it, it's the sort of environment you suck it up and do it." {PhD student}

Several of the city's largest hospitals, a major medical school and cutting-edge research centers are gathered along one crowded street. The health complex seems to have overgrown the area. The main street is intensely busy, particularly in the morning and late afternoon. The road is too narrow for the traffic, causing constant congestion and nervous driving. Physicians, nurses, hospital workers, students, scientists and administrative personnel, recognizable by their hospital attire or their badges, walk from one building to another. They generally walk fast, in small groups, looking down or chatting with each other. They are focused on their destination – their building or intermediary stop at a coffee shop or food place. The other pedestrian group is composed of patients and their families: worried parents taking their child to the hospital, parents struggling with a crying or unruly child, mothers carrying small babies snuggled on their shoulders. These groups also walk fast, although at mid-day, some families stroll around at a more relaxed pace.

Eastern Medical Area is a major medical community. The area includes five leading hospitals specializing in cancer, diabetes, childhood diseases and maternity. Cutting-edge research is performed in the many laboratories and research centers located within the hospitals. The hospitals treat rare diseases and seek to develop medical innovations. They house several research centers and laboratories, providing funding, infrastructure, qualified personnel

(researchers with both MD and PhD degrees and holding medical as well as scientific appointments) and research materials (mostly in the form of patient tissues). The area also includes a medical school that dispatches its students to the hospitals and research centers. A museum and a library serve to conserve and display the history of the area. It is both an exciting and a sad place. A feeling of excitement comes from the constant activity of its young, international and striving professional population: medical residents, physicians and scientists from various countries. Sadness is latent. Severe and rare diseases both in adults and children are being treated in the area. Patients and their families are omnipresent, either going to a hospital for examination or treatment or taking a break outside from the hospital.

Eastern Medical area is home to one of the largest stem cell communities in the United States. When stem cell research was nascent and public funding restricted, several hospitals provided the initial funding and laboratory infrastructure necessary to develop stem cell research. The medical school provided a steady supply of medical students and an interest in bridging research and medical innovation, a focus generally called "translational research.[9]" as opposed to "basic research." Hospitals also provide the human tissues necessary for research: fertility clinics provide the surplus embryos issued from in-vitro fertilization, other hospitals supply diseased tissues necessary for the study of disease-specific cells where stem cells are theorized to play a role (such as sickle-cell disease, leukemia, Alzheimer's disease or Parkinson's disease). While

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[9] Translational research focuses on the pursuit of scientific knowledge with a focus on medical application.

some stem cell research is conducted in independent academic centers, hospitals and medical schools have provided the main home for stem cell research. Some of the most preeminent stem cell centers in the United-States are located at the University of Wisconsin Regenerative medicine center, Yale School of Medicine, Harvard University Medical School, Boston University, Tufts University School of Medicine. This close working relationship between hospitals, medical centers and laboratories using stem cells as research models has shaped the ethical discourse centered on care and medicine and the structure of the stem cell community.

Med Lab began as a small community of cell biologists studying blood diseases. The founding identity of the laboratory was tightly focused on stem cell research and scientists shared the ethos promoted by the stem cell community in the public sphere, emphasizing in particular, the close association between stem cell research and medicine. As the laboratory experienced academic success and increasing funding, it added other teams with diverse expertise and background. The discovery by one laboratory member of the role of a particular gene in blood cell development as well as in cancer led to the creation of a team devoted to the study of this gene. Members constituting this team are primarily molecular biologists, a sub-community of biologists using different methods and tools than cell biologists. Another phase of expansion followed the discovery of a new technique for obtaining "pluripotent" cells or cells "coaxed" or engineered into behaving similarly to embryonic stem cells.

Med Lab confronts on a daily basis the high aims and difficult material reality that are pervasive to EMA. In this chapter, I first review the moral ideals of scientists. But scientists' sense of ethics also emerges from their everyday work with specific materials. I then review how the

three scientific communities that compose Med Lab, the *Mouse*, the *Stem Cell* and the *Reprogramming* communities, have defined distinct work ethics in relation to their tools (mice, stem cells and reprogrammed stem cells). Finally I review how the different hierarchical levels within Med Lab entail different approaches to what constitutes good and ethical work. Ethics pervade Med Lab: its social order is constituted around ethical divides.

1. High aims: the morality of stem cell research

The love of science

> *And belief is the part of science that comes before the hypothesis. It's the part of science that makes you interested in a concept, you know? It's emotional -- it can even be --you know ... who has looked through a telescope for the first time hasn't had some type of religious experience seeing the beauty of the cosmos? You know that feeling. Like the first time someone tells you they love you, you know? It's that same type of thing. Well, that's the type of passion that is in just about every scientist I have ever met. And then they build on top of it this veneer of empiricism, but this underlying passion is still what drives them {Will, senior scientist}.*

This passion for observing nature is shared by most laboratory members. They say, witnessing the "beauty of nature" is both a privilege and what drives them to do science. As one postdoctoral fellow notes: "If you do not share this passion, then [science] is not a good place for you: The hours are long, the pay is bad."

Many describe this initial passion as the main reason to be a scientist and to choose their particular discipline or laboratory. One researcher put this passion into words:

> *I had already made plans to interview at the X Laboratories in Vancouver, British Columbia, which is a beautiful place, to work on blood cells. But then I saw an ad from the W Institute, which caught my attention because it's a really great place. But what really caught my attention was that it said, "To study the origins of human hematopoiesis using human embryonic stem cells." And everything instantaneously came together. It was one of those moments of* satori. *I said, "This is it. [...] And so I was so excited I could hardly sleep. I wrote to [PI] the next day, and here I am.*

While always fast paced, scientists often stop to admire the "nature" they witness and share their excitement about it. Scientists looking at cells through microscopes often exclaim at what they see, offer bystanders a chance to look and describe at length a particular feat of their experimental materials. While they rarely interrupt their work to take a break and will more likely run than walk between two tasks, they often pause to share what they see: a beating heart in a petri dish, small batches of stem cells that form colonies, cells that are being fed, infected cells or damaged embryos that "repair" themselves. These displays are always accompanied by detailed explanations of the materials, the equipment that is used, and, most importantly, the 'mysteries' they are trying to understand. While scientists seem to never have enough time to complete their experiments, they always take the time to admire the workings of nature they witness.

The love of nature is coupled with a respect for the ability of science to study and understand it. The institution of science, its universities, institutes, laboratories, eminent scientists and laboratory directors, are the subject of unyielding admiration. Scientists routinely exchange news and gossip continually about laboratories, institutes and laboratory directors. Such gossip is generally positive and full of praise. Technicians and students will discuss the time when one director showed his laboratory to an actress or to the owner of the local baseball club. News about new institutes is exchanged when visitors come to the laboratory. Technicians interrupt their work to eavesdrop as postdoctoral fellows discuss the latest discoveries in personal terms (who did the discovery, what was his or her scientific path, whether they have met the person or know someone from that person's laboratory). Such discussions are usually followed with an evaluation of the social impact of the discovery and some speculation about the scientist's potential for winning a prize.

Nothing represents this passion better than the yearly Nobel Prize pool organized by the laboratory where members try to predict the year's winner of the prize in Physiology/Medicine. For five dollars, laboratory members can enter the pool and the winner earns a special "Nostradamus Crown." If there is no winner, the laboratory uses the money collected to throw a small party to celebrate the Nobel Prize. The pool is an opportunity to discuss at length who should or should not earn the valued prize and why.

Scholars have noted that the major reward in science is reputational which generally translates into funding and career advancement (Bruno Latour & Woolgar, 1979; Merton, 1979). It is little surprise that discoveries are discussed in personal terms and that leading scientists become

charismatic figures for junior scientists. Leading scientists, including the laboratory directors, represent the fusion of scientific careers with scientific ideals. While the hierarchical relationship between laboratory directors and their members (particularly postodoctoral fellows) is generally loose and informal, laboratory directors exert a strong charismatic influence.

The director of Med Lab, a senior and highly regarded member of the stem cell community, exerts such a strong charismatic influence. Members gather weekly with him during laboratory meetings and more rarely for one-on-one meetings to discuss individual strategies and careers. He rarely gives definitive research directions — postdoctoral fellows and PhD students do not have an employment relationship with him – but rather he provides sought after advice and recommendations that are generally followed or at least carefully weighed against potential alternatives. One postdoctoral fellow describes his interaction with the laboratory director:

> *Gary has so much momentum and his lab is so big that he can pour money in whatever he wants. He does not need to publish all small incrementals that are found in his lab and can gather them to publish big leaps. It also depends on people's strategy and orientation. He himself tells me that some people make a career about being very narrow but the question then is "what does it add to our general understanding?" He wants me to be ambitious about the question that I should ask. [...]People here want to ask big questions, Gary wants us to ask big question.*

Caring

The rhetoric of care is particularly prevalent among Med Lab scientists. Because the laboratory is attached to a medical school and a hospital, it has an explicit focus on the medical contribution the laboratory is making. One third of the postdoctoral fellows have medical degrees (MD) and work simultaneously as pediatricians or pediatric instructors at nearby hospitals. As part of their training, new members (PhD students and technicians) shadow pediatricians during their rotations in order to familiarize themselves with hospital work.

The willingness to contribute to medicine is also often invoked by scientists as their motivation to enter the field of stem cell research. Many scientists mentioned that a family illness contributed to their initial motivation to become involved in science. One technician described how his brother's illness spurred his interest in science and, more specifically, in stem cell biology:

> *When I was 11, my older brother, at the time, Chris, had a brain tumor removed. And he was fine; he ended up being OK. [...]I just remember hearing the doctors say one cell had to go wrong for a tumor to start, and that just blew my mind. Like one cell has to go wrong? So I always used to think about cancer, even when I was young, like how that could happen. And stem cells kind of provided the rationale for why cancer even exists in the first place, from, like, an evolutionary standpoint. So it kind of gave an explanation for that.*

Similarly, another postdoctoral fellow explained how her initial interest in biology and blood disease followed her father's illness:

[Research] wouldn't have meant anything to me. But everybody knows what doctors are, so I thought, 'Well that's what you do if you study science. You go become a doctor.' My father was ill when I was in high school. He had a bone marrow transplant because he had leukemia. And so, that has made it... So I've always had an interest in blood and that kind of stuff.

Yet another senior scientist described how his family history led him to his interest in human diseases and ultimately led him to work with human models rather than animal models:

So I started in this lab, and they had a small project on HIV-related lymphoma, so I thought, 'Well, I will work on that. I won't work on this other -- all these old men dying in the veterans hospital,' because my father died in the veterans hospital of blood cancer, and I thought, 'Fate is being very cruel to me.' But in retrospect, it was being very generous to me, because it forced me to deal with a lot of things. And it turned just this horrible story that still pains me into a very motivating sort of will. And so I studied the blood. I studied blood stem cells. I tried to understand the basis of bone marrow failure in children and comparing it to the type of bone marrow failure that these old men dying in the veterans' hospital would get, and to understand the genetic differences. And so that was all about the blood stem cell. And the more I studied the blood stem cell, the more I saw we didn't know very much about it, especially the human blood stem cell. Almost everything we know is from the mouse. And the answer is obvious: we don't do human experimentation the way we do in mice.

The focus on care is also fostered by the PI who through various discussions, jokes or anecdotes reinforces the importance of the link between science and medicine and emphasizes the role society and patients play in making their research possible. Respect for patients and donors is also paramount and constantly reinforced. During one laboratory meeting, a new PhD student was describing a research project she had begun. This project involved using cells from a patient with a genetic disease. She casually waived her hand in the direction of one of the hospitals and mentioned that this was "very convenient" because "the patient was so close." The PI seemingly annoyed by her casual tone, paused and said – referring to the patient - in an affectionate tone: "*She* is the most adorable little girl." A few members smiled in the room. With another pause and taking stock of his effect on the audience, he added forcefully "And *she* is so so sick!" With the mood in the room clearly taking a turn towards the grim, the PI went on to discuss matter-of-factly the potential and flaws in their research approach. When discussing the event in an interview, the PI agreed that while science cannot be limited to looking for cures, the connection to the patient is an important motivation of their activity:

> *There definitely are some very strong compelling stories of human interest that do act as inspiration for us scientifically. And a lot of what we do is; we're not pining away long hours in the lab to save some cute little two year old but I can tell you occasionally, when I'm in the hospital and I'm seeing those two year olds, it makes... It really has a profound effect.*

Historically the rhetoric of care has often coexisted with the rhetoric of science. In stem cell research, the rhetoric of care is particularly central as a result of the history of the field: the move

to human models involving human embryos to find medical cures. The care rhetoric thus provides an ethical justification for the use of embryos. For many scientists, the medical value of their research also constitutes a personal motivation to engage in a controversial field. These stories echo the well-publicized stories of leading scientists who entered the field of stem cell research via, they say, a personal event.

Some scientists, however, feel uncomfortable with the importance many of their colleagues give to care. In particular, they are weary of what they consider as raising illegitimate hopes, hopes he believes that science might not be able to fulfill, in order to gain legitimacy. To them, scientific claims should remain limited to the scientific mandate: Discovering new knowledge. Peter, a postdoctoral fellow expresses this tension:

> *I view research to just further our understanding. I also don't think that you necessarily need to have a very, very tight link between; I did this research with this embryo and now I'm going to cure this kid with this disorder. I think it's very disingenuous to regard the scientific process in that way.*

He explains however that distancing himself from his work's relation to medicine and care raises the question of finding a "spiritual sense" to one's career. He tells me that some people make a career about being narrow but the question then is "what does it add to our general understanding?" He reports on a discussion with his laboratory director who believes that asking big questions is important to find meaning in one's career. Paul himself still believes that he can fulfill this aspiration by contributing small increments to larger questions:

Another thing is that, being a physician, I take for granted the benefit for patients. The will to give a spiritual sense to one's career is more difficult for other scientists. I have this from my work as a physician. I would be happy with generating small incremental changes whereas others would not. There is a sense that big leaps are made with big programs. This is why there is the 'Stem Cell Program.' I don't feel that I need to have a direct relationship to application. There is a benefit to society to just understand things better.

Lurking between these views are deep questions about what is the social responsibility of scientists.

The social responsibility of the scientist

Whether in the public sphere or with families and friends, laboratory members constantly justify the worth of their research. The most universal formulation of the social responsibility of science is to develop additional knowledge that can benefit society through its applications (in medicine, engineering, government or business). Yet whether science should operate in isolation or in concert with other social institutions (medicine, law, religion) is debated. This debate over stem cell research is intense and subject to a good deal of social contestation. Med Lab scientists are divided in whether their responsibility is to strengthen the boundary between science and other institutions by leaving ethical debates to other institutions or to engage directly in social debate.

Many laboratory members share the position that their engagement should be limited to scientific discovery. To them, science sets itself apart from other institutions through non-ideological, rigorous empirical work. In the context of the stem cell controversy where a large part of the

opposition stems from religious groups, defending an enlightened approach takes a heightened importance. Issues such as the lack of understanding on the part of the lay public and challenges to scientists' traditional mode of functioning such as the attempt to regulate animal work (through animal protocols) are often conflated as a generic menace to the enlightenment project. For many scientists, to defend scientific autonomy is to defend reason. One bioethicist close to Med Lab described the stem cell controversy as a contest opposing the enlightened and pre-enlightened positions.

This view of science as "enlightened" and autonomous is apparent in a laboratory meeting I attended. The laboratory directory began the meeting with a summary of a recent conference in which he participated. He noted that the conference speaker linked the current fate of the U.S. to the dependence on Middle-Eastern oil and on credit and discussed what he saw as the dependence on social media. Commenting on the speaker's talk, the director said: "This is the dissolution of rigor. People are spending so much time being entertained rather than doing work [...] It is so much easier to write blogs than to do the hard work of scholarship. Science is the last place where you are judged on the validity of your data." At this point, Will, the senior scientist interjected: "It's the animal protocol again {Laboratory meeting excerpts, December, 17, 2009}." Will was here referring to ongoing public concerns about the mixing of human and animal cells. A number of central experiments in stem cell research involve injecting human stem cells into animals or animal eggs in order to test how stem cells develop in live organisms. These procedures have generated the opposition of several contestation groups who worried that scientists would create chimeras. The notion that scientists can create creatures that are part human, part animal has seized the imagination of these groups. Their opposition has led to

growing oversight of experimental protocols in this area, much to the frustration of scientists who argue that these fears belong more to the realm of fantasy than to the realm of science. To the senior scientist, controversy over the creation of chimeras is the perfect example of how the lay public can threaten science.

For the two leaders of Med Lab, science is at a remove from the lay public because of the rigor scientists apply to the natural world. They believe that they can apply that same rigor to understanding social problems such as ethical controversies. By contrast the lay public is a threat to science: while the public is uninformed, it can nonetheless impede the pursuit of valuable research. Will later explained more forcefully to me that he viewed the defense of science from legitimacy threats as part of his moral duty:

And so I have given far more talks than anybody else in the lab. [...]But I -- it's been important for me, and I see it as being a part of science. If your experiment doesn't work, you are obligated to figure out why. In this case, the science has been prevented from working because of things beyond the science, and I just feel that it was my obligation to try to fix it.

The freedom of scientific inquiry or professional autonomy is perceived by scientists both as a privilege and as a necessity. It is often invoked as one of the privileges of working in science, one that justifies long hours at the bench and relatively low salaries.

Other observers however have often noted that scientific norms are used to defend the power and autonomy of science over other institutions (Gieryn, 1999; Mulkay, 1976).

But autonomy is also viewed as a necessity. The "purity" of science is seen as the only way to maintain its rigor and relevance to society. Attempts by outsiders to define the work of science

are often viewed as a moral threat. As the lab meeting discussion illustrated, autonomy, to scientists, constitutes an ideal to strive for and a moral imperative to be defended.

But other scientists view their social responsibility as being engaged in the social debate. For instance one technician described his interest in engaging in the social debate over bioethics as an important part of his motivation to work in the lab:

> *You have the politics of it, and the ethics, and religious people. It's such an encompassing topic. [The stem cell controversy] brought everyone to the table: politicians, religious leaders, and scientists. And I mean, it was even argued over at dinner tables. So everyone was aware of this subject. So I think that maybe its popularity caught me too. But just when everything went together, it really interested me.*

Similarly the director of Med Lab viewed the social responsibility of science as a moral ideal. To him, the responsibility of the scientist is to be engaged in social debates – albeit as a leader - rather than at a remove from these debates:

> *I have a firm conviction that science exists in a social context and is in part responsive to the constraints of that social context. But I also feel it should be leading, as a leading voice in defining issues of truth and knowledge, and to some extent, the distinctions between sorts of morality and morals.*

Most Med Lab scientists have a strong sense of social mission. However they differ on what constitutes the mission of science (pure discovery or care, enforcing strong boundaries between science and the lay public or engaging in social debates). In Med Lab, finding a "spiritual"

justification for one's career is a self-conscious and openly debated activity, one that requires arbitraging between these dilemmas.

But scientists' ethics are not limited solely to these high ideals; they are also derived from their everyday engagement with their working materials.

2. Three communities in Med Lab: The material reality of science

Tad is gearing up to do virus work in the tissue culture room. He grumbles that this work is so tedious. "Brainless activity." For all his knowledge and time spent studying, he gets to pipet stuff in and out of petri dishes for hours each day, including many week-ends. All this he says for a mediocre salary. As we walk toward the tissue culture room, he stops and shows me an old dictionary placed on a pulpit. The dictionary seems out of place in the modern steel and glass layout of the laboratory where everything appears to be geared towards efficiency and utilitarianism. Seemingly following his train of thoughts, Tad opens the book and looks up the word *Laboratory*. The definition reads "*place of labor*." "Ha!" exclaims Tad, pointing at the definition, seemingly vindicated, before heading to the tissue culture room.

From an external viewpoint, science takes on the abstract form of theoretical knowledge, published papers, controversies over findings and more recently patents. In the idealized rhetoric of scientists, science is about discovery, care and contributing to society. However, the larger part of a biologist's day is dedicated to benchwork: the manual transformation of biological and chemical materials in the pursuit of empirical data. Benchwork is generally perceived as labor-intensive, tedious, gruesome and bloody. Yet besides abstract ideals, ethical understandings also

emerge through scientists' everyday engagement with working materials. In Med Lab, this is most visible in how the different communities in the lab have develop distinct research ethics.

Med Lab gathers three different communities of biologists: *the Mouse community, the Stem Cell community* and *the Reprogramming community*. Table 1 summarizes the three communities and their research ethic. Each community has developed work practices around specific objects and has derived specific understandings of what good, ethical practices with such objects might be.

- Insert table 1 here –

2.1 The mouse community: Sacrificed animals

Sally tells me that she needs to retrieve teratoma[10] from mice. She takes me to the animal facility, which is protected by a badge access. She puts a plastic cover over her shoes and walks through a corridor over a sticky blue mat: two layers means to ensure sterility by separating the animal facility from the external environment. As I prepare to follow her, I am loudly called out by a safety officer: I have stepped on the blue mat before putting a cover on my shoes: an apparent safety breach. The safety officer examines my badge suspiciously and is only reassured when Sally tells him that we are together. We then move on to a small chamber that blows air over us for 30 seconds: an additional sterility precaution. We then put on additional protective equipment: another shoe layer, a fully disposable coat, hair cover, gloves and mouth cover. Sally

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[10] Teratoma are types of tumors that are known to be generated by stem cells and pose a safety threat for patients treated with stem cells.

checks if I am not forgetting any piece of equipment. Once fully equipped, we walk to the laboratory's dedicated animal room. She takes a cage occupied by one live mouse and takes it to a dedicated dissection room at the back of the animal room, a small and windowless room with a concrete wall. The room has one bench with a CO2 euthanasia apparatus. She places the cage on the bench, opens it, swiftly takes the mouse out by the tail, places it in the euthanasia cage and closes the lid, looking away as she does so. While the CO2 enters the cage, she prepares the bench: She lays out two sheets of paper and places carefully instruments around the area: tweezers, scissors, tubes in an ice bucket. She says she should have taken her glasses. The last time she operated on a mouse, she poked a cyst. She would not want to have this squirt into her eyes. Before moving on she inquires about my position on animal work. I reassure her that I am here as an observer and that I am not an animal activist. She looks at me and emphasizes gravely: "It's never nice to do it." She tells me one needs to know precisely what it is for and there are things that cannot be done if you do not work with animals. "As long as you don't lose the respect for the animal," she concludes. I ask if she had to think about her position about animal testing when she entered Med Lab. She tells me that she worked with flies in her previous laboratory, "which were no concern at all." At the beginning she was not sure she would want to work with mice: "It's definitely a process, a transition that you make. I went from somebody who said I would never work with mice to somebody who said I can do some procedures with mice [...] You need to know why it has to be done."

For her work on IPS cells, she needs to see if teratoma develop when cells are implanted in a living organism. To do so, she injects human IPS cells in the upper thigh of mice. After a teratoma develops, she retrieves it in order to get "good data for the analysis."It is the second

time she is doing this procedure and she is not fully comfortable with it yet. While talking she has taken the euthanized mouse out of the cage, placed it on paper and is cutting through the thigh tissue. She carefully uncovers an agglomerated mass of cyst and teratoma and cuts the tissue between the mass and the leg. Once the tissues are retrieved, she places them in a tube with a chemical that "fixates" the tissues and conserves them for future analysis. She repeats the operation with the second mass located on the mouse's other leg. "My god, at last!" she exclaims with a sigh of visible relief after securing the two precious masses in a test tube. The whole operation lasted a little less than one hour.

While experienced members seem to withstand longer time working with animals, newcomers often look visibly strained after relatively short time. For less experienced scientists, the emotional toll is more important than the physical toll. She thanks me for staying there with her; it is nice to have someone when doing it. She says the room is also bad for doing this kind of work: it is smallish, bland and windowless. Neighboring rooms are mostly occupied by caged animals and the whole area is located on a windowless floor insulated from the rest of the building by countless safety and sterility measures. Many laboratory members note their unease at working in these spaces, engaging in gruesome work alone or late at night. The news that a young scientist had been killed by a technician in one such facility in another university was seized upon many scientists to discuss the isolating and sometime nightmarish feelings from working in animal facilities.

Sally cleans up the remains and puts them in a bag. We return to the room with the animal cages where she checks the tumors of another mouse. With relief, she notes that the tumor is not large

enough: it can wait a few days. We then walk to the carcass fridge where she puts the remains of the mouse. We then exit the facility, after removing our protective outfits. We take the common building elevator to go back to Med Lab. Sally did not cover the tubes with the teratoma to be sent out for analysis. She tries to look away from her elevator neighbor who is considering with open disgust the two bloody masses in the tubes she carries. For safety reasons, scientists are required to cover animals when circulating outside the laboratory space and asked not to talk with their friends and relative about their work with animals. While not a requirement inside research buildings, scientists also most often hide animals and animal parts when outside animal facilities so as not to face inquisition from outsiders. Modern research facilities can also build private access from the laboratory to the animal facility in order to increase isolation. Animal work is to be performed behind closed and secured doors and wrapped in secrecy: an ethical decision to be dealt with alone or at best with fellow animal workers.

Mouse scientists are generally molecular biologists who seek to understand the molecular and chemical structure characterizing biological life. Much of molecular biology specializes in understanding specific genes: their molecular structure and their effect on organisms. They either purchase or engineer specific strands of rodents and will use these strands as a "standard tool". Typically, scientists will develop (or obtain) a mouse model with additional gene expression or with lower gene expression. Once they have obtained a particular animal model, they study the molecular composition of its tissues and well as its physiological characteristics. Scientists will use whatever formal or informal tools and techniques they can think of in order to study the effects of a particular genetic modification on the organism from observing the behavior of the animal, studying blood samples and comparing the animals' morphologies.

Working with animals requires extensive and diverse skills such as knowing how to engineer, breed and care for live animals, anatomical knowledge as well as precise surgical and dissection skills. Scientists develop such skills gradually, in close training and in apprenticeship relationships with more experienced members. They typically start raising a small colony; learning the basic skills of breeding and caring for animals. Animal sacrifice is the next milestone.

The performance of the first animal sacrifice is always done with a mentor who will teach the learner how to handle the animal, the proper technique for killing the animal (i.e., euthanasia) and the dissection techniques. For instance, the most commonly used euthanasia technique is CO2 asphyxia. A faster way - and one that is defined as more "humane" in the animal use guidelines- for sacrificing mice is to break their necks. This practice is required for newborn mice that are more resistant to CO2. It is voluntary for adult mice because it requires more skill and a closer intimate contact with the animal. Scientists who break the animals' necks are highly praised for their skill that allows them to minimize animal suffering. Techniques, practices and skills aimed at minimizing animal suffering are watched for, sought, encouraged and praised at all levels of the laboratory hierarchy.

One instance of this shared concern was visible during a laboratory meeting. A new PhD student entered the meeting room late after attending the compulsory newcomer animal training. The Laboratory Director commenting on a particular research project ignored the interruption. The student's mentor quietly leaned towards him and asked about the training. The student replied: "So boring!" Overhearing the discussion, the PI interrupted his comments to address the student

in front of the 35 other scientists present in the room. "I hope that you did listen to the instructions" he asked forcefully and then added, referring to the neck-breaking technique for newborn mice: "You need to know how to take care of these *newbies* properly." After a chastising look at the blushing student, the PI moved back to his ongoing discussion of laboratory research.

Taking good care of the animals and minimizing their suffering is something many scientists care about and constantly monitor. They learn how to use various clues such as behavior or smell to assess whether animals are being well treated. They observe other people performing animal work, particularly newcomers. They give them advice on how to better handle the animal. Experienced scientists will interrupt their own work to look over the shoulder of a colleague performing animal work, cringing at improper handling or giving some advice about how to better work with the animal. A belief in a synergy between the welfare of the animal and the quality of the experimental results is widely shared.

Institutional animal care and use committees (IACUCs), created in the 1970's, have taken on a growing role in academic biology and are generally viewed as having improved awareness among scientists about animal welfare. IACUCs emphasize the link between the quality of animal care and the quality of experiments and scientists generally have good working relations with the committee. While scientists might balk at having their research protocols reviewed for approval by IACUCs, they generally appreciate the hands-on approach and tips given by veterinarians and seek to diffuse their knowledge.

Beyond good care for the animal and good euthanasia skills, working with animals requires elaborate anatomical knowledge and good surgical skills. Surgical skills are needed not only to obtain animal tissues for experiments but they also allow scientists to minimize animal suffering and to economize precious animals and animal parts. Good surgical skills are hence both a technical and a moral requirement.

Animal work is generally performed collectively. Scientists train and watch over each other to ensure the proper handling of materials. A scientist with good surgical knowledge might take some time off his own work, however pressing, in order to direct a surgical operation for another laboratory member. Some mouse scientists do research in tandem in order to swap knowledge and tasks related to animal work. While mouse scientists acknowledge the tensions between collaboration and the individual nature of scientific rewards, they generally value collaboration and describe it as something that makes their work enjoyable and efficient.

"ScienceCore" is a team in Med Lab that works primarily with mouse models. The team is a tight knit community, sharing many tasks, discussing knowledge and experimental approaches. They value their collective work and say they feel lucky to be in a collaborative community compared to other two communities (embryology and reprogramming) located in the main laboratory space. One Postdoctoral Fellow describes his working relation with this community of mouse scientists:

> *The 5th floor has been a really good community to talk to people about science. People have very distinct backgrounds but everyone's very engaged in each other's work, which I think is very important. And I think it's an under-*

appreciated part about science, the communal aspects. Shu [...] and I are collaborating right now on some work. And I've also find that to be very fun because you can back each other up, you can bounce things off of each other, and you can do the things that you like to do, and then give away of the things that the other person wants to do but you don't like to do.

Support from the com munity is not only about communicating practical skills and sharing tasks. Scientists also support each other through what they regard as the gruesomeness of mouse work. In a place where jokes are rare, animal work is the only space where some jokes are to be heard.

The following event illustrates how scientists support each other through these tasks. One morning as I arrive in the laboratory, Sharon is working at her bench, scraping pieces of muscle off mice limbs. A PhD student is observing her and following her explanations. Sharon places the limbs in a small bowl and carefully crushes the bones with a small drumstick. There is a distinct bone crushing sound. "It's weird. It's not something you'd expect to see in a lab." She says she does three or four "washes," meaning she will pour PBS, a cleansing solution, crush the bones and liquid, filter the resulting paste into a tube and repeat the process in order to filter out bone particles and keep the bone marrow cells. "This is very exciting" she says ironically. "You crush and wash, crush and wash, crush and wash." After a while she adds "it's kind of fun...crushing...I kind of like the noise....," her words of course contradict her whole body language that is particularly tense and grim. A Postdoctoral Fellow, working at a nearby bench, occasionally leans forward and cracks a few jokes. "So Sharon, what about all the hematopoietic cells in the muscle?" She smiles briefly. He explains to me that he is poking fun at her because

her PhD thesis was about hematopoietic cells retrieved from cat muscle. Sharon is now only keeping the cells in the bone marrow and discarding all the previously precious muscle tissue as waste. Their inside joke was about the irony of keeping or discarding various tissues retrieved at a high cost.

In a laboratory where jokes are rarely heard, animal work is the only area where jokes abound. A scientist finishing up a particularly gruesome task might pause to tell a joke or a fellow scientist will crack a joke to relieve a tense colleague. Jokes are never directed at the animals but rather at the work itself ("gory," "like a horror movie"), at the experiments they are conducting or at those scientists who could not take this type of work. Through jokes, scientists relieve their tension related to working with animals without acknowledging it explicitly. Through jokes, they informally acknowledge the difficulty and the value attributed to this type of work.

As molecular biologists struggle to link their use of precious resources to the outcome of their work, they must connect their immediate, material and bloody experiences to indirect and uncertain social goals such as scientific knowledge and possible medical cures. A postdoctoral student, who says she was a former PETA member acknowledged that the transition from defending animal rights to doing animal work was difficult:

> *I must have struggled at some point. Like when I was very young, I had a membership to PETA, you know. And so PETA is the People for the Ethical Treatment of Animals. [..] I kind of understood from that perspective what abuses people make... But I came around to work with birds first [and] I realized that it's*

important to take advantage of what we learned from animals to help people in the long run. [laughter]

Another Postdoctoral Fellow also describes his decision to work with mice after assessing this type of work against the gains for science:

Everyone has their favorite approaches to what they want to use and I think I've decided that I like using mice. I like using mice because the results that I get, I feel are more meaningful [than results from cell culture]. [...] So, I've decided in my work to focus as much as I can on fast ways of making transgenic models so that I can get quick data out of a very significant disease model. And therefore, I probably spend 50 percent of my time doing mouse-related work, breeding, managing the offspring, crossing mice, doing experiments with the mice that I've crossed. So, I spend a lot of time probably, I would say, two to three hours a day in the mouse room.

Work with animal models is inseparable from ongoing decisions about the ethics of this type of activity, whether it is the initial decision to work with animals or the ongoing decision about how best to work with these animals. The initial decision requires weighing the sacrifice required (the animals and their potential well-being) and the outcome for society (defined as new knowledge or potential cures). Ongoing ethical decisions are made daily as to how best to treat the animal, how to minimize animal use and animal suffering. For the mouse community in Med Lab, whether and how to work with animals are thoughtful and difficult decisions that involve personal ethics as well as technical mastery and collaborative practices. Distinct ethical

understandings and ethical practices related to their experimental model emerge within the mouse community.

2.2. The Stem Cell Community: Useful embryos and sacred patients

The stem cell community faces a different set of ethical questions and practices. Cells are the "working units of life." Stem cell scientists are cell biologists who take cells as their unit of analysis and study their characteristics, structure, metabolism and dynamics (life cycle, division, death). The basic technique used to study cells is cell culture. While thousands of cell types exist in the human and animal body, scientists focus on a restrained number of well known cell lines: adult or embryonic stem cells, cells from healthy or diseased tissues. Tissue culture largely consists of growing cell lines *in-vitro*, outside of an organism, in the controlled environment of the laboratory. Extracted cells are placed small plastic containers called Petri dish or wells. A number of regular operations are then required to maintain the cells in this artificial environment: they are maintained in a culture medium, "fed" regularly, possibly medicated to prevent bacterial infection, "cleaned" by changing their medium and removing the waste produced, placed in additional dishes when they outgrow their first "home" and kept at body temperature in incubators. "Cells are like pets," said a scientist trying to describe her work.

Indeed they are particularly demanding pets. Feeding and changing media must be performed daily for the most fragile cells and each operation lasts one minute per dish (scientists can easily work with 40 or more dishes simultaneously). Placing cells in a new dish is also a lengthy operation. Cell or tissue cultures are performed in dedicated rooms, tissue culture rooms, with dedicated equipment such as biosafety hoods, large vented and isolated workstations aiming at

ensuring aseptic working conditions and preventing cells from being contaminated by researchers and researchers from being contaminated by the cells (which might harbor bacteria or viruses). Cell biologists can easily spend several hours per day performing the minute tasks required for the maintenance of these cells.

In addition, various manipulations are performed in order to study the effect of different environmental interventions: changing feeding rhythms or performing viral infections in order to modify cell's genetic composition. Maintaining tissue culture is uniformly considered by all in the community to be a lengthy, painstaking, highly repetitive and utterly tedious task. A radio is constantly on in the tissue culture room, variously airing music or NPR broadcasts. Some laboratory members put earphones with their own music and, as they would say, "zone out."

Cell biologists work marginally with animals. Many choose cell biology in part because they prefer cell culture to animal work. As a result, the detailed concern over the treatment of animals is less of a practical ethical issue. Their ethical focus relates to the sourcing of human cells used in tissue culture.

Med Lab is located in a building separate from the hospital. It is dedicated to research and patients never pass the secured doors of the building. Patients are however omnipresent in the material arrangement of the laboratory and, apparently, in the minds of the researchers, particularly cell biologists. The laboratory director and 20% of the laboratory members are pediatricians or pediatric instructors. Pediatricians distribute their workday across the hospital and the laboratory. They source the larger part of their research materials from nearby hospitals through agreements to use tissues discarded as medical waste. Scientists negotiate donation

agreements directly with patients and their families for some specific tissues such as diseased tissues from children, surplus embryos from couples undergoing in-vitro fertilization, or various cells issued from diagnosis samples such as produced from amniocenteses.

Scientists share many stories about the cells they are using as well as their qualms. A postdoctoral fellow explained to me that the adult cells he was working with were retrieved from a child with a disease causing bone marrow failure. He negotiated the consent to use the cells directly from the patient's family. He reflects that managing this relationship is difficult since he needs to manage the hopes of the family and yet be careful not to raise their expectations about his potential findings (or lack thereof). In any case, his research is unlikely to yield useful results directly useful to them. His current dilemma is whether or not to visit the patient. He has decided against it for now. He recalls being once confronted by a nurse while recovering some post-surgical patient tissue. When he went to the hospital to pick up the tissues, a nurse was in the room with the discarded tissues. She denied access and refused to hand them to him, saying that this was wrong, telling him, that the patient should at least know about it. He tried to explain that it was "their right;" explaining that the laboratory had an agreement with the hospital allowing scientists to recover post-surgical tissue without obtaining the consent from the donor because such tissues were considered medical waste. After a long discussion, she grudgingly relented.

Stories about cell donations abound in the laboratory as members need to carefully negotiate and manage the symbols attached to donations and as such are confronted by the multiple meanings such materials have for different groups (patients, nurses, scientists and patient families). Even when the material was not directly "donated" to them, scientists usually want to know the origins of the tissues. Most laboratory members, like Peter, working with HeLa cells would discuss the

origin and the ethical debates attached to these cells. When a book was published[11] about the story of HeLa cells (named after the donor, Henrietta Lacks, an African-American women who did not receive any information n or compensation for her donation), a postdoctoral fellow sent a laboratory-wide email about the book, noting that laboratory members should be interested in the "new book about where HeLa cells came from."

Scientists working with human embryonic stem cell (hES cells) models are the most involved in the ethical debates surrounding donation and the "sacred" nature of cells. All claim that their decision to work with human embryos and hES cells was heavily weighed. Most stem cell scientists strongly assert that it is ethical to work with stem cell on the grounds that the human embryos they use would never otherwise be implanted and grow. Some scientists note that, to them, using stem cells is ethically superior to using live animals and say they feel more comfortable ethically with being a cell biologist rather than a mouse biologist. Scientists in the stem cell community agree that the moral justification also comes from the medical promise of stem cells:

> *I have been working with embryonic stem cells for a while and I have heard all the debates. [...] Like a lot of debates go in with like, "Oh, stem cell, abortion, destroying embryos." But they are just a five-days cell balls; it doesn't feel like life to me compared to a running mouse. Even though it's human cells, I still feel*

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[11] *The immortal Life of Henrietta Lacks* by Rebecca Skloot. 2010. New York: Random House.

like they are just cells. And also, if this [work] really benefits how we are going to cure millions of people, then it's totally justifiable.{PhD Student}

Med Lab uses hES cell lines developed and donated by other laboratories but it has also developed its own lines. A team of researchers working with private funding has derived a dozen cell lines from surplus embryos. Scientists emphasize that these are "poor quality embryos", meaning that these embryos have been discarded from the in-vitro fertilization process because their "quality" was deemed insufficient to lead to a successful pregnancy if implanted.

This decision to produce their own lines was both strategic and ethical. As explained by the scientist leading the *embryology* team, this project showed that research-quality cell lines could be derived from embryos that would have been otherwise discarded due to their poor quality. At the same time, this move also led to a publication in a major scientific review, *Nature*. While scientists working with hES cells acknowledge the "sacred nature" of embryos, they generally distance themselves from the "liveliness" of the cells and emphasize that they are putting surplus embryos to good use.

Moving "into the human" is generally justified because of the added relevance of human models for medical care. Unlike molecular biologists who might covertly admit that they can be satisfied with generating basic knowledge, cell biologists are adamant that their research should be "translational," that it should have a clear and direct application to medicine. They view their social responsibility as providing medically relevant knowledge, even if they admit that their work may not necessarily have major or immediate impact due to the complexity of knowledge creation.

2.3. The Reprogramming community: Hazardous viruses

The reprogramming community in Med Lab emerged following the invention in 2007 by a laboratory member of a technique aiming at reprogramming "adult" cells into an embryonic-like state (Induced Pluripotent Stem or iPS cells). Reprogramming allows researchers to obtain stem cell-like models without using human embryos. Many members in this community mentioned that they would not have wanted to work with human embryonic stem cells. Some new members note that they would not have joined the laboratory if the reprogramming technique were not available. Researchers in the reprogramming community distance themselves from the "caring" ethos and generally do not wish to be involved in the ethical defense related to the use of embryos.

Ethical concerns for reprogramming researchers are related primarily to safety issues. Reprogrammed or iPS cells are obtained through the use of a "human-inducible" retrovirus: a virus with the potential to infect human cells and cause cancer. Using a human-inducible virus was viewed as a more efficient way of reprogramming adult cells than the alternative used by competing laboratories. Another laboratory had developed a reprogramming technique with a mouse-inducible virus. Human cells could then be infected by this virus when implanted with a "mouse receptor," a device that made the cells "receptive" to a mouse-inducible virus. The technique was viewed as safer since the mouse virus could not infect humans. But it was also viewed as less efficient.

Scientists however worry about the health issues related to working with the virus and are particularly attentive to the careful and knowledgeable manipulation of the virus. Many safety

features are included in the construction of the virus. The virus "construct" is "incompetent," meaning that once it has infected cells, it cannot reproduce and infect more cells. The virus DNA is also segmented in 3 separate components or "plasmids" that need to first be assembled before the virus can be injected into cells. Scientists first need to make the virus from the three plasmids and then in a separate step inject the virus in cells placed in petri dish. These precautions however do not rule out the possibility that the virus might "recombine" and therefore become "competent" or infectious. Sterility precautions prevent such recombination: the virus must be contained in the culture dish and must not contaminate the work environment where it can potentially expand and recombine. Viral cultures must be directly injected in cells and not be left unused for a long period of time. Infected cells are also carefully monitored and contained.

In the crowded and busy tissue culture room, careful and skilled tissue cultures are of utmost importance. Meticulousness and thrift, already important values in the other communities are of central importance for reprogramming scientists. Researchers doing viral culture, particularly the less experienced ones, are under close scrutiny by their colleagues who assess their hands-on skills and their understanding of sanity practices:

- Do they bleach thoroughly their environment before and after working with virus?
- Do they vent their work station?
- Do they spill materials when they manipulate it?

While many tacit understandings of what constitutes safe practices are often at odds with the official safety guidelines (see Chapter 4), safety is an ongoing concern for the reprogramming community.

3. Material communities, material ethics

Cultural approaches to science have long noted that the production of knowledge is grounded in the particular organization of distinct communities of scientists. Knorr-Cetina (1999) noted that scientists are organized in epistemic communities: communities with distinct local cultures that shape the construction of knowledge. Experimental materials have increasingly been viewed as shaping such communities (Kohler, 1994; Rheinberger, 1997) and thus helps shape the boundaries between these communities (Galison, 1997). By working with distinct and complex experimental materials, whether bubble-chambers, flies or animal models, scientists derive specific modes of knowing and working.

As scientists engage with specific materials, their properties, symbols and social ascriptions, they derive a distinct work ethic: what it means to work and to work well with such materials. While each community has developed its particular ethical concerns –often in opposition to other communities - some ethical practices are common across communities and define what it means to be a "good scientist."

Sacred objects and ethical practice: Evaluating worth through connections

In Med Lab, the sourcing of the different materials — embryos and other human and animal cells — is justified in the light of the contribution it makes to science. Scientists mobilize the different rhetorics of care or science in order to justify different uses of materials. Animals are "sacrificed" for science, patient cells are treated as a "sacred gift" to science and embryos are "useful" in light of their possible contribution to science and medicine. For scientists, the instrumental use of these materials is not what objectifies them or negates their worth but rather

what constitutes their worth. By connecting these objects to science, scientists redefine their worth. They are no longer "sacred" on religious grounds but rather "sacred" on scientific grounds. The translation of the worth of these objects undergirds the material ethic of Med Lab.

Thrift as moral. Experiments consume large amounts of materials before yielding –when one is a lucky – a small piece of knowledge. Failed experiments are depressing for scientists not only for the time and personal investment lost but also for the materials lost in the process. As one scientist working in another laboratory once told me: "When you mess up an experiment with chemicals, it's not a problem, you just waste chemicals. But when you mess up an experiment with animals, it's not good… That's why people train you. Otherwise I'd be shot through with nightmares."

Wasting materials is a constant concern for many scientists. While waste due to experiments not yielding expected results is considered depressing, waste due to mishandling can be distressing, particularly for newcomers still honing their practical skills. Many scientists get angry when animal parts are lost due to poor dissection skills. Thrift and proper handling is strongly encouraged by the senior members of the laboratory but they can be supportive if waste is accidental. For instance, during one animal sacrifice, a member exited the lab for a moment to place dissected animal brains in nitrogen. When he returned, he was visibly distraught and told his colleagues: "I have bad news, the brains are shattered." A postdoctoral fellow says that it might have come from putting them into nitrogen. Another fellow offered to use the brains for her experiments: "That's fine, it should not matter for the protein extracts. That's fine … whatever…"

Experienced scientists (researchers and technicians alike) will not only be thrifty with biological materials but also with chemicals, radioactive materials and even things as cheap and innocuous as water. One needs to be thrifty in order to save on expensive materials (antibodies, rare chemicals or expensive devices) or materials in short supplies (shared machineries and equipment). Thrift is thought to beget "cleaner" results, results unpolluted by spilled or overflowing water or chemicals, approximate doses and measurements or other unnecessary pollutants. Thrift also implies control over the working environment and safety. In the case of radioactive isotopes, less material used means less material potentially spilled or left unaccounted for. In short, thrift is the hallmark of the good, professional scientist: someone who produces "clean results," controls his work environment and does not waste precious materials.

4. Division of work

Besides its material communities, the laboratory is divided along hierarchical lines. Half of laboratory members are technicians who are employed by the university. The other half is constituted by PhD students and postdoctoral fellows who are recruited by fellowships.

Postdoctoral Fellows: On the cusp of science

Postdoctoral fellows have the most extensive knowledge and experience of the working materials, models and technologies. They are experts of large domains they have generally helped to build. A typical postdoctoral position can last up to eight years. Postdoctoral fellows reach their position generally after having completed a PhD in a different laboratory.

Postdoctoral fellows strongly identify with the scientific profession and most are dedicated to maintaining and promulgating scientific norms. This is particularly true for the most senior

postdoctoral students. Breadth and depth of knowledge is paramount because they are gearing up to set up their own laboratory that will rely largely on their expertise. A new laboratory director must set up the material equipment, models, instruments and techniques for the lab according to the area of research he or she will specialize in and establish the theoretical and practical knowledge needed to operate the infrastructure.

In the knowledge economy of laboratories, postdoctoral students are the net providers of scientific knowledge. Technicians are mostly trained by postdoctoral fellows and PhD students rely on them to get started on their own experimental work. Because of their tenure in the lab, postdoctoral fellows have the most knowledge of typical and unusual protocols, techniques or models. This makes them largely independent in the conduct of experimental work and because they are at the highest echelon in the laboratory, just below the laboratory director, they respond little to authority. Moreover, as the main mentors and providers of knowledge they uphold what they see as the professional standards in the conduct of experiments.

PhD students and technicians rely on postdoctoral fellows for training and mentoring. Such training and mentoring is the occasion for communicating traditional scientific norms. Training generally involves detailing the characteristics of the materials handled, the theories attached to these materials, and the detailed ways of handling them to optimize both experimental results and laboratory safety. For experienced scientists, safety practices are to be deduced from the knowledge of the working materials; this knowledge is gained through apprenticeship, is inseparable from the general scientific knowledge and is considered to be more accurate than bureaucratic rules. Being in charge of one's own safety is also a privilege gained over time as

one masters scientific knowledge and practices. This systematic reliance on personal knowledge both allows for constant assessment of the workplace but also for the maintenance and transmission of this knowledge. From the standpoint of laboratory members, the personal, tacit and detailed knowledge of their working materials leads to the most appropriate ways to "perform safety." It is an approach however that often needs to be defended.

Technicians: the promise of science

Technicians enter the laboratory after earning an undergraduate degree (usually in Biology) and work there from two to five years. They generally move on either to graduate school (a position as a laboratory technician is often considered as a first step in a career as a scientist or physician) or to a more permanent and better paying position in private industry (where a prior position as a university laboratory technician is a highly regarded experience). A few technicians move to permanent positions in academic laboratories as technical experts on particular tasks, technologies or types of analyses. The apprentice, journeyman and master career model does not apply to them. Their laboratory training is more cursory and fragmented than that of a PhD student. While a student largely bears the responsibility for his or her productivity, technicians are employed by the university and are supposed to contribute to the work of the laboratory. Whatever scientific knowledge they gain is a benefit but not the direct goal of their position. Their job is to learn to perform the various routines and protocols that are the basis of experiments: various forms of cell culture, chemical solution preparation, blots, gel runs or animal work.

Technicians are generally employed with the money obtained by a specific grant and are consequently attached to the postdoctoral fellow who obtained the grant or whose work led to the grant. Their role consists in relieving the postdoctoral fellows of the most routine and generally dirty tasks of experimental work such as feeding cells, handling viruses, mixing chemicals or performing animal work. Some technicians specialize in tasks involving specific skills such as the tissue dissection, culture of delicate cells or various type of animal work. Technicians specialize in the "doing of science," their exposure to the theories of science remains fragmented at best and primarily centered on the routine tasks they perform in the laboratory. In addition, technician perform administrative and maintenance tasks: inventory management (tracking, ordering, reasserting), cleaning of shared areas and materials (fridges, incubators, safety hoods, shared workstations). One postdoctoral student describes the rigid hierarchy and the traditional relation of dependence between scientist and technician. She justifies this strict hierarchy by the needs of science (the need of the experimental work):

> *Matt is really technical staff as opposed to somebody whose time in this lab is really about career development. Although I have kept a bit of an eye [on his development] because I know he wants to go on to grad school. For the technical support, one thing that I learned in terms of their productivity, and them being able to do the sorts of thing you need for them to do, one thing I have learned between my previous tech and Matt is to be extremely clear about your expectations. And I think it's better to start with a high expectation than to start with low and then try to tilt, because if people know the requirement of the job A, B and C. upfront when you ask those things of them, then they're pretty much like,*

well, that's the job and that's what I was told. Whereas, if like six months down the road, you suddenly say, "well now, I need you to be here at 7 in the morning or whatever, because that's what the experiment requires" that doesn't tend to go over so well.

PhD Students: In-betweeners

PhD students typically enter the laboratory as rotation students. After rotating in several laboratories, they decide which one is most appropriate for them to pursue their research agenda. They are not employed by the laboratory and are not part of the formal hierarchy. They insert themselves in the social exchange of research. They join a lab to learn the theory and the practical means to take the theory further. They are less in the realm of doing than learning. They will typically spend 6 months to one year primarily observing and reading. Their relative independence comes with the social pressure to appear knowledgeable and competent within the lab and able to learn the practice of science without being a burden to the more experienced scientists. As one PhD student summarized: "You're walking a delicate line between being in someone's way and trying to learn something."

Students not only need to learn vicariously but also need to focus on knowledge elements that will make them valuable members of the laboratory. In order to insert themselves in the knowledge exchange of the laboratory, PhD students need to build their expertise and legitimacy as researchers. PhD students are given more theoretical and extensive training on experimental practices than technicians but they also are under more pressure to conform to the norms of the scientific profession. Specifically, they need to learn theoretical and practical pieces of

knowledge that they will be able to "trade" against other pieces of knowledge with peer scientists. They must learn the tricks of the trade but also conform to the norms of the scientific profession. Students need to appear competent in order to keep benefitting from the teachings of experienced scientists and move up the traditional ladder from "journeymen" to "apprentice" to "master."

Displays of competency are often understood by students as adopting and displaying the informal norms of the laboratory. As newcomers, PhD students and newly hired technicians are generally both intimidated by the amount of knowledge to gain, the strict hierarchy of the laboratory grounded in the mastery of scientific knowledge, and the often hazardous nature of experimental work. However PhD students are under greater pressure to conform to scientific norms than technicians since their career depends on their eventual assimilation within the scientific community. Technicians are located in laboratories but have a work contract that locates them at the boundary between governance by the organization and governance by the scientific profession. PhD students are squarely located within the professional community.

The traditional order of academic laboratories, based on knowledge and expertise reinforces the dominance of senior researchers (primarily postdoctoral fellows) over more junior researchers (PhD students, junior postdoctoral fellows) with technicians being both subjected to the professional laboratory hierarchy and to the bureaucratic governance of the organization that employs them.

From laboratory life to factory life

Team size in biology has increased during the past decade along with research teams in science and engineering generally (Wuchty, Jones, & Uzzi, 2007). We are now in an era of Big Science. This increase has been accompanied by a rise in cross-laboratory collaborations as well as an increase in the size and diversity of laboratory teams. Jones (2009) argues that the burden of learning has increased with the increase in the stock of knowledge, leading to a rise in specialization. Scientific fields now have become more specialized with longer doctoral and postdoctoral tenures.

Epistemic communities that only occasionally related to one another in the past now interact within the same laboratory space. Scientists who traditionally worked independently now contend with a more structured environment where regulation encroaches on traditional professional practices. These trends have increased the hierarchical and skill-based division of labor as well as brought bureaucratic practices into spaces traditionally previously dominated by professional norms of autonomy and collegiality. The freewheeling laboratory life described by Latour and Woolgar (1979) has now come to resemble, in many ways, factory life. Med Lab with its relatively large size, important hierarchical stratification, and coexistence of various experimental communities is representative of this new organization.

As laboratories – particularly in biology – come to increasingly confront contested conceptions of worth attached to their working materials and practices, these internal boundaries become ever more salient. Med Lab is a space of deep ethical questioning. In their everyday work, laboratory members engage with ethical questions regarding both the abstract ideals (the mission of science, the social responsibility of scientists) and their everyday work (how to engage with living or potent and highly symbolic materials, how to minimize animal suffering, how to respect patients

and "sacred" materials, and how to ensure personal and collective safety). Yet these concerns diverge along hierarchical and horizontal lines leading to ethical heterogeneity.

Table 1: Three communities in Med Lab and their work ethic

	Mouse community	Stem Cell community	Reprogramming community
Experimental Models	Mice	hES cells	iPS cells
Expertise	Molecular biology	Cell biology	Cell biology Genetic engineering
Main activity	Animal work	Tissue culture	Tissue culture Virus work
Sourcing	Animal providers and animal facility	IVF clinics (Embryos) Other laboratories (hES cell lines) Mice (Animal ES cell lines)	Hospitals Private providers
Work style	Informal Collective	Meticulous Individual	Meticulous Individual
Work ethic	Caring for animals Collaboration Thrift Knowledge creation	Contribution to medicine (Translational science) Meticulous Thrift Patient-centered	Tolerance Safety knowledge Thrift Meticulous

CHAPTER 4: CONTENTIOUS SAFETY

In 2008, a young technician at UCLA was transferring a tablespoon of t-butyl lithium, a chemical that ignites on contact with air. She somehow spilled some on her sweatshirt which instantly ignited. She died 18 days later from her burns. When the Occupational Health and Safety Agency (OSHA) investigated the accident, the diagnosis was clear: the technician had not been wearing her laboratory coat and could not locate the laboratory shower. The second level of diagnosis reported was that the laboratory did not enforce safety practices such as constantly wearing a laboratory coat. On May 4, the California Division of OSHA cited the university for multiple "serious"—i.e., potentially life-threatening—violations, including its inability to show that the technician had been trained to handle the dangerous substance and the lack of proper protective attire. The university was imposed with $31,875 in fines. For scientists, the diagnosis was equally clear: The technician did not know what she was working with. She had not been properly trained or mentored by fellow scientists. The story joined the seemingly endless stock of other safety incidents that scientists narrate to one another: tubes spinning out of an improperly locked centrifuge, radioactive materials spilled by a careless scientist and tracked across the laboratory by ants (of all things), Hydrofluoric acid, a chemical lethal on contact with skin, spilled on the interstice between glove and laboratory coat, etc.

The UCLA case exemplifies the contest between the professional and the bureaucratic approach to safety: two competing diagnostics (a failure of compliance with legal regulation or a failure of scientific knowledge) and two treatments (punishing non-compliance or increasing scientific

knowledge and knowledge sharing) are proposed. The core of the contest however is not solely the control of a particular jurisdiction or a claim of expertise but, more importantly, a contest over how to perform safety. As two communities lay claim to expertise over the performance of safety, safety itself becomes contentious.

In this chapter, I detail the competing approaches to safety in Med Lab. As illustrated by the UCLA case, different conceptions of what constitutes safety coexist in the lab: a scientific and a regulatory approach. Safety issues are not just settled at the boundary between competing occupations but constitute ongoing contests among scientists (See table 1 for a summary of the two safety frames within Med Lab). By ongoingly negotiating between two modes of doing safety, Med Lab scientists craft new safety practices. These new practices allow them to forge a better safety in practice. While these new practices reinforce scientists' authority over safety, they also allow regulatory safety to penetrate the space the laboratory. I argue that the tolerance of different ways of doing safety allow scientific to problematize safety. Safety is indeed only improved when contests abound. Indeed breakdowns in laboratory safety occurred in one areas in the Med Lab where scientists did not actively contend about how best to perform safety: radiation work.

1. The professional approach to safety

I feel pretty safe. We do have some chemicals that you certainly won't want to drink because they would be toxic obviously. I think it's just you're trained and we have chemical fume hoods so if it's something really noxious... So, for example, if you splashed a little Phenol on yourself you would get burned, right? So when

you work with this thing, you work with it in a fume hood so you're not inhaling it and you wear gloves and you're really careful not to splash it around. I'm pretty conscientious about that. You make sure you throw it away in the appropriate waste container and that's what you do. I don't really worry about it too much but I know enough about it to know that I wouldn't set it up on my bench and not [work with it all day] because the fumes would probably make me sick. Obviously, if I was working with an acid or something, it would be a similar sort of thing. So yeah, I don't worry about the chemicals because I pretty much know if something's toxic and when I should wear gloves. {Postdoctoral Fellow}

When you are making [Agarose] gels and you pour Ethidium Bromide in and it's still hot, you want to be very careful, because the Ethidium Bromide can vaporize, and then it's more harmful. So now I try to not be anywhere near it when I add Ethidium Bromide, and then I just leave for a while. Whether everyone does it or not ...It's one of those things where everyone has to do everything to make it completely safe and you doing little things doesn't necessarily do much.{PhD Student}

I also found it very strange how one of the steps in making virus is to concentrate it, and the centrifuge we use to do that is at the end of the hall. And so what you do is you get everything ready in the tubes, and then you take all your virus stuff off appropriately, and then you grab that and walk down the hall. And in theory, the virus is in a canister with a tight lid, and you are holding a rack that's holding

those tubes. So in theory, you are protected in some way, but I still just feel weird about it. And then you are walking all the way down the hall and all *the way back. I think we are definitely getting more lax compared to what it used to be, which worries me a little bit. {PhD Student}*

A constant question that scientists face is how to know that they are safe, how to feel safe. As these quotes illustrate, for scientists, safety is derived from the detailed knowledge of their environment: their working materials, the material layout of the laboratory and the human layout of the laboratory (who works with what and how, who knows what). Their biggest concern – as illustrated in quotes 2 and 3 – is not whether they know their materials but whether they can trust their co-workers: Will everyone adopt the same precautions, will they foster a safe environment, and will co-workers avoid them when carrying hazardous materials down the busy hall? When describing whether they are safe, scientists generally comment on other's behaviors: they note whether or not "people know what they are doing here" or whether they are "lax," "sloppy" or "lack attention to hygiene." Being safe and ensuring safety in scientific laboratories is a deeply collective endeavor centered on assessing whether others are safe and signaling to others that one is safe, and hence trustworthy.

Embodied safety

Embodied practices are a major way by which scientists seek to ensure their own safety and the safety of their working environment. Scientists use embodied practices as smell and bodily awareness to assess and control the working environment.

Scientists continually assess their environment through smell. They scan their environment for various smells that would reveal someone working with some "potent" materials such as Phenol or Ethidium Bromide. They identify the products through their smell and will remark if a smell stems from some toxic product that might have been handled with insufficient care. For instance, one day a technician sprayed Isopropanol on a machine after using it. Isopropanol is a highly flammable compound that has the potential to explode on contact with air. A strong smell emerged from the machine. The scientist working at the bay behind the machine came to the group of technicians saying in an aggravated tone: "Did you guys just spay alcohol?" The technician who had just sprayed the machine tried to adopt a relaxed attitude: "Yeah, did you get spayed?" "No, I just *smelled* it very strongly," responded the scientist reproachfully. This prompted the technician to grudgingly admit: "Yeah it might be Isopropanol" The scientist had used smell to both detect the material and the inappropriate quantity used that posed a safety hazard in the laboratory. She also insisted that the perpetrator admit his safety breach.

Smell can also serve to identify a misplaced product or a solution placed in an unlabelled container. Smell also serves as a way to distinguish what might be harmful or not. As a general rule, scientists use masks when working with compounds that have an intense smell. Through smell, scientists learn to rely on their deep knowledge of materials rather than on the labels. But they also assess whether co-workers are keeping their environment safe. Smells signal that a co-worker might not be working in safe conditions. Deciphering smells is the laboratory is therefore a critical safety skill that scientists need to learn.

A core aspect of laboratory safety is to keep all surfaces clear of potentially harmful materials such as chemicals, biomaterials or radioactive isotopes. This is particularly challenging as most materials can be harmful without necessarily being visible. In addition, containment and segregation of products is inherently self-defeating: to avoid tracking materials from surface to surface, scientists would need to change gloves each time they touch a different surface. When daily tasks involve manipulating products at one bench, retrieving ice in common storage areas, using common incubators, fridges, centrifuges, biosafety hoods, microscopes, analysis machines, reagents, doors and elevators, and so on, the possibility that each person is ensuring proper containment between each task is visibly unrealistic. As a result workers have developed the habit of minimizing surface and body contact by keeping their hands to themselves (such as crossing their arms or keeping their hands alongside their bodies or avoiding the touch of a door if someone has already opened it). For a scientist, minimizing protective equipment to promote bodily awareness is "the best way to handle things."

Thrift as safe practice

Shannon sits at her workstation: She takes a culture dish and places small amounts of a saline solution into it with a pipette. The solution forms eight tiny "bubbles" in the dish. She places mice embryos in each bubble and starts cutting them up with the needle of a syringe. The bubbles become filled with blood. Once she has removed the sack, she prepares a new dish with 8 new bubbles and places the embryos in the new "clean" bubbles. She throws the first dish in the sharps bin. Matt works with batches of 3 embryos. He has filled his culture plate with saline solution. When he removes the sacs, the solution also becomes tainted with blood and he takes a

new dish that he fills anew with solution. After transferring the embryos to a new dish, he throws the old one, still full of solution in the bin. I ask why they do this operation differently. Matt acknowledges that Shannon might have taught him to do it her way and he forgot and developed his own way of doing it. Shannon then explains forcefully and at length why she chose to perform the routine her way. She tells me she can repeatedly wash the embryos by vacuuming the liquid with a pipette and reinserting clean solution while keeping the same culture dish. Moreover the debris stays contained, and does not crowd the other embryos. She also disposed less used solution, thereby diminishing contamination risk.

We have seen that thrift is a hallmark of good scientific work. Experienced scientists always use the minimum quantity of a material needed for an experiment, even if it is as benign, cheap and easy to obtain as a saline solution since precise use of any material allows for better experimental performance and diminished risk of contamination. Thrift also requires skills and knowledge as one needs to master the minimum quantities needed to perform an experimental step and to manipulate instruments with precision. But thrift is also useful when working hazardous materials or materials that are rare such as expensive materials or materials that are retrieved from animals. Thrift is the hallmark of the safe scientist. Hence thrift combines both scientific performance and safety.

While scientists would not describe themselves or others as thrifty, the notion that thrift is desirable and that thrifty scientists are admired is also obvious when considered the use of the opposite term: the sloppy scientist. The common view in the lab is that the sloppy scientist does not handle animals well and causes suffering. The sloppy scientist does not handle materials well

and risks spills and contamination. Finally the sloppy scientist is likely to generate sloppy results: spilled materials or mishandled experimental step might generate unclear or false results.

The following comment on a radiation incident illustrates how the possibility that some laboratory members might be sloppy can override the immediate concerns of having safety incidents:

> *[The radioactive spill] made me upset.... The radioisotope P32 has a half life of 14.7 days. The amounts used are low, the radioactivity is low. Direct skin contact can cause - at most - a burn. But the situation in which it was used ... while I was concerned about the radioactivity, I was more concerned by the lack of attention to hygiene. If that person ends up being sloppy... I am very intolerant to of people making messes for others to clean {Will, Senior Scientist}.*

Thrift is a core value. It is associated with skill, knowledge, precision, clarity and trustworthiness. It is a core aspect of safety and is at the same time deeply associated with professional practice. Thrift is constantly encouraged and sloppiness strongly shamed and condemned.

Signaling and avoidance tactics

One of the biggest challenge of knowing that one is safe stems from understanding one's co-workers' behavior and assessing whether their behavior is safe. Scientists deal with this issue by constantly signaling to one another the types of materials or hazards they are working with and whether they should be avoided or not. When experienced postdoctoral fellows put on a

laboratory coat, they signal that they are working with a particular hazard that requires added protection and other members will tend to avoid them. As a laboratory member comments about one experienced postdoctoral fellow: "For instance, I never see Sam wearing his lab coat, except when he is working with radioactivity...So then I know." Similarly scientists working with potent chemicals or biohazards such as viruses will take the additional precaution of wearing their laboratory coat and thereby signaling to others that they are working on a particular hazard. This signaling can be preceded by a formal announcement during laboratory meetings when new hazards are introduced. For instance, one postdoctoral fellow formally announced that he had decided to work with Hydrofluoric acid, a compound that can be lethal on contact. He showed the first response kit designed to deal with a potential poisoning and described the procedure to follow. Signaling is a particularly detailed, case-by-case approach.

In response to signaling, laboratory members also enact careful avoidance tactics. Members wearing laboratory coats are more carefully scrutinized and avoided when they walk about in the laboratory. In the tissue culture room, a particularly small room where scientists work with an array of chemicals and biomaterials, attention to and avoidance of one another is particularly heightened and has become a self-conscious choreography that scientists themselves refer to as the "tissue culture dance." Before standing up from their work station, scientists scan their environment, pick up their culture plates and other working materials and hold them high in the air so that colleagues can see and anticipate their moves and move their materials out of the way of others. One work station is dedicated to work with retroviruses with highly infectious potential. Scientists always announce to co-workers that they are about to handle retrovirus before beginning their task. This announcement was initially meant to request that co-workers

put on a laboratory coat as an additional layer of protection. While co-workers almost never heed the request to put on a laboratory coat, the signal is nonetheless always uttered and newcomers are at the same time dutifully reminded that the signal means hazardous materials are being used and extra-caution is needed when going about the tissue culture room. If the signal is omitted, colleagues might enquire whether the person sitting at the retrovirus workstation is indeed going to work with retrovirus or not.

Constant risk and ongoing attention

For scientists, danger is a constant threat, more or less visible, more or less under one's own control, more or less dependent upon one's colleagues' behavior. Danger is low when one is working with materials straightforwardly identified as harmless such as ice or physiological fluid. Danger awareness rises when one goes to the cell culture room where more "potent" materials are handled or to the hazardous waste storage area. Laboratory members tend to tense up slightly; they observe their colleagues, what they do, where they sit, what they wear. When working at their bench, even with relatively innocuous materials they remain attentive to their environment: where their colleagues stand, what they do and above all what they wear (gloves, lab coats, safety glasses). Scientists wearing a lab coat are more carefully avoided, suspect smells are constantly investigated and the source of it often spoken to and shamed. In this way, safety is construed as an ongoing and collective effort to minimize contact and contamination. Scientists view safety as hinging not on their ability to protect themselves but on their ability to enforce safe practices on all co-workers.

Learning the scientific way

Newcomers learn safe practices through on-the-job training and mentoring by experienced scientists. This training involves detailed explanations of the characteristic, effects and health implications of the materials used in the lab and the best way to handle them safely according to the norms of scientific work. Newcomers are initially only allowed to observe and listen to instructions without touching working materials. One PhD student summarizes her first few months in the laboratory: "When you are a rotation student, you are assigned to a postdoc and that postdoc is always with you, helping you, watching you, correcting you, reminding you that you need to do this before this... it goes like this, apprentice, journeyman and master model." Newcomers are rarely given protective equipment but are constantly given instructions about avoiding all contact with materials (be it the experimental materials or the laboratory infrastructure). A recurring request is "do not touch anything." Newcomers are also carefully socialized into avoiding contact with co-workers by paying attention to who is around them and who is carrying what. In this phase, experienced scientists are careful to minimize any kind of contact for observers: they rarely ask them to carry materials or, if they do, they will hold the doors open for them. Once a new member becomes more knowledgeable, they are given small repetitive tasks such as cell culture, reagent preparation. Here again, attention is given to embodied practice. Postdoctoral fellows observe and emphasize practices aimed at minimizing the tracking of materials from one space to another by comments such as "watch your hands," "you need to bleach this," "I change my gloves each time I exit this room," "I avoid touching the bench surface with my hands," "you should avoid breathing this." Careful judgments are made about a person's skillfulness at manipulating experimental materials. Good embodied skills also allow for the precise performance of experimental work and obtaining "clean results" – results

that are not blurred by external contamination or by unwanted mixing of the various solutions used in experimental steps. From this perspective, the needs of science and safety are tightly coupled while being constantly monitored and enforced.

The mastering of these embodied skills is one of the most admired qualities of a researcher. However, laboratory members acknowledge that gaining these skills is both difficult and a work in progress. Occasional mishandlings are however tolerated. Incidents occurring as a result of the mishandling of materials are rarely shamed. On the contrary, laboratory members will go to great lengths to save the face of perpetrators. While numerous incidents are narrated in order to foster safe practices, the name of the perpetrator is generally kept secret. Safety incidents such as spills or cuts generally call for the intervention of safety officers. However most scientists will deliberate about calling such officers, since the intervention of a "hazmat team" might generate unwanted visibility for the laboratory and expose the perpetrator of the incidents. The preferred option is to attempt an internal clean-up and have a private discussion with the person responsible for the incident. Many laboratory members note their dread of causing an incident — less because of the threat it might pose to them or co-workers, and more because of the damage it would cause to their reputation as scientists. However when such mishandlings occur, co-workers go to great lengths to ignore such mishandlings. The following event illustrates this well. One senior postdoctoral fellow was performing viral work in the hood dedicated to human-inducible retrovirus. At the end of her task, she picked up her samples and walked towards the exit of the tissue culture room. As she walked past three other laboratory members, she dropped her samples that fell on the floor with a large crash, causing a small panic among the group of three scientists conversing nearby. The three scientists jumped out of the way and the other

laboratory members working in the room all swiftly interrupted their work to explore the floor. As soon as they had visually established that none of the vials had broken and that contaminated materials had not spread on the floor, they all returned to their work without comment, ignoring the perpetrator who swiftly picked up the samples. Gaining experimental skills is an ongoing effort, reinforced by respecting the learner's efforts and admiring those who attain mastery of such skills.

Consistent with this model, new students do not own protective equipment (lab coat, glasses, radiation badge). This makes them dependent on their mentor for protective practices. As explained by a student: "During rotations you don't *have* lab coats. (...) you don't have that option unless someone tells you 'this is dangerous, here, I'm gonna lend you a lab coat.' So it's not your *prerogative* to wear." The ability to master protection, as well as general scientific knowledge is to be achieved with experience and membership amongst the profession of scientists. As new members become socialized into the scientific profession they become socialized into specific norms regarding safety. Such norms are perceived generally as incompatible with the norms promoted by the regulatory apparatus.

In this approach, safety is learned through scientific education (learning the characteristics of materials) and extensive apprenticeship, mentoring and socialization. This mode of learning reinforces the notion that safety is inseparable from science and that scientists are the sole experts. The scientific approach allows scientists to remain in control of their environment and to enact a detailed and collective approach to safety. At the same time, the traditional system makes newcomers dependent upon the knowledge of senior scientists. This social and material

organization of laboratory work subjects junior scientists (mostly PhD students and technicians) to the superior craft and knowledge of senior scientists (primarily postdoctoral fellows).

The professional approach to safety is deeply linked to professional knowledge. It depends on the intimate knowledge of working materials, gained though many years of training and practice. It is often obscure for non-scientists (safety officers, technicians) and newcomers (new PhD students, more experienced scientists changing topics and experimental materials). This professional approach to safety also renders newcomers dependent upon expert scientists.

Safety — or, as scientists see it, the collective ability to avoid contact between bodies and any substance that could cause changes to their biology — is a central concern, constantly conveyed and reinforced in the course of everyday work. At the same time, these professional safety practices often take a form that renders safety knowledge arcane and non-scientists dependent upon expert scientists.

Attitudes towards bureaucratic safety rules

Scientists trained in the scientific approach to safety often view the practices promoted by safety regulation as, at best, inferior to their own practices and, at worst, counterproductive. One common complaint is that the lack of knowledge held by safety officers leads them to follow and enforce rules rigidly. To scientists, this rigid application prevents a more adequate approach to safety driven by expert knowledge. One anecdote recounted by one scientist, illustrates their frustration:

When I was at [hospital], we had a chemical spill of Sodium Hydroxide. It was from a large [container] that had a diluted solution of sodium hydroxide. I think it was .4 normal. So it was still alkaline, it was still caustic, but it wasn't like people in bunny suits, hazmat suits had to come, but there was quite a bit of it over the floor. [...] I called the safety office and they freaked out. I tried to talk to them about it but what they were doing was they were reading the safety materials datasheet for Sodium Hydroxide which includes all of the potential hazards and all of these things, but it really gives no guidance on concentration. So they were acting as though there was concentrated source of highly purified source of sodium hydroxide that was loose in the hospital and they came with their suits on and they spread this powder around that coated everything in the laboratory that made everyone cough and sneeze. [...] it made a situation much worse than what was there before and the part that they seemed very immune to [hearing] was that it was a very very dilute solution and that their response was overly enthusiastic. And I remember telling him: 'If you put one drop of sodium hydroxide in the ocean, the ocean would become a dilute solution of sodium hydroxide, wouldn't it!' But that's hardly the same as spilling a 50 gallon of 12 normal or whatever the maximum is of sodium hydroxide in the middle of the hospital. But he did not say anything and so I was very frustrated.

Scientists also consider bureaucratic safety rules as competing with self-reliance by imposing technologies that impede professional means of ensuring safety. One postdoctoral fellow

explained how the safety layout of a room for radiation work prevented her from remaining in control of her exposure to radiation:

> *I was especially concerned the last time I was pregnant, because I irradiate mice regularly for bone marrow transplantation, and I was setting up these experiments where I was irradiating mice, at least once a week. And it occurred to me that, well, I've got my one little radiation badge here that they monitor every three months. And I thought, maybe I should just, out of curiosity's sake, take the Geiger counter down there and just go ahead and irradiate my mice and measure what the radiation level is with the Geiger counter. I had been told by the radiation safety people here that you just stay in the room, it's fine, there's no radiation, you're safe, you have your badge. Now this is in stark contrast to my experience in my doctoral lab, where the same equipment was treated with horror. It was the same machine, but when you went in there to radiate your mice, you push go and you run out the door. And you close the door, and it's locked [...] When I saw [the equipment of this lab] I assumed that they would have you leave the room but they make it difficult for you to leave the room here. So when I was pregnant, I started leaving the room but it was a big burden and I had finally taken the hand-held radiator counter there. And again, it was screaming so it was consistent with the same equipment in my doctoral lab.*

Safety regulation penetrates academic science slowly in the form of ongoing new rules, monitoring programs, and safety artifacts such as protective equipments, architectural devices or

monitoring devices. This array of materials and rules gradually redesigns the material arrangement of the laboratory and the practices related to it. Areas where scientists once navigated freely become secured with mechanisms forcing scientists to wear additional equipment before entering or exiting different areas. Routine gestures and tasks are modified to accommodate complex waste disposal systems. Highly repetitive tasks such as those involved in tissue culture require, not only mastering the complex and embodied practices of manipulating dishes, pipettes and tubes simultaneously, but also remembering where and how to dispose of supplies such as sharps, liquids, instruments to be sterilized or biological materials (each of which have a specific disposable stream and procedure). Such seemingly small additions become less than mundane when one can spend up to six hours per day performing routine procedures involving these materials. Gestures become multiplied in a place where work is already intensively manual and routine and where competition dictates a constant search for reducing experimental steps. Finally, safety systems also redesign and reclaim the use of equipment that was once the privilege of scientists. The used laboratory coats, vented hoods, laboratory benches that were previously under the sole authority of scientists (and symbolically were part of their status), are now claimed by the safety offices as part of their jurisdiction.

As safety systems gradually redesign scientific space and practice, they also encroach upon and reshape scientific knowledge. Tasks previously dictated by the scientists' craft and learned through apprenticeship are now interspersed with regulatory procedures. Scientists will often interrupt their flow of work to wonder where to pour radioactive liquid (4 waste streams), whether a particular bleach can be poured down the drain, or how to dispose of a particular chemical (the storage area for chemicals can have up to 10 bottles and displays a long list of

interactions between different chemicals). More often than not, laboratory members need to ask co-workers or call the safety officers before disposing of their materials given that disposal rules change fairly rapidly over time, can vary from one university to another, and are generally unknown by first time users. Through the introduction of technology and non-scientific personnel, regulatory safety introduces rigidity in the practice of safety. Such rigidity is not just perceived as unproductive by the scientists but also viewed as detrimental to the performance of safety.

The detrimental aspect of the rigid application of regulatory safety is well illustrated by the use of Personal Protective Equipment (PPE). Scientists worry about co-workers constantly wearing protective equipment as these workers might then pay less attention to embodied practices, be less concerned with personal safety, and hence less inclined to avoid surface contact and more likely to spread materials around the laboratory. For instance, someone wearing gloves may no longer worry about contaminating himself or herself and thus be more likely to touch surfaces and increase surface contamination risk. Similarly, a person wearing a lab coat may worry less about handling hazardous materials carefully and be more likely to pose a greater hazard for his or her colleagues than someone without a coat who may focus more on the careful handling of materials. Someone constantly wearing a laboratory coat eschews the case-by-case signaling practices and impedes co-workers's assessments of whether he or she is working with materials requiring extra safety precaution or he is just being lazy. A laboratory member who follows regulatory safety prescriptions not only creates doubt about his or her capacity or willingness to handle safety through embodied practices but also threatens the subtle knowing system of the laboratory.

As a result, the wearing of personal protective equipment at all times, a regulatory mandate, is heavily stigmatized. During training, senior scientists emphasize not using protective equipment in order to enforce the command to not touch surfaces. "You don't need to wear gloves, just don't touch anything!" is a commonly uttered remark. Comments that shame such practice abound: "Laboratory coats are for when you are cold," or "oooh you are wearing your lab coat." Newcomers are diligently taught that laboratory coats impede swift and skilled movements needed to perform fast and reliable experiments. Wearing a lab coat, they are told, makes it more likely that they will spill stuff or impede their movements. Newcomers are often denied a laboratory coat. One technician whispered to me conspiratorially that there was a closet with spare laboratory coats that I could use. I was told this however only after I had spent several weeks in the laboratory. Experienced laboratory members constantly shun any request to wear a laboratory coat when it comes from a more junior member – although they might be attentive to what the junior member is doing after he or she uttered the request. Scientists will often joke at the idea of wearing a laboratory outside precise circumstances.

Not wearing a laboratory coat is a sign of membership in the community of professional scientists who are in control of their environment. But in addition, scientists believe that not wearing PPE develops safe and sound embodied working habits such as keeping one's hands to oneself, avoiding touching surfaces, handling materials carefully and keeping surfaces clean. From this perspective, following bureaucratic safety rules undermines the collective effort aimed at promoting a safe working environment.

2. The bureaucratic approach to safety

I feel that in a lot of cases, every chemical you order, it says wear goggles, wear gloves and in 90% of them, the vast majority of scientists would consider that way overkill. And it's hard for me to come into the lab and know which one is overkill and which one, they really are lazy about it and I should wear protective measures. Cause they all say, do this, this and this and it's not always clear which one merit the distinction. [So how do you decide?] So I generally wear my lab coat. {PhD student}

For members who do not possess the scientist's expertise or experience, such as newcomers or technicians, the belief is that the regulatory approach constitutes better protection. The application of regulation is perceived as reassuring and liberating by laboratory members who do not possess the detailed knowledge of the materials used in the laboratory.

The regulatory approach to safety entails a higher trust in the ability of safety rules to provide adequate protection. Scientists favor this approach when they feel their personal knowledge does not allow them to follow the scientific norms. A second reason to adopt regulatory safety practices stems from a lack of trust in the ability of professional norms to ensure that the environment is adequately safe.

One laboratory member who wore her laboratory coat on a regular basis and sought to follow the regulatory guidelines explained she did so because she did not trust other scientists to leave the environment as safe as she would expect.

And I also find it strange that we used to have people who just stored their white virus gown next to the virus hood, and now people store it at their bench. Which

means then you are taking it off, walking through the lab with it, storing it near where you work, which I also find a little discomforting.

Because she felt that people were getting lax with the practices aiming at containing the retrovirus, she increased her own personal protection practices. She wore her laboratory coat, changed gloves often and used paper to open doors. Several other scientists decided against working in this area of the laboratory that was perceived as less safe and clean, and moved on to a space dedicated to another team that was known for following formal safety rules more diligently. Adoption of regulatory practices in this sense is an individual action, one that undermines the collective effort to maintain a safe environment.

Yet another reason newcomers favor regulatory safety is that it allows them be become less dependent on the knowledge of senior scientists: they no longer need to ask scientists about the best way to handle a specific material.

The adoption of regulatory safety allows laboratory members to be more independent of senior scientists and this can constitute an act of resistance to the established social order dominated by expert knowledge. But, as resistance from the collective order, it is also a departure from the collective effort to maintain a safe environment. Table 1 summarizes the two approaches to safety in Med Lab.

-- Insert table 1 here --

3. Contentious interactions and the performance of safety

As different groups mobilize competing sets of rules in order to perform safety, Med Lab has become a site of ongoing contest with some scientists seeking to introduce part of the bureaucratic safety rules and others defending and maintaining professional safety knowledge and practices. However contentious interactions also allow for the transmission of safety knowledge and the creation of new safety practices. Table 2 summarizes the types of contentious interactions by role in Med Lab.

- Insert table 2 here -

Introducing regulatory consciousness

Many laboratory members who adopt regulatory safety practices also seek to promote these practices. Some laboratory members promote the use of protective equipment as a way to normalize the practice:

> *I don't have safety goggles so I steal Suneet's when I think that I am going to do something that expressly requires them; that is going to splash or has the potential to do so. And I steal them maybe once a week, twice a week. So probably more often than most people in the lab would. I just think that if people in the lab wore them more often they'd get [used to it].*

However the adoption of bureaucratic safety practices is often stigmatized by laboratory members, particularly for PhD students and new postdoctoral fellows who desire to become scientists. As one PhD student put it:

You have a certain amount of political capital and you decide how to spend it and if you're always asking for a lab coat and glasses, then that's who you are going to be, the rotation student with lab coat and glasses.

Yet some scientists still accept the stigma and adopt some practices fostered by the formal safety system. Some members also organize as small groups in order to promote the enforcement of rules. For instance, two PhD students and one technician supported each other in constantly wearing their laboratory coats at all times, despite derogatory remarks from other laboratory members. As a result of their collective effort, they were able to withstand the push-back from other laboratory members and engender a sense of pride in their practice:

Yeah, we're the lab coat bay. I work next to Natasha and Iris is right behind us and people walk in our bay and say "oh, people are wearing their PPE." But I don't care. We're the lab coat gang! {PhD student}

While scientists promoting the regulatory approach to safety often do not have much influence beyond their own group, they promote talk about regulation. As they seek to make the regulatory approach to safety more "normal" or "accepted," they also engage in conversations that make the scientific approach to safety less taken for granted. They resist the normalization of the scientific approach to safety, they problematize it. For instance, they resist the idea that protective equipment should only be worn occasionally and they also question the legitimacy of senior postdoctoral fellows in enforcing the

scientific approach to safety. In short, technicians and PhD students bring regulatory consciousness to the laboratory.

Defending science

At the same time, technicians and new PhD students often lack the professional precision of more senior members. Technicians throw dishes full of liquids in bins dedicated to sharp objects, do not know how to dispose of various chemicals and generally pay less attention to whether they are avoiding surface contamination and materials tracking across the laboratory. Newcomers will touch surfaces known to contain a carcinogenic chemical compound with their sleeves or, worse, with their bare hands, and then move on to other places in the laboratory, tracking the chemical along with them.

For experienced scientists, building responsibility comes from enforcing professional norms based on collective awareness and embodied practices. This is often done by delegitimizing bureaucratic practices. One postdoctoral fellow summarized this position when commenting on a bureaucratic rule that requires scientists to wear an additional, disposable laboratory coat when working with some viruses (The Biosafety level 2 + or BSL2+): "The BSL2+ is a *joke*! These are just things to make you feel better. How many layers do you need? It is more about how you bleach things." He was particularly aggravated that some laboratory members would diligently follow the bureaucratic procedure and then carelessly take virus vials across the laboratory and place them in a centrifuge used by everyone where they could spill.

Senior laboratory members actively discouraged the usage of bureaucratic practices. One instance took place when Matt, a technician, entered the tissue culture room in order to work at

the Retrovirus station. Tim, a postdoctoral student, tells me that Matt is going to work with the retrovirus and that this is why he is wearing an additional disposable laboratory coat. Tim says matter-of-factly that we should all be wearing our laboratory coats. Yet neither he nor any of the postdoctoral fellows present make any attempt at putting their coat on. The technician looks at us and begins gravely "Yeah, they should all be wearing ...." The other three postdoctoral fellows all interrupt their work and look at him reproachfully; no one puts on a coat.

In the defense of bureaucratic or scientific approaches to safety, both are depicted as moral acts, as ways of enforcing the "right" approach to safety. Depending on one's perspective, one *should* or s*hould not* wear gloves, one *should* or *should not* touch surfaces, one *should* or *should not* wear glasses. Yet through these actions, laboratory members problematize both approaches to safety: professional approaches are depicted as esoteric and insufficient, regulatory approaches are depicted as rigid, individualistic and at odds with professional autonomy.

Blending professional and bureaucratic approach to safety

Some postdoctoral fellows seek to blend both approaches to safety in order to improve current practices. In these instances, fellows seek to maintain the collective side of professional safety and the enforcement mechanism of bureaucratic safety.

Will, the senior scientist, in particular seeks to combine both approaches. A laboratory inspection was an occasion for blending the two. Will wonders why they do the inspection: is it for safety or for compliance? The safety officer told him that they did this to make sure that the labs were safe but also to make sure that the labs regularly took measures to be safe. He is considering implementing bi-monthly laboratory inspections in order to get people to keep the place clean,

the issue however is how to enforce an internal clean up when there is no formal safety inspection by the safety office. Will worries "about how much people know about who does what and the complexity of monitoring such a large lab." Because the laboratory has grown from a team of 15 researchers to several teams comprising 40 members with broad-ranging levels of knowledge and experience. He recalls when, a few years ago, Kitai, an experienced Postdoctoral Fellow needed to use Hydrofluoric Acid (a compound that binds to Calcium and is hence lethal on contact) to prepare needles for an experiment. Kitai bought a Hydrofluoric Acid first aid kit and showed it at the laboratory meeting. While he said "If I faint on the floor, here is what to do" he was also essentially saying, "Hey I am bringing a new hazard in the lab, here is how to deal with it." Will believes no one should bring such a hazard in the laboratory today, as they would not know how to manage it. The laboratory has become too big and too diverse. People know what is going on at their benches but do not know what people do three benches away. To him, professional safety practices have become insufficient to deal with local safety issues. However he also believes that regulatory guidelines are equally insufficient for dealing with safety: "They have a one year safety refresher where safety people put the lab members in the meeting room and talk very fast." He wonders why their knowledge is so "superficial." For Will, improving the local safety of the laboratory requires blending the two systems.

In preparation for the inspection, several technicians were tasked to clean common equipment and surfaces. These tasks involved cleaning equipment potentially contaminated with radioactive isotopes (hybridization oven), workstations visibly stained with carcinogenic chemicals such Ethidium Bromide (electrophoresis station) or more prosaic surfaces colonized by various strands of bacteria. The technicians performed their tasks amid ongoing complaints that their role

should not be to clean up dirty and hazardous materials for the researchers. "This is wrong in so many ways!" commented the laboratory manager after clearing a colony of bacteria that had grown behind a thawing bath. PhD students and Fellows were in charge of cleaning their own bench. Preparing the laboratory for the safety inspection was an occasion to clean up the chemicals waste disposal area, check if various chemicals were appropriately stored, clear up cluttered corridors and fridges as well as give a refresher to scientists on some safety rules: can we keep liquids above the first shelf (no), what space should be left about our shelves (18 inches), what do we do with hand pipettes[12] (you can hide them), etc.

Yet during the day of the inspection, most laboratory members shunned and mocked the safety inspector. A group of postdoctoral fellows, including the senior scientist, sat outside the laboratory during the inspection. When the safety officers left, one of the fellows asked the technician ironically: "Did we *pass*?"

For the senior scientist, this laboratory inspection served as one occasion to blend the two safety frameworks: professional knowledge and bureaucratic enforcement. Formal safety rules were used as a tool to reinforce ongoing safety practices. Yet the inspectors were met with overt defiance. Successful enforcement was enabled by blending professional norms (keeping it internal) and regulatory compliance (cleaning up the laboratory, putting it into a safe stage).

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[12] Hand pipettes require the scientist to aspirate liquid in the tube with the mouth. Given the risk that a scientist could swallow hazardous materials in doing so, hand pipettes are largely forbidden and have been replaced by automated pipettes. However many scientists prefer to use hand pipettes because they are more precise.

Many senior laboratory members shared in the ambivalence over the insufficiency of professional norms to promote collective compliance and oversight and the insufficiency of the bureaucratic apparatus to provide safety knowledge. They also sought to blend the two sets of rules. One postdoctoral Fellow sought to systematize the cleaning of the tissue culture room. After obtaining agreement from several of laboratory members, she sent an email to all laboratory members in order to organize the cleaning of the five biosafety hoods in the tissue culture room. She volunteered to clean the hood for retrovirus work, the hood that posed the most health and safety threat, as a way of getting the others to do the task. But more was involved than doing the dirty work: she also took on the work that required the most expertise. Similarly other postdoctoral fellows volunteered for laboratory jobs in areas they cared about such as retrovirus work in order to organize the performance of safety. Laboratory jobs enabled blending because they allied scientific expertise (one could only be a representative when one mastered the topic) and bureaucratic enforcement (the person had the authority to train, issue guidelines and expect these guidelines to be followed).

Only Fellows who had been in the laboratory for a number of years sought to organize collective compliance with safety regulation. They were able to build on their authority as respected professionals but they also used the bureaucratic apparatus (inspections, formal roles) as a tool for enforcement. In doing so they directed other member's aggravation toward the external bureaucratic apparatus, not themselves. Scientists who performed such blending took care to distance themselves from the bureaucratic apparatus (as Will who stayed outside the laboratory mocking the safety inspectors with the other laboratory members). In most cases, blending

required a careful balancing act between enforcing bureaucratic rules and maintaining legitimacy as a professional scientist.

Selectively enforcing bureaucratic rules

June announces that she will work with retrovirus and begins working at the retrovirus table. Sandy, the new technician is working at her hood without wearing her lab coat. Will enters the room with an unusually concerned expression. He asks June to step outside. She comes back one minute later and quickly puts her lab coat on. For the next 30 minutes she takes her lab coat off when going out of the room and puts it back on again when sitting back at her station. When I asked Will about his surprisingly forceful enforcement of bureaucratic rules, he told me that he kept an eye on newcomers, because he said, they become particularly absorbed by what they do and forget about safety precautions.

The decision rule in this instance seems rather arbitrary but, nonetheless, the senior scientist invoked bureaucratic rules to overcome the perceived shortcomings of scientific norms to adequately protect newcomers. Similar to blending, the selective invocation of bureaucratic rules allowed experienced laboratory members to introduce and legitimize regulatory practices in the laboratory.

4. Making safety visible through contentious interactions

The performance of safety in Med Lab takes the form of periodic but ongoing contentious interactions as different groups mobilize different sets of rules. The mobilization of both sets of rules (bureaucratic and professional) constitutes small acts of resistance. Experienced scientists mobilize professional rules to resist bureaucratic encroachment by the university and its

oversight system. Newcomers and technicians mobilize bureaucratic rules to resist the professional authority of scientists.

Resistance is "a diagnosis, a consciousness, of the constitution of social structure and power (Ewick & Silbey, 2003)." Through contentious interactions, scientists problematize each framework for performing safety. They bring awareness of the power relations underlying the different types of practices and the limitations of each framework. Yet awareness of these power dynamics and limitations does not necessarily produce ambiguity about safety. Rather it allows the coexistence and creative use of the various rules for doing safety. The frictions between the two safety frameworks allowed for the creative use of safety rules whether through blending or selective enforcement.

The larger portion of contentious interactions occurs around the most hazardous or most commonly used materials (retroviruses, commonly used chemicals) and, as such, they facilitated the circulation of both bodies of knowledge regarding these materials. Contentious interactions also made visible the type of practices each laboratory member adopted. It allowed scientists to understand how safety was performed by co-workers. This allows the maintenance and diffusion of safety knowledge in a context of heterogeneous frameworks as well as the definition of alternative, creative possibilities.

As I discuss below, it is precisely in an area where contentious interactions did not occur that scientific and local knowledge declined and repeated safety incidents did occur.

Breakdown of peer visibility and control: Radiation work

Contentious interactions occurred primarily around tasks involving commonly used viruses and chemicals. Few contests erupted around radiation work since few scientists would speak up to defend, discuss or enforce the traditional practices of radiation work. Instead, Med Lab came increasingly to rely on the bureaucratic apparatus that involved a set of standard procedures, regular safety checks by radiation inspectors, and the wearing of a radiation monitoring badge. However several incidents involving radioactive compounds occurred during my stay in the lab. Internal investigations of these incidents revealed a lack of local knowledge regarding radiation work.

The first incident surfaced when one postdoctoral fellow, Sam, discovered radioactive liquid in a hybridization oven (an oven dedicated to radioactive materials). In order to trace the date and perpetrator of the spill, he sought out the log for radiation work. Workers using radioactive materials need to sign a log stating the date of utilization, the quantities used and the quantities disposed of and all the radioactive isotopes need to be accounted for. Workers also need to sign a formal statement that they have checked themselves and the workspace use for radioactivity and that there is no remaining radioactivity. There had been no log entry since Sam had used the hybridization oven last. This was inconsistent with the existence of a radioactive spill. This fact aggravated Sam. He had bought the oven on his own grant but shared it with the rest of the laboratory members. He first thought that the spill was a deliberate act – possibly targeted towards him - because he "could not fathom that someone would know so little about radioactivity and still feel comfortable using it." As a result he sent a stern email to all laboratory members asking for the person who committed the spill to come forward. When the person came forward and explained his actions, it became clear that he had not been trained properly. He had

completed his PhD in another laboratory where he had not worked with radioactivity. Upon entering Med Lab, he had gone through the one-hour standard safety training that provided insufficient knowledge for performing radiation work. He then went to the laboratory's radiation representative to ask for training but still did not get the correct information. As a result, Sam concluded that the incident was the result of bad internal training and resolved to keep the event internal. With the senior scientist, he "talked to" the postdoctoral student but did not pursue the issue any further.

A second incident occurred a couple months later. During a weekly routine inspection, the safety officer notified the laboratory that the station for radiation work did not meet regulatory standards. The station was particularly crowded with equipment that could be contaminated, waste containers were full and radioactive waste did not seem to have been disposed of properly. The laboratory manager asked Andy, the laboratory representative for radiation work, to "clean up the place." Faced with this obligation, Andy acknowledged that he did not know how to "clean up the place" or even identify what the problems were. He then asked Sam who was the most knowledgeable person regarding radiation work to help him. They both went to the radiation station where Sam performed detective work. He explored the station to look at the kind of work that had been performed. He then explored the log book which was empty. The last entry was done by Sam himself who knew he had not left the station in this messy state. Looking into a container for normal – uncontaminated waste - Sam noticed an empty bottle of Tritium, a radioactive compound. Furthermore the bottle had been entirely used with no log of it. Finally Sam noticed a third misuse of the station: other radioactive materials were disposed of in the wrong container. The chain of misuses made Sam nervous. Tritum is not detectable with the

Geiger counter and traces in the laboratory can only be detected by weekly swabs performed by radiation inspectors. Sam pondered aloud whether to call the safety office but ultimately decided against it. He identified who had used the station based on his knowledge of the type of work involving such materials and of the projects performed by the laboratory members. The incident made visible serious flaws in the laboratory's tacit safety system: Some scientists were using radioactive compounds without a detailed knowledge of the materials (their half-lives, the need to check for residues with a Geiger counter) and the laboratory radiation representative did not have sufficient knowledge to promote and enforce good practices. The laboratories had become overly reliant upon safety officers and formal rules to identity and enforce good practice. Andy refused to be the radiation representative on the grounds that he did not have the scientific knowledge that allowed him to understand and apply the formal safety rules. He had been named representative when the previous representative, a PhD student, graduated and left the laboratory. The next best qualified person had been pregnant and the senior scientist had been reluctant to give her responsibility that involved additional radiation exposure. Andy had been given a quick tour of the radiation work station and cursory explanations by the former representative. Because he had never performed radiation work himself, Andy relied on his memory of the one-hour safety training he received upon entering the laboratory and on formal procedures. This did not allow him to train and satisfactorily monitor new users but because there was a formal apparatus and representative in place, the system seemed satisfying both to laboratory members and safety officers. Trust however broke down with the repeated incidents.

In the aftermath, while many laboratory members began wearing their radiation badges regularly, they were unhappy about the practice because the safety office did not communicate the results

of the badges' analyses. Several scientists limited their work involving radioactivity because they no longer trusted this work to be safe. Unable to find a person willing and able to be a knowledgeable radiation representative, the senior scientist nominated a fellow who was located on a different floor from the radiation station and performed little radiation work. This increased the feeling of distrust among laboratory members. Scientific expertise regarding radiation work was no longer available. Scientists had come to rely increasingly on equipment within the jurisdiction of safety officers (monitoring badges and periodical "swabs" with delayed tests and non-disclosed results) rather than the social and material apparatus under their own control (the Geiger counter, local traceability, training and close monitoring of new users). In doing so, they relinquished their local expertise. Radiation work became administered primarily by the bureaucratic system and, at the same time, was no longer supported by the professional knowledge of scientists. As a result, radiation work became a distrusted and declining technique in the laboratory.

5. Discussion

Studies of professions highlight that professionals (such as physicians, lawyers, accountants or scientists) have historically maintained a level of autonomy from social demands in exchange for providing essential social services requiring a degree of expertise (Abbott, 1988; Freidson, 1988). Such independence has often been viewed as problematic with respect to the regulation of professionals in organizations (Freidson & Rhea, 1963; Matthews, 1991) or with respect to the accountability of professionals vis-à-vis other social constituents. On the other hand, followers of the Weberian view of bureaucracy see the pervasiveness of bureaucratic rules and apparatus as leading to the increasing rationalization of organizational action and as such the neglect of other

institutional considerations (M. Weber, 1968; Jackall, 1989). Both the professional and the bureaucratic perspective argue that institutional actors tend to reinforce boundaries between different institutions (professions, bureaucracies). These perspectives, however, pay little attention to how actors also blend different institutional rules in their everyday actions.

Reviving an interactionist perspective on institutions, scholars in the "inhabited institutions perspective" (Binder, 2007; Hallett & Ventresca, 2006) highlight that actors are located within a heterogeneous context where bureaucracy coexists with a professional logic. In these contexts, actors do not purely rationalize their actions nor seamlessly follow institutionalized scripts. Rather, they combine and generate practices that are intended to satisfy multiple demands and do so in interaction with others (Binder, 2007, p549). Actors skillfully navigate different and, at times, competing logics (Heimer, 1999). Rather than a source of instability and confusion, ongoing negotiations of different templates for action are sometimes a source of creativity and institutional change. In the inhabited institutions perspective, institutional blending and creativity is thought to arise primarily through consensus, be it solidarity (Hallett & Ventresca, 2006b) or collective decision-making (Binder, 2007; Heimer, 1999). Yet it is also through disagreement and forceful assertion of what is personally viewed as right that the limits of one institutional framework become visible and that creativity arises.

In Med Lab, both the bureaucratic and the professional mode of performing safety alone are limited. Technicians lack theoretical knowledge and newcomers lack local knowledge. Both tend to rely on standard formulae in their work, formulae most often provided by the bureaucratic system. Lacking expertise, they adopt the rules rigidly without concern for the nuanced and less

visible aspects of safety. For professional scientists, safety practices are deduced from the knowledge of the materials with which they work – the cells, the chemicals - knowledge gained through their apprenticeship is inseparable from general scientific knowledge and simultaneously considered by scientists as more accurate and useful than legal bureaucratic knowledge, including rules about safety. While some scientists seek to reinforce the professional mode of doing safety, others blend or selectively enforce diverse rules: they translate rules into local knowledge and practices while at the same time allowing for the co-existence of the professional mode of protection with the regulatory mode of protection.

In this context, and consistent with the inhabited institutions perspective, the diversity of rules is an opportunity for creative action. Scientists try, reject or blend different types of rules according to the demands of their local context (the material layout, levels of knowledge, level of professional autonomy). They skillfully and creatively mobilize different sets of rules in order to get work done. Professional and bureaucratic safety rules here become cultural "repertoires" (Swidler, 1986) mobilized differently to solve specific problems.

The inhabited institutions perspective emphasizes that competing institutional logics are a source of creativity and institutional change through the ongoing mobilization of diverse sets of rules by organizational actors. But these logics are often combined seamlessly or through decision-making. This works adds to the inhabited institution perspective by emphasizing that creative response to and adaptation of different logics or rules are not frictionless. Rather it is the friction at the boundary between different logics that allows for creativity, improvisation and mindful adoption of rules. Through contentious interactions, different sets of rules become part of the

local safety knowledge and become used mindfully. Contention allows task visibility and role visbility and logics problematization.

Task and role visibility: Contentious interactions also make visible what rules are being adopted, by whom and why. As they defend their particular practices, actors constantly define how they do safety. This constant reiteration allows for safety knowledge to be made visible. Task and role visibility allow the two safety systems to co-exist because laboratory members know how co-workers perform safety and are able to respond to what they may view as a safety breach.

Logics problematization: Rules are generally invoked in the course of contentious interactions. Actors most often mobilize a set of rules as a reaction to another set of rules. As a result of the contentious interactions, the different rules for doing safety are made visible, open to criticism. By problematizing the frameworks, actors are able to craft new courses for action in response to safety problems.

Contentious interactions promote task and role visibility which allow for the everyday performance of safety in a context of heterogeneous safety systems. They also allow for the problematization of extant ways of doing safety, a central condition for creating new practices. This framework extends the inhabited institutions perspective by showing that contests allow for creativity. The overlap between different institutions is rarely frictionless. However, these frictions allow the interpenetration of these institutions at the level of everyday practices.

Creative responses to safety in heterogeneous environments

Such a perspective on the practice of safety seems antithetical with extant accounts of safety in organizations. Indeed safety is most often viewed as a matter of tight coupling and the close following of scripts where creative responses or complex "repertoires" might seem as something to be eliminated. As Silbey (2010) notes, the majority of accounts of safety cultures tend to depict culture in the context of complex safety systems as needing to be "tamed," controlled or otherwise made efficient lest it might break down as any piece of complex equipment. Some accounts have sought to problematize human interactions in complex systems and emphasize the complex and situated nature of such interactions (Hutchins, 1995; Weick & Roberts, 1993). But, for these authors, safety is ensured through the tight ongoing coordination between actors and depends on these actors' situated cognition: their understanding of themselves and their role as part of the larger socio-technical system. While these approaches leave room for creativity or improvisation in the performance of safety, they view safety as one system, not as multiple and contending systems. Actors view themselves as part of a same system of practices. For instance, Weick and Roberts (1993) write that in order to achieve group performance, people must act as "social forces"(i.e. part of an integrated system of action) and "when people act as if they are social forces, they construct their actions (contribute) while envisaging a social system of joint actions (represent), and interrelate that constructed action with the system that is envisaged (subordinate)" (Weick & Roberts, 1993, p. 363). Performing – read safe - group action hinges on tightly-coupled coordination where people know the system, what their role within the system entails, and how to act within this system. Joint action also entails the subordination of individuals to the collective action. Joint action in this perspective hinges on carefully

choreographed action where deviance (Vaughan, 1996, 1999) might lead to breakdowns and accidents.

The larger number of these studies have focused on tightly coupled systems with catastrophic potential such as nuclear power and petrochemical plants (Perrow, 1984), aircraft operations (Weick, 1976) or space shuttle launching (Vaughan, 1996). Yet not all socio-technical systems require such tightly coupled coordination or even make it desirable. Scientific laboratories are such a case in point. While many tasks in the laboratory are highly repetitive and become routine for laboratory members, laboratory operations themselves are not routinized. Natural turnover in laboratories is relatively high since the tenure of technicians and researchers in an academic laboratory ranges from one to eight years. During the 17 months of fieldwork at Med Lab, fifteen members (or over a third of the laboratory population) at all levels (technician, PhD students, postdoctoral fellows) left the laboratory and were replaced by new members with varying levels of knowledge and skills. Most new technicians had never worked in a laboratory before. While postdoctoral fellows had worked in previous laboratories, they had be trained to work with different materials and socialized in different local practices. In addition, laboratory members also switch teams often and need to learn new techniques and how to handle new hazards. Even without changing teams, scientists constantly integrate new materials in their work or change the properties of materials as they move forward in their experiments. New viruses, for example, are often constructed or existing viruses modified, making it a challenge for laboratories to keep track of the all the viral constructs available. In the course of their everyday work, scientists "tinker" with various materials in order to make them amenable to their inquiry (Knorr-Cetina, 1999). In this constantly changing context, the knowledge base and routines are constantly

updated and the group faces high needs for teaching and transferring complex knowledge. Safety practices and knowledge need to be constantly updated in order to adapt to the constant introduction of new hazards and modification of extant ones and to the evolving social layout of the laboratory. In this volatile environment, the tight following of safety scripts is unrealistic.

Although ongoing contention around safety is a source of dissatisfaction for laboratory members, these contests allow members to resist the normalization and mindless application of safety rules. Indeed, conformity to a rule (whether professional or bureaucratic) can be a source of accident or misbehavior. As organizational actors "normalize" rules, they follow them without questioning their intent and consequences (Vaughan, 1996, 1999). Indeed, the most important safety breakdowns in the laboratory occurred when one part of the knowledge (professional knowledge) broke down.

Laboratories are complex sociotechnical systems where humans need to constantly interact with and through complex materials and technologies in order to achieve collective outcomes such as safety or research. In contrast to tightly-coupled systems such as nuclear plants or extraction platforms, work and technology in scientific laboratories are far more flexible and hence more subject to interpretation.[13] In this respect, scientific institutions as loosely coupled systems resemble educational institutions (Spillane, Parise, & Sherer, 2011; Weick, 1976), medical institutions (Heimer, 1999) or nonprofit social-service institutions (Binder, 2007) where actors

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[13] Observers have long noted that such interpretive (Pinch & Bijker, 1984) and material (Knorr-Cetina, 1999) flexibility is at the basis of scientific and technological creativity.

negotiate between the competing demands of their profession (medicine, education, social work) and organizational demands for reliability and accountability. In these contexts, flexibility, creativity and detailed understanding of heterogeneous modes of functioning can offer a more adaptive approach to safety.

Table 1: Professional and Bureaucratic approaches to safety

Content of the logics	Professional Logic	Bureaucratic Logic
Normativity	Search for truth and knowledge (Science)	Safety Accountability
Relevant knowledge	Scientific knowledge	Knowledge of formal rules
Relevant materials	Scientific objects and materials	Safety artifacts
Mode of learning	Formal (scientific) education Apprenticeship Mentorship Socialization	Formal safety training Manuals
Risk	Constant	Discrete event Probabilistic
Safety	Merged with practice	Abstracted from scientific practice
Relevant expert	Scientist	Safety officer
Responsibility	Collective	Individual

Table 2: Contentious interactions in the laboratory

Role	Logic	Actions	Outcome
Technicians PhD Students	Bureaucracy	Promote bureaucratic logic Cannot enforce	Bring in regulatory consciousness
Post-doctoral students (Defendors)	Profession	Assert professional logic Delegitimize rigid application of bureaucratic rules	Defend professional knowledge
Post-doctoral students (Creators)	Profession and Bureaucracy	Selectively enforce bureaucracy Blend profession and bureaucracy Maintain professional legitimacy	Create new (hybrid) practices

CHAPTER 5: BIOETHICAL MAZES

In this chapter, I examine how the stem cell community produced innovations that ended up challenging the public moral position actively promoted by the community. Between 1998 and 2007, stem cell research emerged as a scientific field grounded in the creation and use of a highly cont roversial tool, human embryonic stem cells (hES cells), that are derived from human embryos. The scientific community took a clear public stance defending the morality of using human embryos and hES cells for research. During this period the stem cell community also continued working and innovating with hES cells despite regulatory restrictions and considerable public opposition. And yet surprisingly, in 2007, several groups of scientists announced the discovery of an alternative technique, reprogramming, which enabled the engineering of cells akin to hES cells without using embryos.

I explore how scientists shifted from leading a crusade in favor of the use of embryos for research to crafting and aligning behind a technological alternative. I argue that innovation practices in stem cell science emerged from scientists' local struggles over ethics more so than pressure from the public opinion and public policy.

1. The public face of stem cell research: boundary-work and the defense of scientific legitimacy

1.1. The rise of stem cell research and the stem cell community on contested moral grounds

When Jamie A. Thompson and his team at the University of Wisconsin first announced the successful derivation of hES cells from human embryos in 1998, excitement rippled through the scientific community. Embryonic stem cells, also known as "pluripotent" cells, can become any type of cell in the body and as such, hold the potential to create virtually any type of human tissue. This "potency" has generated many hopes (and "hypes") for regenerative medicine and for applications in cures for diseases involving cell disorders such as Parkinson's disease, Alzheimer's disease and various types of cancer. But their potential is not limited to medicine: stem cells have the ability to divide indefinitely under good laboratory conditions: one "line" of cells can be grown indefinitely and used by many different scientific teams. This property makes stem cells precious for cell biology: they are a convenient and unique model to study cell development and fate under controlled laboratory conditions. As such they provide a core tool to understand early human development in particular and cell development in general. In short stem cells were viewed from the beginning as a crucial new tool for both medicine and science.

The revolutionary news however launched a fierce ethical controversy. Embryonic stem cells can only be obtained through the destruction of early human embryos and such a practice raised concerns for many, in particular among Catholic and Evangelical Protestant groups. While many countries have dealt with biomedical ethics by defining the practices that are legally permissible and not, the United States sought to adopt a complex "middle-ground" position. Rather than authorizing or forbidding the use of embryos and hES cells, the federal government only restricted public funding for research involving such materials while leaving privately funded research largely unregulated. Governance of privately funded research was left to the scientific community and their hosting institutions (universities, private organizations or hospitals). This

middle-ground position has set the stage for a continued confrontation between stem cell proponents and opponents for the use of human embryos and hES cells in research.

The US government has traditionally relied on the restriction of publicly funded research, mostly administered by the National Institute of Health (NIH), as a policy tool in lieu of an encompassing regulatory framework. Since 1995, research involving fetal tissue was prohibited from receiving public funds but could operate without regulatory constraint if privately funded. When hES cells were discovered in 1998, they fell into a regulatory gray zone: while it was clear that the use of human embryos to obtain stem cells could not be publicly funded, it was less clear whether the resulting materials (stem cells) could be used with public funds. Three years later, amidst peaking controversy, President Bush settled the issue by authorizing the funding for research using a select number of hES cell lines and prohibiting funding using any newly generated (or "derived") lines. This decision marked the beginning of a decade long crusade by scientists and stem cell research proponents to have this regulation relaxed, accompanied by an equally fierce crusade by stem cell opponents to stop or, at least, severely restrict the use of all human stem cells.

In 2007, four teams of scientists (one based in Japan and three in the US) announced the discovery of a technology enabling the "reprogramming" of adult cells into a state akin to embryonic stem cells. The new cell types became known as "Induced Pluripotent Stem (iPS) cells." They share a large number of characteristics with hES cells, including the capacity to become different cell types (pluripotency). Opponents to the use of human embryos for research hailed the discovery as a way to generate "ethical" cell lines, a process that would bypass to need

to destroy human embryos to generate stem cells. The scientific community was also enthusiastic over the scientific potential of the new technology. Yet many scientists were concerned that these cells were not equivalent to hES cells and therefore did not have the same potential for science and medicine. IPS cells required the injection of chemicals that made them inappropriate for injecting into patients. In addition iPS cells exhibited significant differences from the hES cell counterparts raising questions about their quality and potential for medicine. The discovery also challenged the moral position advocated by the stem cell community: The notion that some lines could be more "ethical" than others threatened the narrative that all scientific practices were ethical because they were at the service of science and medicine. So while iPS held important scientific potential, they could also threaten valuable research performed with hES cells.

It might be argued that external institutional pressure (social contestation and restriction of public funding) induced innovation in the community. However, institutional pressure only partially explains the pattern of stem cell research in the United States. As Owen-Smith and McCormick (2006) point out, restriction of public funding did not chill stem cell research. Moreover, studying the effect of federal and state regulation on the prevalence of stem cell research per state, McCormick, Owen-Smith and Scott (2009) show that state-level institutions (local regulation and research infrastructure) could not entirely account for the distribution of stem cell research prevalence by state. While macro-level institutional pressure had some effect on the prevalence of stem cell research, work went on despite funding restriction and vocal opposition.

Indeed, following regulatory changes in 1995 and 2001 which restricted funding, the stem cell community re-organized some of its practices. Medical and research institutes mobilized private donors. Scientists organized the diffusion of stem cell lines within the community through the private exchange of materials and knowledge (Scott, McCormick, & Owen-Smith, 2009). Many laboratories began functioning in a dual mode: scientists used public funding where it was authorized and completed their research programs with private funds. In addition, the stem cell community mobilized lobbyists, bioethicists and media figures to counter the moral challenge to their activity. They created advocacy and support groups such as the International Society for Stem Cell Research (ISSCR) and other institution-specific groups. These groups elaborated codes of ethics and rules of practice in an effort to influence public policy. By 2004, the stem cell community had accommodated to the regulatory constraints and organized strong resistance to their challengers. Hence, inventing a technology that would bypass the use of embryos seemed unnecessary and had the potential to undermine efforts to shape public perceptions and policy.

1.2.The moral challenge: Religious and political groups

Following the legalization of abortion in 1973 (Roe vs Wade), public concern turned to the use of fetal tissues in research. Opposition to the use of fetal and embryonic cells grew with the discovery of hES cells in 1998. Opponents leveled arguments on three main themes: (1) unborn human life is sacred (2) harm to embryos is akin to harm to human beings and (3) uncontrolled science is a threat to society.

The sanctity of human life: Opponents to stem cell research argued that the only boundary that differentiated a cell mass (such as egg or sperm cells) and humans was conception. Most of the

embryos used to derive hES cells were the so-called "surplus embryos," embryos created through the in-vitro fertilization process, non-implanted and kept in a frozen state. Opponents sought to emphasize the moral status and human potential of such embryos by arguing that these embryos could successfully become human beings if "adopted" by willing couples. This argument was taken up by President George Bush when he announced his 2001 decision to restrict funding for stem cell research: "A number [of surplus embryos] have been donated to science and used to create privately funded stem cell lines, and a few have been implanted in an adoptive mother and born and are today healthy children ("President Bush's Address on Federal Financing for Research With Embryonic Stem Cells," 2001)." The President also compared these embryos with snowflakes: "like a snowflake, each of these embryos is unique with the unique genetic potential of an individual human being." (New York Times, Aug 19 2001, *Bush's gift to extremists*). This metaphor was taken up by activist groups who launched campaigns to "adopt an embryo" and labeled children born from such adoptions "snowflake babies."

Do no harm. A related argument was that society needed to protect its more vulnerable members from unfettered scientific and medical research. This argument echoed the scandal surrounding the Tuskegee clinical experiments where physicians were charged with not providing adequate medical treatment to African-American males infected with syphilis. This view also mobilized tropes related to the scandal regarding the intervention of physicians in concentration camps in Nazi Germany. The argument of the "harm already done" had been first used as a justification to allow the use of the medical knowledge gained through medical experiments viewed as imoral. By using the same symbolic terms, opponents placed stem cell research in the same category as

these infamous precedents. Embryos were categorized as "vulnerable members" akin to prisoners or mentally retarded patients.

Uncontrolled science and the "slippery slope." That some individuals would be destroyed in the name of medical science constitutes a threat to us all." wrote one Kansas senator in an open letter backed by Roman Catholic and Protestant groups. This concern was grounded in the argument that the destruction of embryos was not only a direct moral threat to specific human beings but a broader moral threat relating to how societies conceived of the status of humans: authorizing the destruction of embryos could open the door to other scientific and medical practices that could pose a moral threat to societies such as cloning, hybrid engineering or eugenics. This argument known as the "slippery slope" was also echoed in President Bush's address following his 2001 decisions:

> *Embryonic stem cell research is at the leading edge of a series of moral hazards. The initial stem cell researcher was at first reluctant to begin his research, fearing it might be used for human cloning. Scientists have already cloned a sheep. Researchers are telling us the next step could be to clone human beings to create individual designer stem cells, essentially to grow another you to be available in case you need another heart or lung or liver (2001 Presidential address).*

The "slippery slope" argument emphasized the threat of a scientific activity whose norms and practices were unchecked by society. In the late 1990's and early 2000's, stem cell research was new and indeed operated in a relative normative vacuum. No specific code of conduct was

devised by scientists who relied primarily upon the generic norms of science and more specifically upon the norm of community to assert that scientists were responsible enough to self-regulate. Religious and many political groups deemed this insufficient. Some scandals were seized upon to show that science could not be trusted to operate in what was presented as a normative vacuum. Shortly after the 2001 presidential ban, news that a team of scientists led by William E. Gibbons at the Jones Institute had created some embryos in order to use them to derive stem cell lines created uproar in the religious community and discomfort in the political and scientific spheres. Religious leaders called the work "ghoulish" and "unconscionable" and called into question the ethical claims of the stem cell community. Richard Doerflinger, a bishop and prominent pro-life advocate said the work "crosses a very important line in terms of treating life merely as an instrument for others." Another pro-life advocate said "Those who have advocated destructive embryonic stem cell research have been assuring people and assuring President Bush that they only want to kill the so-called leftover embryos. This report shows how phony those assurances are." (Gay Stolberg, 2001). Scientists involved defended the ethics of their research by highlighting that they had complied with existing scientific protocols. They had received the authorization to perform the research from their institution and had obtained donor consent. Dr Gibbons who oversaw the research noted that donors were informed of the research goals before the embryos were created which he argued is "the purest way to obtain the highest quality of informed consent". While the scientific community had adopted a unified front in defense of stem cell research, some scientists expressed publicly their discomfort and sought to distance themselves from the research as illustrated by one scientist's quote in a journal: "You will hear none of the scientists who are involved in this work talk about making embryos to

destroy them in any way. We don't think it's necessary." Similarly many ethicists and government officials distanced themselves from the Gibbons team (Gay Stolberg, 2001).

By yielding the "slippery slope" argument and emphasizing some "scandals," opponents of stem cell research argued for the need for strong norms to restrain research foray into human life and cast scientific research in opposition to such norms.

- Insert tables 1 and 2 here -

The generation and use of hES cells have raised serious bioethical questions, that most countries have confronted. However, while the US government maintained a relatively tolerant policy, the debate was couched in strong and confrontational terms opposing scientific values to religious ones. As a result of the rhetorical effort of opponents, Med Lab scientists and the stem cell community at large had to confront both the ethical challenges and the religious rhetorical form which opposition to stem cell research had taken.

1.3. In defense of stem cell ethics: Med Lab and the stem cell community

When the stem cell controversy erupted, scientists became involved in the debate. Initially mobilized by government officials looking for scientific expertise, scientists also quickly took a proactive stance in defense of stem cell research. As early contributors to stem cell research, Med Lab scientists became involved in the public controversy.

From science to ethics. As soon as the existence of hES cells became known, the director of Med Lab sought to obtain these cell lines and use them for his current research on blood and bone marrow formation. He viewed human models as more relevant than animal models for searching

for medical cures. Having obtained them through an informal exchange, he became rapidly known in the community as an early mover into hES cells. In 1999, soon after the controversy erupted, he was mobilized by his research institute to discuss stem cell research with government officials seeking to understand the issues raised:

> *There was this enormous political debate going on at the time. And [...] I got drawn into it because Ted Kennedy who saw this as an issue was close to [my] institute. He called the institute, said, "Do you have anybody who knows anything about embryonic stem cells?" And I was doing this. So, as a junior person, I was identified and I ended up [going] on down at the Senate, the Democratic Policy office lunch with the three Democratic Senators talking about stem cells. And, you know, Harold Varmus[14] was supposed to show up. [...] And Harold cancels at the last minute [...]. He was hired by the administration. He's an administration employee, and it was very controversial at the time. And so he sent one of the NIH spokesman, and we talked about stem cells and where they were going. And I would say there was political opposition to use stem cells.*

In response to political opposition, Med Lab scientists amongst other members of the stem cell community began to take a proactive stance. They mobilized the media in order to explain stem cell research to the broader public. They sought to clarify the potential of stem cell for scientific

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[14] Head of the National Health Institute (NIH): NIH is a major provider of public funding is science and medicine. NIH would later become one of the institute regulating the distribution of public grants for stem cell research.

research but also for medicine and explain the scientific grounding of controversial techniques such as stem cell derivation, nuclear transfer, cloning or of the creation of hybrids. They gave technical details on the type of embryos that were used and the rules they complied with. They sought to put these techniques in the context of the broader scientific and medical challenges they were trying to pursue.

"Enlightened" and secular ethics. Public interventions, initially understood as a way to provide scientific information, gradually moved onto a more ethical terrain. Why use surplus embryos and not create embryos specifically for research? How did scientists set the developmental boundary that deemed embryos usable or not for research? How was consent established? How did they think about opposition to stem cell research? Ethical and scientific issues were inseparable. As the director of Med Lab recalls: "I was kind of sucked into it scientifically and then ultimately found myself having to justify the work based on my own ethics." Because he had an initial training in philosophy and ethics, he became increasingly involved in the public debate:

> *I did a tutorial with John Rawls.[...] So, I have a very good foundation in the basics of the major ethical frameworks, sort of classical utilitarian, classical deontological, all the different sort of tensions. And so, that has served me very, very well in the discussions with a lot of bioethicists in thinking about the various assaults on the fundamental concepts of the early embryo. I can reason well, not an expert but I'm pretty fluent with the fundamental tenets of the arguments. And*

so that coupled to my scientific understanding, has made me more comfortable than maybe some of my colleagues are in going out and getting involved.

The senior scientist also became particularly knowledgeable on philosophical approaches to ethics. He became involved in the university's history department in order to understand the historical foundations of the current debate and also established links with bioethicists in major university centers. He viewed his role as providing a rational approach to the ethical debate as opposed to ideological and non-rational perspectives offered by stem cell opponents. Med Lab scientists also established collaborative links with bioethicists and with other prominent stem cell scientists engaged in public debates over ethics. They organized courses and public conferences where leading ethicists and prominent religious figures could debate the issues.

In shifting their public intervention from purely scientific matter to ethical debates, scientists began to craft a public ethical position primarily grounded in secular philosophical principles, particularly utilitarianism and pragmatism. To the notion that embryos were distinct human beings and should be considered "sacred," scientists responded that if embryos were to be destroyed, they might as well be used for something useful (like research). Stem cell research defenders seized on public misinformation and on the religious ideology of many opponents to argue that their work was pragmatic and not ideological. For instance, they criticized the "adopt an embryo" movement as unrealistic given the sheer number of surplus embryos (it is estimated that there are about 400,000 frozen embryos).

Finally stem cell scientists presented themselves as caring for sick and disabled patients rather than favoring the status-quo of a "god-given order." This position was bolstered by prominent

media figures who spoke publicly about their disease and the need to find a cure. Saving patients became presented as a moral imperative driving stem cell research. Overall, scientists developed a rational, secular ethics grounded in the philosophy of the enlightenment in opposition to the religious arguments of their opponents. They presented themselves as "enlightened" scientists in opposition to the "pre-enlightened" religious groups.

- Insert tables 3 and 4 here -

Building the ethical infrastructure. Scientists also sought to influence the ethical standing of stem cell research by crafting a regulatory infrastructure. Stem cell research had so far operated in a dual regulatory regime: federally funded research operated under strict federal guidelines while research performed with private funding remained entirely ungoverned. This regulatory gap gave opportunities for opponents to point to the lack of ethical grounding of early embryo research. In response, Stem Cell scientists formed the International Society for Stem Cell Research (ISSCR) whose goal was to define the guidelines for the conduct of stem cell research and advocate for the application of these guidelines by the National Academy of Science (NAS) and the federal government. NAS also established a panel of scientists tasked with providing "guidelines for the responsible practice of human embryonic stem (hES) cell research (NAS 2005 report)." The goal of the panel was to provide a framework that would both regulate privately funded research and provide a basis to challenge the rules governing publicly funded research. The panel viewed this attempt as a way to protect science from ongoing and further external challenges:

We wanted to set up a mechanism so that science could proceed [...] We thought of it then as building a ring fence around stem cell research [...] within this ring fence, then research should proceed as usual. {R. O. Hynes - Committee member - NAS guidelines for Stem Cell research}

The NAS recommendations devised a number of guidelines for deriving hES cells regarding: 1) donor consent and compensation for gametes, blastocysts, and cells; 2) the derivation and culture of early embryos (limited to 14 days); 3) banking and distribution of stem cell lines and 4) the use of stem cell lines, including the limitation of human-animal chimeras and the request for oversight by local review boards. NAS recommendations also included the creation of an institutional oversight committee, the Embryonic Stem Cell Research Oversight Committee (ESCROC), whose role would be to review the compliance of the research protocols (privately or publicly funded) with the NAS guidelines. As soon as these NAS and ISSCR guidelines were established, stem cell scientists began to adopt them as their own standards, many adopting rules in compliance with both guidelines. Universities hosting stem cell laboratories implemented ESCROCs for the supervision of research protocols involving human embryos and hES cells.

Policing the boundaries and shifting the debate: Scientists also used the guidelines to police their boundaries. One example was a very public clash in 2005 when a stem cell researcher from the University of Pittsburg announced publicly that he was suspending his ties to a South Korean team led by Dr. Hwang because of possible ethical violations. Violations related to the way some research materials, oocytes, had been obtained (New York times, 11/15/2005). Two women in the laboratory appeared to have donated oocytes. This was a violation of the NAS guidelines for

stem cell research which required that egg donations be anonymous. The internal ethical rift continued. Dr. Hwang Woo Suk had earlier claimed to have obtained the embryos through cloning. He later admitted to having fabricated the evidence. This latest scandal drew the wrath of stem cell opponents who seized on the event to question the overblown promises of this type of research. But the most virulent condemnation came from the stem cell community itself. A panel was set up to investigate the research performed and established that some results were indeed fraudulent. One of the leading panel members announced in a press conference: "We determined that this is a grave misconduct that damages the foundation of science (Sang-Hun & Wade, 2005)." Another researcher said Dr. Hwang "was not a scientist." Unlike the Gibbons scandal where no standard existed in the research community to assess whether this constituted ethical practice or not, scientists here were on familiar terrain and condemned Dr. Hwang for not complying with their standards.

Researchers with a lax approach to research ethics as defined by the stem cell community were not the only ones subject to strong condemnation. Physicians and institutes offering promising cures using stem cell research also attracted the attention of stem cell scientists. They warned the public not to heed calls for miracle cures by what they called vendors of "snake oil." They seized on stories of families taking their children abroad to get useless stem cell injections. Through these actions, stem cell scientists sketched a definition of ethical practice as one that complies with the NAS standards and is backed by institutional arrangements (validated by ESCROCs, university arrangements and submitted to peer scrutiny).

Through vigorous boundary-work, scientists shifted the moral debate from the religious to a secular terrain. Moral breaches were no longer defined as revolving around the status of the embryo but rather as a question of method (the respect of the ethical guidelines defined by the scientific community) and an issue of rigorous knowledge and information. The real threat to society was no longer the destruction of the embryo but the false medical promises issued by non-scientists. Stem cell scientists then became the defenders of rigorous and responsible science and medicine. Moral dissent arising from religious worldview was defined as illegitimate and irrelevant.

Unifying to support hES cell research: New techniques, private strains and public unity. During these early events, the stem cell community spoke with one voice. If there was ethical dissent within the community, it was not voiced publicly. Many laboratories working with animal stem cells did not make the move to human models but did not speak publicly about their rationale. The director of Med Lab recalled encountering resistance within the community when trying to convince colleagues to move from animal to human models:

> *I actually brought Joseph Iskowitz to try to convince [colleague scientist], to get him to work with hES cells and [scientist] practically threw us out of the office saying it was bullshit, it's not interesting. Why work in the human... They're so much more difficult and have more problems.*

Yet, such decisions – and their motives – remained private. The stem cell community only spoke publicly about the scientific promise and ethical justification of its research. When the discovery of Reprogramming was announced in 2007, the news that science could potentially move beyond

using embryos immediately renewed the ethics debate and tested the scientific community's public stance on stem cell ethics. Scientists and bioethicists on both sides of the debate had long discussed the possibilities for generating stem cells without destroying embryos (see for instance Melton, Daley, & Jennings, 2004; Spotts, 2005). Some techniques, such as cloning had proved successful in generating stem cell lines in animals. While scientists had saluted these early successes, they had strongly questioned the ethical superiority of such alternative methods and warned that they would divert precious resources. While continuing to question the ethical superiority of alternative methods for generating stem cells, several laboratories engaged in the race for finding alternative methods, first in animal, later in human cells. One team pursued the cloning method. Another team looked for "reprogramming factors": factors that would allow adult cells to revert to a stem-cell like state. In 2006, the second team, led by Dr ShinyaYamanaka announced having successfully reprogrammed mice adult cells into their pluripotent state. The announcement led to a race among major stem cell laboratories to apply this method to human cells. In the course of 2007, four laboratories announced having successfully performed such reprogramming with human cells: two laboratories had never created stem cells from human embryos but were pioneers in looking for alternatives and two laboratories (including Med Lab) had previously created human models and caught up with the pioneers by applying their knowledge of hES cells.

After the discovery, the scientific community continued its effort to assert the moral legitimacy of using embryos. Scientists strongly rejected the label of "ethical stem cell lines," a designation used by some opponents to refer to iPS cells. All teams emphasized that the discovery of reprogramming would not have been possible without the prior knowledge gathered by

generating and working with hES cells. With the presidential campaign approaching, scientists intensified their lobbying for the lifting of funding restrictions and the acceptance of the NAS guidelines as official guidelines. After the victory of Barack Obama, scientists pushed again for the enactment of his campaign promises. When President Obama effectively reversed the Bush restriction, defenders of stem cell research hailed the decision as "removing politics from science" and saluted the fact that the decision "freed researchers to explore these remarkable stem cells, learn from them and possibly develop effective therapies using them (Stout & Harris, 2009)."

In the face of continuous moral challenge on the public front, scientists responded by delegitimizing their opponents: they depicted opponents as uninformed and extremist groups, opposed to science and medical progress. Their moral legitimacy relied on the establishment of an interactional order where stem cell opponents were denied credibility and moral standing. These actions allowed the community to mobilize important constituents: patient groups, private donors or public advocates. It also helped to structure the stem cell community around shared rules that came to define what good and ethical practice. For scientists, the victory came at the cost of a growing polarization between science and religion. Stem cell scientists became the defenders of a "strong" and polarized public position. The director of Med Lab summarized the dilemma:

> *I think there has been a tension in our society about the sort of scientific world view and the so called religious world view. So it's kind of secular and non secular. But I fundamentally think that they don't have to be inconsistent.*

We raise questions about the nature of personhood, what we should do as a community, be protecting in the notion of personhood. And I think it really does come down to whether or not, we as a society have a strong stated interest in protecting blastocysts.

This strong public position has been continuously maintained. Any new episode of contestation has led to the main spokespersons in the stem cell community – Med Lab scientists included – to speak up in defense of the ethics of their practice along the tropes crafted in the early 2000's.

2. Internal ethics work: diversity, collaboration and innovation within the laboratory

As central actors in the public debates, Med Lab scientists strongly shared the positions defended on the public front and sought to translate them it in their everyday work. Yet the dominant norms in Med Lab over what constituted good and ethical practice became contested over time (See Table 7).

2.1. Phase 1 (1998-2004): The unified position

Consistent with the view they promoted in the public sphere, Med Lab strongly believed in the morality of using surplus human embryos for research and in the close association between scientific and medical progress. This statement by the head of the embryology program summarizes the ethical position of many laboratory members:

I don't regard [frozen embryos] as immediate human beings because they're still there in liquid nitrogen. Unless someone is going to step forward with a uterus

that's ready to go and make them into human beings, then they're not... They might as well be used into something more useful. {Postdoctoral Fellow, Pediatrician - Head of the embryology program}

In philosophical terms, this is known as the utilitarian argument: the idea that the moral worth of an action is determined by its ability to maximize utility for all sentient beings. Utility here is understood as useful knowledge creation with the potential for medical cures. This position represented the dominant position of Med Lab at its inception.

In addition, as mentioned earlier, many scientists shared a strong commitment to the avowed goal of contributing to medicine through stem cell research. For instance, several members cited a family illness as a motivation to do research with stem cells. One technician explained his motivation to join the laboratory as follows:

When I was 11, my older brother, at the time, Chris, had a brain tumor removed. And I just remember hearing the doctors say one cell had to go wrong for a tumor to start, and that blew my mind [...] So I always used to think about cancer, even when I was young. And stem cells provided the rationale for why cancer even exists in the first place.

Similarly the senior scientist explained his motive to work with stem cells through his father's illness:

My father died in the veterans' hospital of blood cancer, and I thought, "Fate is being very cruel to me." [...] But it turned just these horrible stories into a very motivating sort of will. [...]And so I studied the blood. I studied blood stem cells.

Scientists coming at their work from this perspective often viewed challenges to their activity as deeply illegitimate. They viewed the public as ill-informed and viewed their duty as clarifying these misconceptions. For instance, the senior scientist explained his engagement in public policy as driven by the willingness to inform the public about their work:

[I became] more and more alarmed, especially early on in the debate -- 2002, 2003 -- that a lot of people with some very strange ideas were on television, but I really didn't see any scientists making the case, or saying, "Oh, I don't want to make Frankenstein, actually -- I just want to study the liver." You know? And so this big -- this mass hysteria erupted. And so I just started talking more and more about it.

Scientists often depicted their opponents as ideological or "pre-enligtened." During laboratory meetings, some scientists openly discussed ongoing moral debates and voiced their contempt for some public controversies that were, to them, overblown. Defending the ethics of their practice was here presented as a moral imperative. As the senior scientist of the laboratory put it:

In this case, science has been prevented from working because of things beyond the science, and I just feel that it was my obligation to try to fix it.

Scientists not only sought to defend their ethical position in the public sphere; they also used their work as a vehicle for furthering the ethical position of stem cell science. In 2001, Med Lab sought to derive its own stem cell lines with private funding. The Embryology team was constituted and placed under the supervision of Peter, a Postdoctoral Fellow. The team sought to create new embryonic stem cell lines in a way that could justify and bolster the morality of using embryos for stem cell research. First, practices were aligned with the public effort to place stem cell research ethics as a methodological issue centered on donor consent: if donor consent was appropriately sought and obtained, then it was considered ethical to use the materials (eggs or embryos) for research. In line with this argument, Med Lab scientists developed a stringent consent process in order to obtain embryos and they negotiated directly with potential donors at a nearby IVF clinic. The move was strategic on the ethical front. Their idea was to enact the alternative to the Bush administration guidelines that had been proposed by the Institute for Stem Cell Research and the Institute of Medicine (led by scientists and physicians). Peter, the head of the embryology team explained their strategy:

> *[We] had certain principles in mind and one big one that was ignored by Bush's rules was the consent process used to obtain the embryos. So [we went] through a rigorous approval process here, two institutions, two IRBs, two consent forms. Our consent forms were modeled on the ISSCR guide lines, the Institute of Medicine guidelines.*

When the Obama administration overturned the funding restriction, Med Lab scientists immediately pushed for the enactment of the new guidelines and for opening their lines to public funding, as Peter explained:

> *We knew that we had a good chance to be approved. And rather than wait to have the committee be formed and hear the details about how to do it, Will just basically inundated [them with] all our paperwork so for every [hESC] line we wanted to prove we sent all the documentations which I had all ready to go and Will packaged it all tightly. We were able to show everything. We had very well documented proof of the rigorous approval process and I think that got our foot on the door. I think it also showed that we were eager to get it [approved], that we had done it very above board, in a good way. And so it wasn't too surprising then that our lines were approved as quickly as they were.*

As a result of the early effort, 11 hES cell lines from Med Lab were among the 13 first lines to be opened for public funding. Since the approval, Med Lab has become one of the major suppliers of stem cell models.

The team's efforts to contribute to translating their ethical position into concrete achievements did not stop at the regulatory level. When defining what types of embryonic cell lines to craft, the laboratory also sought to contribute to the ethical debate. The first cell lines were derived from "surplus" embryos: embryos generated by the IVF process that the procreating couple did not desire to use or donate to other couples for reproductive purposes. Med Lab scientists

decided to go one step further by using "poor quality embryos" (PQEs). Like surplus embryos, PQEs are issued from the in-vitro fertilization process. However these embryos have a number of defects that threaten their ability to develop normally if implanted. As a result, physicians discard them. The embryology team decided to use these embryos to derive new stem cell lines. The avowed purpose was both scientific and ethical. On the scientific front, using a different type of embryos would allow for a publication in a top scientific review (the research was later published in *Nature*) while creating research models for the laboratory:

> *You couldn't just publish, "Oh, I made embryonic stem cells." You know, that had been done. These are these kinds of experiments that are like you do it once and that's it. [...] so we came in a little bit late.*

On the ethical front, using PQEs allowed the laboratory to show that otherwise "useless" embryos could become useful research materials: good quality stem cell lines could be obtained from materials otherwise considered as waste. This both supported the utilitarian argument and showed that scientists took seriously social concerns about using embryos. While their ethical concerns were not separate from strategic concerns, scientists sought to constantly translate their ethical position into concrete practices and technologies.

2.2. Phase 2 (2004 – 2007) – Emergence of dissent

Ongoing advocacy of this strong moral position however also gradually created discomfort for other scientists. Some scientists disagreed with the close link drawn between science and medical care. For instance, one postdoctoral fellow sought to distance his work from the immediate possibility of finding medical cures:

I definitely don't think, "Oh, I really love my work because I think it's really important.' [...] And if I were to measure the value of work as how much it is going to affect human health or human well being, then I don't think stem cell biology and cancer biology would be a on the top of my list.

To him, the ethics of his work lay in the rigor of the scientific contribution:

I don't see [issues around the use of embryos as] huge issues to me, personally. There are the less obvious things like, 'When are things reportable or when are results solid enough to report them in a paper?' [...] The rigorousness of science has an ethics to it.[...] Because once you put it out there, you're putting it out there as a truth, that people often take at face value.

Scientists adopting this view refused evaluating the worth of using some materials by their contribution to medicine. Another scientist noted how the link between research and medicine created ambivalence when he was dealing with diseased patients and their families who supplied research materials. While he was grateful that these patients would give their cells to science, he needed to emphasize to them that there would likely be no progress that could be applied to their situation. To him and to other scientists, making clear this disconnect between research and medical contribution was a core ethical principle.

Another source of divergence was found in some members' ambivalence regarding the use of human embryos. For instance, one postdoctoral fellow noting her Catholic background mentioned the difficulty of defining her position regarding stem cell research. While she viewed the use of surplus embryos as morally justified "if they would have been destroyed anyway," she

was uncomfortable with other possibilities such as the creation of embryos for research. She said she found it difficult to draw the boundary between what was morally justified or not. Her double affiliation as a stem cell scientist and as a Catholic created for her much ambivalence.

Yet, this collective awareness of existing divergent perspectives only surfaced in 2004 when the laboratory went to a public hearing culled by the state senate. The senior scientist recalls:

> *The first time I made a public policy mistake here, Gary and I were both invited to testify [...] the whole lab came to the testimony because it was a public, open testimony day. [...] the whole lab came and sat, and stayed the whole day [...]. And it was assumed that everybody was personally OK with human embryonic stem cell research. And people joked around; they make comments about some of the testimony. Well, it turned out that there were a couple of people in the lab who were offended by the tone of the commentary, and that they actually were personally opposed to human embryonic stem cell research on moral grounds, and we just didn't have any idea. It was just something we took for granted ... [...]And of course, people are free to believe in whatever they want, but sort of coming to that realization was an important one, because we were taking for granted things that we shouldn't take for granted in terms of our interpersonal relations.*

This event precipitated a crisis for the laboratory. In order to deal with internal dissent, senior laboratory members decided to organize monthly ethical discussions. The topics of these discussions included a variety of topics such as: *where does human life begin? Human/Non-*

human Chimeras, International perspectives on Human Embryonic Stem Cells, and *Altered nuclear transfer: an ethically valid alternative to cloning?* Discussions were led either by an ethicist, a postdoctoral fellow, or a PhD student. The discussions were an opportunity for laboratory members to inform themselves on the ethics of stem cell research and to define and discuss their personal position. These discussions allowed laboratory members to shift their personal perspectives from strongly partisan toward a more tolerant attitude regarding the divergent moral perspectives in the laboratory.

> *An important experience of dealing with this [...] was the realization we are not objective scientists who can prove that it's okay to work with these cells, versus wing nuts on the other side, religious fanatics who are just off the chart. That I share a lot with secular philosophers who are very opposed to it and who have [valid] arguments. And so I just found that important for myself to not just ignore that aspect of the work. And not just do it because everybody around me does it without hesitation.*

Through these discussions, the laboratory's shared moral understanding shifted from a position where the morality of stem cell research was taken for granted to a position where morality meant accepting ethical difference amongst scientists. As Will, Med Lab's senior scientist, summarized it:

> *[...] Just as we should feel comfortable to discuss our scientific differences, we should feel comfortable to discuss our personal differences, and that this is our*

view of utopia: the open exchange of thoughts and ideas without recrimination. That's one of the things that make science so international.

While Med Lab continued a strong campaign on the public front to defend the ethics of hES cell research, it began acknowledging internally the diversity of moral positions. In order to do so, scientists had recast the norms of science to apply it to ethics. The ideal of universalism or the "open exchange of thoughts and ideas without recrimination" no longer solely referred to empirical debates but also to ethical debates. Scientists came to place divergent ethics on the same level as divergent empirical results. To them it represented a scientific opportunity.

2.3. Phase 3 (2007 – 2009) – Material innovation and heterogeneous ethics

Of these scientists whose diverging perspective had led to the opening up discussion in the laboratory, Roni, had been recruited in 2003. His plan was to work on searching for alternatives to embryonic stem cell technologies. The decision to recruit him was mostly strategic for the laboratory director since there were then talks in the stem cell community about possibilities of finding alternative methods for generating stem cells. The new postdoctoral fellow claimed a strong religious affiliation and refused to personally use embryos for research. Yet he related his refusal to work with embryos to a scientific opportunity. He presented his decision to not work with embryos as a mix of ethical and scientific reasons:

I preferred to focus on reprogramming or on working with germ lines rather than deriving hES cells, and rather than destroying eggs and then doing the transfer.... Because I didn't want to destroy eggs and also I knew that the efficiency is so low that if you want to really contribute to science and if you want to contribute to the

general uses of these pluripotent cells, if you want to apply it to a lot of patients, the efficiency must be very high.

He mobilized ideas from both the scientific and non-scientific and religious communities:

I talk with many people... even my wife. [...]I talk with people in church who don't do any research but I also talk with stem cell scientists and non stem cell scientists and I go to the journal club or some talks that may be relevant to stem cell science but in a lot of cases, I get many new ideas from the non stem cells field.

In 2007, his effort was rewarded. His work led to the discovery of a technique for reprogramming cells into a pluripotent state and placed Med Lab among the first four laboratories to announce such a discovery. This marked a new era for Med Lab both scientifically and ethically. *Science Magazine* listed reprogramming as the "breakthrough of the year in 2008" (Vogel, 2008). Since then, research using induced Pluripotent Stem cells or iPS cells has grown to become a major alternative to hES cells (See table 5). For Med Lab, this breakthrough gave the material legitimacy to the plurality of ethical positions: stem cell scientists could now choose between two sets of materials and techniques. The "reprogramming team" was constituted and expanded rapidly to comprise 40% of the laboratory members (See table 6).

- Insert tables 5 and 6 about here -

Reprogramming scientists were either newly recruited scientists or researchers who had transferred from other projects. The reasons invoked were both strategic and moral. Some

admitted joining reprogramming purely for strategic reasons. For instance, one scientist explained he joined the reprogramming team after spending many months trying to unsuccessfully develop a particular type of mouse that he had hoped could become an experimental model. He then chose to shift and use the newly created iPS cells as a model to explore new scientific problems:

> *So it's around this time that basically, in this lab, Roni is figuring out that [reprogramming] technology. And it was very, very much right on top of each other that [my] mouse basically had no phenotype and that this technology became available. [...] So [I] just chose the things that [I was] interested in, [...], then I just decided to throw that technology at those things and see what came out.*

Other scientists mixed personal preferences with strategic thinking when deciding to join a specific team. For instance, one new PhD student on the reprogramming team explained that she decided to join the laboratory to work with iPS cells because she was interested in the medical promise of stem cell research but she disliked the need to use human embryos:

> *There are some fatal flaws with hES cells that would have prevented me to jump in as wholeheartedly as I did with IPS technology which is that the genetics will never match and that you require human embryos to generate them.*

She and several other members of the reprogramming team mentioned that they would not have joined the laboratory if reprogramming had not been available. The reprogramming team grew from one Postdoctoral Fellow in 2007 to 20 scientists by 2011

as researchers joined from outside the laboratory or from adjacent teams (See table 6). Divergent ethical positions had been translated into a concrete material innovation and ongoing research.

New members on the reprogramming team came to take the co-existence of diverse ethical perspectives for granted. For instance, one scientist on the reprogramming team who did not want to work with hESC cells emphasized the tolerance in the laboratory of diverse positions:

> *I don't have any problem with the deriving of hES cells, but it is like drinking beer. Some people drink beer, some people drink wine. I think we can drink any kind of alcohol.* [...] *I think the reason that our lab does not have anything to do with ethical issues, for me, is because [there is space for] your preferences like IPS cells and lab derived stem-cells from embryos.*

While in the previous phases, the focus of laboratory members were on legitimizing emerging ethical differences, the focus in this final phase focuses on maintaining the legitimacy of the original position of the laboratory in favor of using human embryos. Some members of the embryology teams were disgruntled about what they viewed as the ethical qualms among the newcomers. The embryology teams had more difficulty replacing scientists who moved on to other projects or laboratories. Despite these difficulties, the senior members of the laboratory sustained their efforts to legitimize the use of hESC both externally and internally. The laboratory continued public interventions and conferences aimed at discussing the ethics of research using human embryos and hES cells. The senior scientist of the laboratory also took a role more dedicated to bioethical discussions in the laboratory.

- Insert tables 6 and 7 here –

3. Embedding ethics in the innovation process

The internal ethical positions differed by scientists in the laboratory, they are highly codified. Scientists reframed ethics as part of science and this reframing allowed them redraw the boundaries between expert and non-expert knowledge.

3.2. Ethics as a substantive part of science

The decision whether to work with different materials took on an ethical meaning as part of the creative process of scientific discovery and contribution. For instance, a PhD student cast her ethical position not as a personal one but as a matter of scientific and medical ethics in general:

> *Because if that work were therapeutically oriented - I am looking at IPS cells to find a treatment - then,[if] this treatment cures cancer, I can see a far-sided future [where], if you don't believe in stem cells research, you're not invited. Clearly it's more complicated than that. I would much rather work on a treatment that everyone would be able to partake in, regardless of their moral views.*

The leader of the embryology team also explained that he understood his work and the use of embryos as part of his broader contribution to science:

> *[...] being a physician, I take for granted the benefit [of science] for patients. The will to give a spiritual sense to one's career is more difficult for other scientists. I have this from my work as a physician. I would be happy with generating small incremental changes whereas others would not. There is a sense*

that big leaps are made with big programs, this is why there is the "Stem Cell Program".

In contrast, ethical discussion detached from scientific concerns was generally dismissed. The following event illustrates this. Max, a technician was dissecting mice embryos in order to retrieve their aorta. Sharon, a postdoctoral fellow and Max's supervisor joined in. They had a total of 75 embryos to go through that morning. While Max had begun earlier, Sharon was catching up easily. She occasionally asked him how many he had dissected, noting her own number of dissected mice, making it plain that she was outpacing him. During the task, Max began discussing his involvement in a bioethics seminar organized by Eastern University. One participant was opposed to stem cell research and believed that conception began at birth. This led to a discussion on stem cell ethics. Sharon acknowledged it was a complex issue, adding: "I do not agree with everything, the idea of creating non-viable embryos is a slippery slope." Max continued to talk about the dilemmas of using of embryos for research by mentioning the *Fireman's argument*: "if you had to choose, should you save 20 embryos or the 5-year-old girl?" The argument goes that if you had asked Jefferson about slaves and the 5-year-old girl, he would have chosen the girl." He explains that this argument put forth by pro-lifers purports that our disregard for embryos is as culturally backwards as that of historical disregard for slaves. He continues thoughtfully: "If life begins at conception…." At this moment Sharon glanced at Max's work and interrupted him "How many embryos have you done?" Max said: "10" Sharon said: "17." After the last interruption, both scientists returned to their silent work. The postdoctoral fellow's nudge was clear: Ethical talk should not distract from ongoing work, ethics were not part of this task.

As this last example illustrates, diverging ethical positions that were not part of the creative strategy of the laboratory were deemed unproductive, illegitimate. As a result, several scientists sought to weave their ethical preferences within their strategic vision of their field of inquiry. This later move enabled scientists to place ethical debate on the same basis as the empirical debate: as part of the core process of doing science. This mobilization of alternative ethical positions at the service of science strengthened their capacity for scientific creation and innovation.

3.3. Bioethics is for experts: Redrawing the jurisdictional boundaries of science

Such mobilization suggests that the only relevant actors in the ethics-science debate could be researchers. As scientists pushed back against ethical discussions which they saw as a distraction from science, they cast non-scientists as irrelevant to the ethics debate. Outsiders were not invited to the debate and this was also true for technicians: ethics became a matter reserved for scientific experts.

While researchers were involved in decisions over how to integrate ethics into their everyday work, technicians were much less part of this process. Technicians joined the laboratory to so specific work that may or may not have entailed working with hES cells. Those who decided to work with human embryos and hES cells were highly regarded and praised for their skills. The career of these technicians however was strongly attached to their working materials. They became specialists in stem cell techniques as opposed to researchers who tied their reputation and presentation of self to an area of inquiry (cancer, blood, or early cell development). One episode illustrates this difference between technicians and scientists. The day following the

lifting of the federal funding ban on stem cells, a technician from the embryology team joined me and asked with excitement if I had heard the news. I asked if it made a difference to her, telling her that I had spoken earlier with Peter, the postdoctoral fellow in charge of the embryology team who had showed little interest in the news. She told me somewhat bitterly: "He doesn't care; he is moving to his new laboratory, we are staying." Peter was about to move to a new position as a laboratory director. He had applied for and obtained the federal grants necessary for the establishment of his own laboratory before the federal ban was lifted. This had meant crafting a research program excluding the use of the hES cell models he had developed with private funding. While he lost the ability to work with his models, he did not lose the abstract knowledge and reputation he accrued from developing those models. In contrast, the technician's reputation and expertise was tied to the material model she had worked with, not to the abstract knowledge that had been developed through her work.

Technicians were not just more dependent upon the working materials for their expertise and reputation than researchers; they also lacked the social skill or scientific knowledge to craft their image towards the lay public. Many Postdoctoral Fellows admitted managing their image in front of outsiders to the laboratory. The leader of the embryology program explained he assessed his audience when discussing his work. He generally privileged the abstract aspects of his work over its material aspects: he would discuss the type of research he was engaging in – understanding early cell and embryo development – and only discuss the particular materials – embryos and stem cells if he felt comfortable with his audience:

I was at the barber yesterday and the guy's asking me, "What do you do?" And he's got like a sharp pair of scissors. [laughter] If someone asks me what I do, I don't say, "I destroy human embryos to make human embryonic stem cells." I say, "I do stem-cell research." And then you'll get a sense of what their feeling is like. So that's usually how I approach it.

Another postdoctoral fellow noted that when she prepared for her wedding, she did not tell the details of her work to her Catholic priest:

Well I am Catholic. It is strange we got married last year with my husband and we had a religious ceremony and we thought, well we are getting married religiously but the priest would probably not approve much of the things we do in our lives. But it is just a ceremony really, for your friends and family.

While this position created ambivalence for her, she nonetheless worked out her public image with her religious community. In contrast, technicians do not generally work out their image when presenting themselves to the public. One technician recounted how she once mentioned working for a stem cells laboratory during a meeting with her church:

I am very involved in my church at home and I was having a conversation with someone and that person asked me what I was doing and I said 'I work in a Stem Cells lab.' You know I wasn't thinking, 'I'm in a Catholic church right now.' And there was this older woman and she looked at me, angry-eyed, with this angst in her eyes and I got really scared [laugh] and she in polite terms but basically called me a baby killer and walked away.

The technician was particularly distressed that she was not given an opportunity to explain her work to the group of churchgoers. She admitted neither having made up her mind strongly regarding the ethics of stem cell research nor having devised a strategy for presenting herself and her work to external audiences:

> *I was in shock because, you know small town and Catholic Church and this woman is literally ... [nervous laugh]. But overall I guess I never really had a strong political stance on it or moral stance on it. But I am open-minded, I accept things the way they are and go along with it [nervous laugh].*

Alex, another technician, newly recruited to work with one embryology team, professed a high enthusiasm for being part of such an exciting place:

> *Will extended an offer to me [...] I had not even considered Eastern City. But I would have been mad to turn it down, because it's a very good position, and it gives me a lot of opportunities to collaborate. Like just this area is so dense with research, it would have been foolish of me to [decline].*

However he was weary of the reaction of people in his hometown: "[...] people in my family will tell other people, acquaintances, 'Oh, yeah -- he works with embryonic stem cells,' and apparently they flip their lid over it." For these technicians and their families, sharing the prestige of working in a highly regarded laboratory also means sharing its stigma. They do not distance themselves from the material aspects of their work as the researchers do.

Finally, within the laboratory, technicians had less legitimacy than the scientists when discussing ethical aspects and as a consequence were less involved in the ongoing ethical discussions. While the brown bag ethics discussions were open to all laboratory members, they were organized and led by researchers or ethicists. At the bench, technicians were also given little opportunity to discuss bioethical issues, as exemplified by the earlier interaction between Max and Sharon.

Technicians are considered staff. They are viewed (and view themselves) as occupying a specific role that is to assist researchers with the technical tasks involved in experiments. Researchers typically unload the more repetitive or distasteful tasks involved in the experiments such as tissue culture, animal work, or the preparation of various chemical and biological agents needed. Researchers often seek to compensate for the demanding and often dirty work expected from technicians paid a relatively modest salary by including them in the research aspects of their tasks. They typically explain the purpose and broader context of the experiment. When postdoctoral fellows know that their technician is interested in applying to medical school or to a PhD program, they will informally mentor him or her to "think like a scientist:" they then focus more on the theoretical and planning aspects of experiments as opposed to telling the technician simply how to practically complete the experimental steps. Yet, aside from these breaching encounters, the contributions of technicians are viewed by researchers mostly in terms of their productivity. As non-researchers, technicians were deprived of the community's main means of developing their ethical position: Participation in the scientific process of innovation. As such they were excluded as legitimate actors in the shaping of the group's shared understandings of ethics.

The technicians' identity is attached to the materials of the laboratory, in this case stem cells. But at the same time, technicians have less of a say in understanding and shaping the meanings attached to these materials. The forging of ethical understanding is a scientific matter, reserved to researchers. The sidelining of technicians reinforced the notion that ethical issues are a scientific matter best left to experts.

These practices reflect the rhetoric and actions of scientists in the public sphere: The only scientists who publicly admitted their discomfort with using hES cells were those who found technological alternatives. When scientists admitted this personal preference they still took great care in upholding the moral legitimacy of hES cell research by celebrating the scientific accomplishment and casting themselves as players in this research stream. Consider one additional event.

In 2010, two scientists filed a law suit for unfair competition against stem cell science. Their argument was that federal funding of research using hES cell models amounted to unfair competition because it put scientists who refused to work with these models for religious or moral reasons at a competitive disadvantage. Not only was the case recently dismissed (Gardinier, 2010) but it also attracted the wrath of the stem cell community. The scientific community cast the two scientists as outsiders by emphasizing the troubled relationship these scientists had with their respective institution. This instance exemplifies the redrawing of the boundaries of science where scientists with divergent positions were included only insofar as they were willing to contribute to science rather than work against it.

In this interactional order, outsiders or non-scientists such as opponents or technicians were denied legitimacy over ethical matters. Abbott (1988) refers to the domain over which professionals claim authority through expertise as "jurisdictions." Studying specifically the work of scientists in maintaining authority over science, Gieryn (1983) notes that scientists constantly redraw the boundary between science and non-science through rhetorical actions in order to maintain authority over their domain. In this case, stem cell scientists came to include ethics as part of their internal jurisdiction or domain of expertise. The integration of ethical debate as part of the scientific process further strengthened science's ability to operate and innovate independently of other institutional challenges. It expanded the domain over which scientists claimed authority.

4. Discussion

Scientific and technological communities generally profess to place non-scientific matters such as ethics beyond their domain of expertise (Gieryn, 1983). Thus if we are to concentrate on the public actions and talks of scientists, we may miss important ways in which other institutions – religion for instance – penetrate science and constitute an opportunity for change and innovation. From this, several implications arise. First, contrary to what scientific or technological communities profess, ethics can be an integral part of the innovation process and local ethical divergences may constitute opportunities for innovation. Second, the constitution of moral legitimacy is not a post-hoc justification process but rather is grounded into the constitution of new products and activities.

From boundary-objects to contested objects: ethical frictions as creative opportunities

Star and Griesemer (1989) define boundary-objects as epistemic objects that both inhabit several intersecting social worlds and satisfy the informational requirements of each of them. Boundary-objects facilitate collaboration across different communities precisely because they represent different meanings and can help translate and transfer knowledge across communities (Bechky, 2003b; Carlile, 2002). My study adds to this understanding of knowledge sharing and innovation across communities by looking at how the multiple meanings represented by some objects and artifacts might also by contested. Stem cells are contested objects in the sense that they represent competing meanings for different groups. As a result, they generate ethical friction or conflicts among multiple principled standpoints (Stark, 2009). In Med Lab, one group sought to embed their own principled standpoints into a first round of technological creation (hES cells derived from PQE embryos). Principled disagreement with this technology led to the creation of novel technologies (IPS cells). While IPS cells may not be an exact equivalent to hES cells, they nonetheless opened new technological possibilities and served as a gathering point for scientists with diverse motives (ethical or scientific).

Moral legitimacy as emergent from local practices

Struggles over legitimacy have generally been studied at the boundary between competing institutions or groups. In this paper I build on the call to consider the local embeddedness of institutional contests (Hallett & Ventresca, 2006a; Binder, 2007). The inhabited institutions perspective highlights that far from being "institutional dopes", organizational members can actively negotiate among competing frames or "logics" provided by the various institutions and

their logics that penetrate organizations. In the case of stem cell science, the acknowledgement of locally diverse ethical positions was an opportunity for the creative enactment of these positions. This enactment can be viewed as related to what Fligstein (2001) defines as social skill or "the ability to induce cooperation among others." In the stem cell community, scientists skillfully used rules and resources in their attempts to shape their environment. As members of a nascent field with high social ambiguity over what was the "right thing to do," they were able to craft moral justifications that appealed to actors with different interests and identities. On the public front, they crafted a clear ethical position shifted their interests and practices. Once this position proved untenable internally, they nuanced this position in practice in order to collaborate across diverse ethical perspectives. At the same time, they maintained the initial ethical position on the public front and continued the work of gaining external legitimacy. Through this "dual ethics work" (public moral homogeneity alongside private moral heterogeneity), scientists strengthened their own field of activity and expanded their authority by integrating ethics within their domain of expertise. In this case, the moral legitimacy of stem cell science emerged from the local attempts of scientists to embed their own ethical positions in the structure and practices of their community.

This case highlights how moral legitimacy is produced through the everyday work of organizational actors as they embed their ethical views in the structure of their institution through rhetorical actions and material innovation. Moral legitimacy is not just a post-hoc justification of a new product or activity; rather it is an integral part of the change and innovation process as it is practiced through everyday work.

Table 1: Rhetorical oppositions developed by stem cell research opponents

Religion	**Science**
Moral	Amoral
Sacred	Material
Religious	Secular
Pure	Tainted

Table 2: Tropes used by opponents to stem cell research

Religion		**Science**	
Expression	**Content**	**Content**	**Expression**
Sanctity of life "Adopt an embryo"	Conception is the only known boundary	Destruction of human life	Embryo destruction
"Do no harm" "Harm already done"	Lead a good life Dignity of human life	Science can harm vulnerable individuals	Early century medicine World war medicine
Community	Be a member of your community (share rites, beliefs) Moral beliefs must be communal Science and religion must dialogue	Uncontrolled science can lead to immoral practices Uncontrolled scientists can harm society	"Slipery slope" Rogue scientist Scandals

Table 3: Rhetorical oppositions developed by stem cell research advocates

Science	Religious opponents
Secular	Religious
Enlightened	"Pre-enlightened"
Rigorous	Uninformed
Pragmatic	Ideologist
Democratic	Absolutist
Caring	Indifferent

Table 4: Tropes used by stem cell research advocates

Religion		Science	
Expression	**Content**	**Content**	**Expression**
Science should be autonomous	Research is progress Science is a moral imperative	Religious beliefs hinder progress Barriers to knowledge production hinders scientific and medical progress	Barriers to science
The social responsibility of the scientist	Scientific norms ensure responsible behavior	Distrust in science and scientists is misplaced	Uninformed public "Frankenstein"
"Surplus" embryos	"Good use" of embryos Pragmatism of science	Assumptions about frozen embryos are misplaced Symbolic beliefs are misplaced	"Adopt an embryo"
Translational research	Searching for medical cures is a justification for science Finding cures for humans is a moral imperative	Indifference to human suffering Fatalism	Barriers to progress

Table 5: Research mentioning hES cells and iPS cells (Source: Web of science)

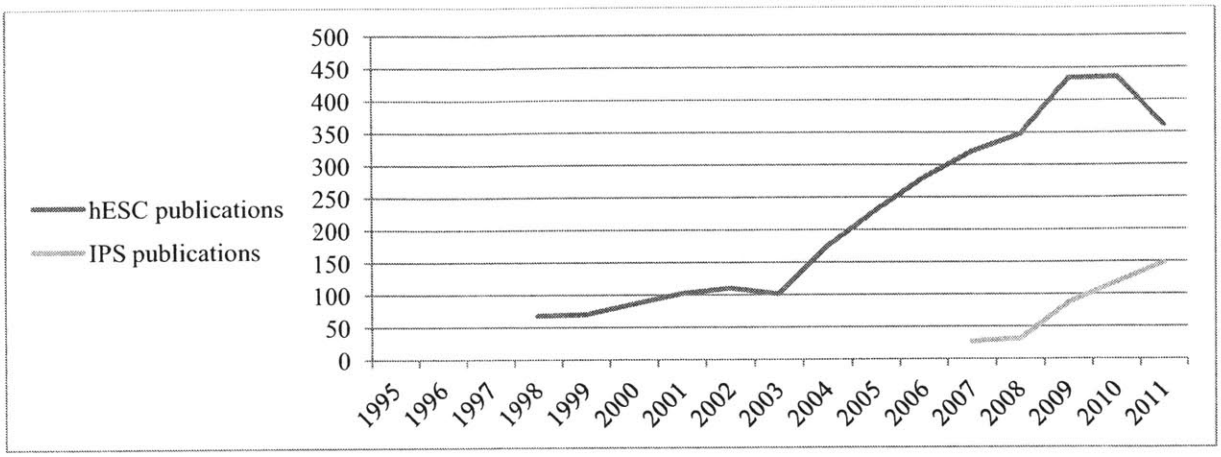

Table 6: Changes in number of scientists on the embryology and reprogramming teams over time

	2007	**2009**	**2010**
Embryology teams	12	12	7
Reprogramming team	1	18	20

Table 7: Ethical and material trajectory of Med Lab

	Phase 1 **1998-2004** **Unified position**	**Phase 2** **2004-2007** **Emergence of dissent**	**Phase 3** **2007 –** **Heterogeneous position**
Individual Strategies	Recruitment of post-doctoral fellows to work on alternative to hES cells	Risk-taking strategy of one post-doctoral fellow (mostly moral reasons)	Pragmatic strategies of followers: joining the successful alternatives (mix of moral and strategic reasons)
Laboratory's ethical trajectory	Unified internal perspectives Public policy interventions	Redefinition of the ethical position of the laboratory to include tolerance for diverse moral and religious perspectives Open ethical discussions in the laboratory (Brown-bag series)	Decrease of the ethical contests and discussions Legitimacy of hES cell research upheld (knowledge and techniques developed by hES cells research made the development of the alternative possible) Continued public policy interventions

Table 7 (continued): Ethical and material trajectory of Med Lab

	Phase 1 **1998-2004** **Unified position**	**Phase 2** **2004-2007** **Emergence of dissent**	**Phase 3** **2007 –** **Heterogeneous position**
Laboratory's material trajectory	Mouse and human ESC as main model	Mouse and human ESC as main model	Invention of Reprogramming Rise of the Reprogramming team Leveling of research with hES cells
Key Dates	1998- Isolation and patenting of hES cells 2001 – Funding restriction for hES cell research	2007 – Discovery of reprogramming (IPS cells) by 4 laboratories including Med Lab	2008 – Modification of funding restrictions of hES cells (redefinition of "ethical" stem cell lines based on consent) 2009 – Eleven hES cell lines of Med Lab approved for federal funding 2010 – Continued controversies, attempts to revoke the approval of hES cell lines, vigorous boundary-work from the scientific community

CONCLUSION

Safety and bioethics constitute two of many ethical dilemmas related to knowledge and technological communities. These are significant issues for several reasons. First, workers in knowledge communities constitute a growing part of the workforce (Blackler, 1995; S. R. Barley & Kunda, 2006). Moreover a significant amount of innovation and entrepreneurship occurs within networks of knowledge workers and expert communities (Powell, 2001). Finally, knowledge communities operate within increasingly complex and polarized ethical frameworks. Bioethical issues are endemic to biotechnologies (Radin, 1996; McCarthy & Kelty, 2010) and medicine (Almeling, 2007; Anteby, 2010; S. Epstein, 2007). But ethical dilemmas also extend beyond bioscience and medicine to include other scientific or technological areas such as nanotechnologies, finance and energy production. The ability to navigate complex ethical issues is therefore central to the functioning of many knowledge communities, to their ability to innovate and to their relation with social constituents. The energy industry is a case in point: traditional energy organizations have notably struggled to develop green technologies while standalone organizations that develop sustainable energy sources have struggled to expand.

Several studies have shown that competing logics can be either detrimental to organizational action (Besharov, 2011; Turco, forthcoming) or kept at bay by communities desirous to maintain autonomy from social expectations (Ho, 2009; Meyer & Rowan, 1977). A growing number of studies suggest however that the coexistence of heterogeneous moral frameworks can be generative. Moral heterogeneity can lead to the creation of new practices as actors blend (Binder, 2007) or recombine (McCarthy & Kelty, 2010; F. Murray, 2010; Stark, 1996, 2009) competing institutional logics.

What makes knowledge communities open to external ethical frameworks? How do these communities become capable of translating competing moral frameworks into everyday practices? How is it that rather than solely enforcing strong boundaries between their institution and other logics, stem cell scientists engaged with surrounding controversies and integrated contending positions within their practices?

To answer these questions, I extend Fligstein's notion of social skill to develop the metaphor of *skilled games* and apply it to the actions of Med Lab scientists. As noted earlier, Fligstein developed the notion of social skill or the ability to induce others to cooperate as a core mechanism in the construction of local orders. Central to the notion of social skill is that actors need to motivate others to cooperate. They do so by taking the perspective of other actors to persuade them to cooperate. Rules and resources are the constitutive blocks of social life but actors must be able to use them skillfully. Skilled actors induce collaboration by defining collective interests and identities that allow for institutional change.

To the concept of social skill, I add the notion of game. Games are recurring patterns of interactions that occur within a given social order and obey to the internalized rules of this particular local order (Burawoy, 1979; Goffman, 1969). Social actors adopt a particular role yet are aware that they play a game, that these interactions are deceiving. For instance, in Med Lab, safety interactions can be viewed as a game. Postdoctoral fellows adopt the role of defenders of professional practice while technicians more likely play the role of defenders of bureaucratic rules. While these games maintain the status quo, they are nonetheless significant because they can shape local practices.

Heterogeneous ethical frameworks provide two sets of rules that can be a resource for creativity but these resources need to be mobilized through skilled games by organizational actors. These ongoing games are made possible through *the inclusion and management of heterogeneous perspectives*, *shared rules of the game* and *the maintenance of dissenters in the contending game.*

Inclusion and management of heterogenous perspectives. As Stark (2009) described, the coexistence of multiple mode of governance or *heterarchy* is a source of creativity. Yet the coexistence of multiple frameworks in itself is insufficient. One dominant moral frame might become normalized and therefore unquestioned by organizational members. A community must be able to maintain ongoing local tension among different frameworks. In Med Lab, this means the careful inclusion and management of moral heterogeneity. The laboratory director pursues actively a "generalist" strategy", which means following diverse scientific leads, as opposed to a specialized strategy that many laboratories pursue. As a result, he recruits scientists with diverse profiles and interests, leading to the coexistence of diverse research communities within the lab. He also recruited a few scientists who requested to work on alternatives to human embryonic stem cells. Will, the senior scientist, also favors diversity and seeks to include the view point of dissenters in the lab dynamics. In the safety contest, Will takes seriously some bureaucratic rules and seeks to implement them and blend them with professional rules. In the bioethics contest, as it appeared that the laboratory harbored moral dissenters, he supported them and organized ethical discussions that served as a forum for scientists. Scientists in Med Lab are constantly encouraged to speak up on all matters ethical. The two leaders actively seek and manage heterogeneity and uphold the internal legitimacy of dissenters. The two leaders play both

legitimacy and a collaboration game: while they defend the moral legitimacy in the public sphere, they tolerate and encourage internal dissent.

Shared rules of the game. These games occur in specific social worlds regulated by the internalized norms of their members. In this case, games occur within the social order of Med Lab, heavily influenced by the norms of science (see chapter 3). But a number of rules emerged that allowed the games to go on. First contentious interactions are limited to specific spaces: the bench for safety, bioethics discussions and laboratory meeting for bioethics. Contention is hence limited to designed space and does not pervade the laboratory. Second, roles are ordered. Laboratory members play different roles depending on their hierarchical position and their location in a particular research community. Third, ethical dissent follows the rules of the community: it is expressed through scientific innovation rather than by public contest that would undermine scientific legitimacy. These rules allow the contending game to be ordered and structure and allow for the following condition: the maintenance of dissenters in the contending games.

Maintenance of dissenters in the contending game. The initially dominant group in Med Lab did not seek to defeat the dissenters but rather engaged in ongoing discussion and collaboration with them. After the invention of reprogramming, researchers using embryonic stem cells became the minority dissenters. But they remained legitimate and productive members of the laboratory. Internal dissenters are kept in the collaboration game as long as they also play the legitimacy game.

This study contributes to the micro-foundations of institutional change by building on Fligstein's framework. The maintenance of a public unity in defense of human embryonic stem cell research is expected both from a micro-institutional viewpoint: the dominant group defends the status quo. Yet more unexpected is the local inclusion of ethical dissent. The ongoing inclusion of dissent can be viewed as skilled games. Through skilled games, organizational actors are able to creatively blend multiple institutional logics in practice. This blending allows the institutions of science, law and religion to further interpenetrate and reinforce one another.

There is evidence that the stem cell controversy has led to a growing institutionalization of ethical considerations in both science and the law. By claiming expertise over matters ethical, stem cell science has regained authority over its practices. The last regulatory episode of the "culture wars" related to stem cell science occurred in 2010 when a judge sought unsuccessfully to overturn the lifting of the ban on federal funding. Stem cell research and regulation, a hot topic of the presidential elections since 2000 has been absent from the 2012 presidential campaign. Stem cell research remains a heavily regulated field but the federal rules adopted are now more aligned with the rules defined by the scientific community. Scientific bioethical committees, meetings and lobbyism groups have remained in place both at the National Academy of Science and within the stem cell community. More importantly, research with human embryonic stem cells and research with reprogrammed cells have both grown despite concerns that reprogrammed cells may be technically inferior to embryonic cells. Scientists can now make a choice according to their scientific and ethical beliefs.

The law has also expanded its authority and infrastructure over matters ethical. Presidential bioethics committees have become permanent. Federal regulation of bioethics has expanded at each controversy. Even when the funding ban was lifted in 2010, the result was more regulation and the creation of a new NIH committee to oversee the application of the new federal rules. The interplay between science and law has resulted in the reinforcement of both institutions.

Contribution to sociomaterial approaches

This story is also a story about people working with contested objects. Materials are inextricably bound with social practice (Barad, 2003; B. Latour, 2005; Orlikowski, 2007). Moral orders are grounded or materialized in particular objects and their reproduction is inseparable from these objects. While the notion that some objects are socially contested is widespread in sociology and legal studies, there is little theorization around the performativities of such objects. How do these objects shape work practices? How does one work with materials that embody highly competing notions of ethics? What does it mean for the worker's identity? In this work, I have taken seriously the notion that materials, through their meanings shape how one engages with them, how work practices are structured around and with them. In Med Lab, the invention of reprogramming shifted the moral order of the laboratory. To choose not to work with human embryonic stem cells became an easier choice, one that was increasingly made by laboratory members. The laboratory became less concerned with pushing the boundary of what is considered ethical. The moral order of Med Lab became more conservative, less in favor of moral risk-takers or moral entrepreneurs and more in favor of safer moral choices. At the same time, the sum of its research became more aligned with social expectations, allowing research to

move into directions more comfortable for society but that were nonetheless scientifically productive. Reprogramming made possible the shift towards a more conventional ethos. But it undermined the moral risk-taking ethos that had traditionally dominated the laboratory. The socially contested technology of embryonic stem cells fostered moral risk-taking both for those who chose to work with these objects and for those who chose to search for alternative. The less contested reprogramming technology fostered more conservative practices and undermined earlier research efforts in spite of continued attempts at defending the morality of stem cell research. Contested objects, objects that embody and represent competing meanings can shape work and innovation practices. In order to better understand how, I draw on our understanding of the role of boundary-objects on work practice.

Boundary-object are objects that embody several different meanings relevant for distinct communities (Star & Griesemer, 1989). As such, they facilitate collaboration and knowledge-sharing across occupational communities (Bechky, 2003b; Carlile, 2002). One might hypothesize that contested objects can stymie collaboration because they embody incompatible meanings. This study adds to the literature on sociomateriality by showing that contested objects do challenge collaboration but they also facilitate creativity. The source of creativity lies in organizational member's attempts at overcoming collaboration issues. In Med Lab, contested objects introduce boundaries across communities. Each community develops its own work ethic in relation to their experimental models and partly in opposition to the other communities of Med Lab. Laboratory members define their work preferences in opposition to other's preferences (for instance some members preferred to work with mice rather than stem cells while other considered that using stem cells was preferable to animals). As a result, contested objects

introduce conflicts. Yet these conflicts allow knowledge sharing, albeit with ongoing frictions. In addition, contested objects introduce a need for closure, for conflict resolution. In seeking to resolve these conflicts, Med Lab members craft new practices that bridge the two sides of the debate, allowing for the interpenetration of different logics.

Contested object presuppose the local existence of multiple modes of governance. Objects may be contested in the public sphere but consensual, normalized in a given community. While social contestation is grounded in extra-local phenomena, their local mobilization depends upon the members of a community. For these members, when working with morally contested objects, there is no morally "safe" option: one must make a moral choice, take a moral risk. Morally contested objects introduce creative disruption until morally "safer" or consensual alternatives are crafted. While contested objects introduce disruption, their resolution leads to closure. The maintenance of moral frictions then depends upon the ability of social actors to continually problematize the objects they work with.

Breakdowns and limitations

Moral frictions are hence susceptible to breakdown and closure. A number of such breakdowns occurred in Med Lab.

First, skilled games can wane. If contestation wanes, the coexistence of different rules becomes problematic. The most dramatic example in Med Lab is the radiation incidents. When contentious safety interactions are no longer sustained in the area of radiation work, crucial knowledge, scientific knowledge, is no longer asserted and maintained. Laboratory members come to rely upon an incomplete body of knowledge: bureaucratic rules. Contentious

interactions can easily break down in general, for instance as a result of organizational members favoring consensus over the defense of a set of practices. Because ongoing improvisation and creativity here depend on a specific type of interactions – skilled contending games - one framework can overcome the other and become rigid when these interactions are no longer sustained.

Second, problematic too is the silencing of actors deemed irrelevant. In the interactions around safety, newcomers and technicians are maintained in the game. But in the debates over bioethics, technicians and newcomers are largely marginalized. There, divergent moral positions are tolerated as long as they are at the service of science and not against scientific progress. Not all scientists are equally able to legitimize their ethical positions. Because legitimation occurs through the creation of scientific knowledge, only high-status expert members (experienced postdoctoral students) are able to work on the integration of divergence. Technicians and PhD students have less leeway in aligning their work with their moral position and self-conception. Hence contestation largely remains within the social order of the laboratory. Divergence is tolerated only when divergent members respect laboratory norms and do not seek to challenge science itself. Outsiders – as non-experts – are still denied the legitimacy to assert their position and to shape scientific inquiry.

Third, the existence of skilled games presupposes the existence of skilled actors. Local actors must be able to play the game. To a certain extent, Med Lab members became skilled by seeking to understand, engage with and apply alternative moral understandings. Yet they are also highly educated and inclined to devote their career to research. Ethical search has become one more

project for them. The director of Med Lab also engaged in public debate because of his background in and knowledge of philosophy. It is unlikely that communities engaging in more routine work (for instance engineering communities) are equally able to mobilize ongoingly competing frameworks for doing work.

Fourth, one must account for the role of regulation. In the two cases studied, legal regulation leaves much room for professional discretion. Safety regulation does not aim at replacing all safety practices but is rather designed to be an addition to professional practices. Stem cell regulation from 2001 to 2010 was a particular case of federal regulation that mostly amounted to funding restriction with privately funded research left unregulated. These laws allow for heterarchy. Can heterarchy unfold when the law is either too restrictive (In France and Germany, stem cell research is so restricted as to be virtually inexistent despite important scientific centers) or inexistent?

Finally and perhaps most noteworthy, creative contests require local norms of tolerance for dissent *and* a vigorous public and political opposition. Without these two conditions, change is less likely to happen. Dissenters in the laboratory are the last echelon in the broad ecology of contestation to traditional scientific practices. To view laboratories as inhabited by institutional actors is to reassert the need for competing institutions that provide opportunities for problematizing what may otherwise be taken for granted and for taking seriously local actors' attempts at coupling organizational practices with institutional demands. This unlikely ecology is hence easily susceptible to rigidification. The radiation work breakdown is one such instance. Another instance is also the adoption of a morally safer technology: Reprogramming. As noted

earlier, the laboratory became more conservative as more members shifted from morally risky endeavors with human embryonic stem cells to morally safer research with the technological alternative. New laboratory members in the reprogramming team did not question their choice or expressed much moral ambivalence regarding their research. They also massively chose to join the reprogramming team. With socially contested technologies moral risk-taking is unavoidable. With the invention of safer alternatives, moral risk is only optional. Closure is perhaps inevitable if moral dilemmas can be overcome, however unsatisfactorily.

Ethical conflict and social responsibility

Morality is closely related to social responsibility or the alignment of institutional templates and practices with social expectations. Many areas exist where social consensus about what is moral is sufficient to consider whether organizational action is socially responsible or not. Yet organizations can also operate in areas where no such consensus exists. This is the case of stem cell science where the moral imperative of medical progress is pitted against the moral imperative of respecting human life. These dilemmas raise the question of how might we think of the social responsibility of organizations delving in contested areas.

For organizational members delving into socially contested areas, heeding the demands of various and sometimes competing stakeholders (shareholders, patient groups, environmental groups or regulatory agencies) often proves challenging. This challenge is heightened when organizations are composed of powerful expert communities. Local ethical contests are however a means by which alternative logics can penetrate otherwise closed and autonomous expert communities.

In Med lab, ethical contests led to the production of scientific knowledge and technologies aligned with both contending groups: proponents and opponents of stem cell research. Similarly, safety contests led to a closer alignment with some social expectations – expectations of standardization, visibility and accountability promoted by the legal institutions. In effect, the inclusion and management of ethical heterogeneity led to the closer alignment or coupling of practices with diverse social concerns whether these concerns related to safety or bioethics.

In socially contested areas, the inclusion of moral heterogeneity can be an occasion for coupling practices with social expectations. As noted earlier, such coupling is more likely to occur when internal dissenting perspectives are actively maintained and managed, when organizational actors are socially skilled and when regulation is flexible. The close alignment with social expectations does not end moral risk-taking (although it makes it more difficult). The initial dominant position in Med Lab has become the dissenting one but is nonetheless kept in the game. As long as strong moral oppositions continue, it seems preferable for expert communities to pursue both avenues simultaneously rather than one or none. Most importantly these cases show that moral legitimacy is not necessarily a post-hoc justification of extant practices but also that institutional practices are constituted as ethical (or socially responsible) through ongoing local struggles, reason enough not to underplay the social responsibility of the doers.

Directions for future research

Stem cell research is an examplar of intense bioethical contestation with its unprecedented mediatization, intense social mobilization and unlikely regulatory roller-coaster. It is however only one of the many pervasive ethical dilemmas that face biotechnologies and medicine. As

biology promises to foray ever more into the living in order to bring scientific and medical progress, it paves the way for new complex ethical issues.

Studies that explore how expert communities include ethical heterogeneity are largely studies of scientists (for one exception, see Stark, 2009). This is unsurprising as scientists are more likely to engage in constant search for alternatives. Future research could address how communities such as engineering or medical communities that engage in more routine work are able or not to integrate diverse templates. The medical community faces several bioethical dilemmas but at the same time must contend with established routines. Important bioethical dilemmas are those relating to medical trials: moral imperatives of doing no harm to trial subjects are in tension with imperatives for finding reliable cures for patients. It may be fruitful to apply the framework developed in this dissertation to study how moral imperatives are balanced and how moral frictions may shape medical trial practices and processes. Another avenue may also be to explore the particular challenges that engineering communities in the energy industry face when seeking to integrate the development of traditional and renewable energy sources. This would allow to explore further the conditions that lead to or hinder productive moral tensions.

Other directions for research would be to study how legal regulation might shape communities' ability to include ethical heterogeneity. Without regulation, communities may not need to include ethical dissent in their practices. Conversely too much regulation may stymie moral risk-taking. In countries that heavily regulate bioethics such as France or Germany, how are communities shaped by these regulatory challenges? One may study strategies that organizations and expert communities adopt to deal with preventive regulation in such countries.

As institutions become more interconnected and as scientific and technological communities seek an edge by moving into morally contested terrains, bioethics will likely continue to vex regulators and place the responsibility of moral choice on those who decide to engage with contested objects.

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