Publicly Private: Legitimacy and Power in the Laboratory

Undergraduate Research Thesis

Presented in partial fulfillment of the requirements for graduation with *honors research distinction* in Comparative Studies in the undergraduate colleges of The Ohio State University

By

Lee Knupp

The Ohio State University

April 2024

Project Advisor: Dr. Christopher Otter, Department of History

Introduction

The laboratory is a curious place—a physically bounded site with various material extensions that has become central to scientific knowledge production. The constructivist nature of the laboratory is well-established amongst scholars but is not reflected in understandings of science and lab work outside of science and technology studies. Explicitly tying historical examples to critical studies in various disciplines sets up a conversation about how privacy is used in and around labs today. A formulation of imaginaries—broad, deep ways of imagining one's social existence, relationships, and norms and the notions that underlie them—by Charles Taylor involves "a widely shared sense of legitimacy" about how things are ordered based on a common understanding of what is real (Jasanoff 7). Jasanoff recognizes that science and technology are missing from classical accounts of social imaginaries; she calls out the failure to engage with knowledge and its materializations in creating imaginaries of social order (Jasanoff 8). Scholars are aware of the relations of histories of science and technology and political histories, but a detailing of these interconnections is missing (Jasanoff 10). This project, in acknowledgement of this gap, argues that scientific work, particularly when it is pulled firmly into the public, often has explicit political implications. The laboratory, as a historical product, has become central to justification and truth production in society at large. In this context, private/public divisions are strategic performances of legitimacy and mystification used to construct and reinforce scientific authority. This is evidenced in the historical construction of what a laboratory is, perspectives on how labs are designed and used today, and processes of exiting the lab.

Laboratory studies became a focal point of sociology of science in the 1970s, largely led by Karin Knorr-Cetina and Bruno Latour. Knorr-Cetina expertly lays out the constructivist nature of scientific knowledge, using the laboratory as a site of analysis, and in *Laboratory Life* Latour confronts the difficulties of studying science anthropologically. Both scholars elaborate on the resistance met when treating science and scientists as cultural entities whose knowledge production is constructed by their own assumptions and practices. It had been more common before this specific attention to laboratories for sociologists to construe science as another world, where common practices, like reading and writing, are done as part of a larger project—something more in line with an objectivist perspective. Knorr-Cetina asserts that labs display more concern with making things 'work,' valuing success over truth (Knorr-Cetina 4). She and Latour narrow in on processes of selection and translation, both directly by human decision and through apparatuses that serve to distance results or 'substance' from the rest of the process. The notion of a black box—a term used to describe something that has been intentionally complicated to be seen as one object that cannot be unpacked—is formulated as a strategy scientists and labs use to bolster or legitimize their work (Latour, *Science in Action* 131). Latour details a sort of qualified dissenter that can set up their own lab. Now, thoough, claims of mistrust can gain traction among the public like never before. A "layperson," however, does not have the symbolic capital to question boundaries in and around the laboratory; thus, the lab is a black box itself. This paper, in analyzing the edges and particularities of the laboratory, is part of the project of opening the black box that the laboratory has come to be. Knowledge is not discovered or inherent; it comes "to be" through active engagement of scientists and objects in particular situations (Subramaniam 2). The formation of knowledge in this constructivist manner requires establishing boundaries to define different objects and agents.

To understand the boundary that is being traversed when laboratories perform legitimacy and transparency, we have to consider what 'public' means in the context of this project. Jurgen Habermas' work on the public sphere clarifies potential definitions:

> "We call events and occasions 'public' when they are open to all, in contrast to closed or exclusive affairs—as when we speak of public places or public houses. But as in the expression 'public building,' the term need not refer to general accessibility; the building does not even have to be open to public traffic. 'Public buildings' simply house state institutions and as such are 'public'" (Habermas 1-2).

In this project, public is used to refer to ideas of who is deemed appropriate or is allowed to access spaces, materials, and projects as well as places that are specifically constructed as public. Private, then, is made up of what is deemed unfit to be public, emphasizing the deliberate, active restriction of who has the ability to enter and act in the lab. Private has many varying connotations, including the domestic sphere. It is difficult to conceptualize, then, what private means in the realm of science, as it is not a term you often hear scientists use to describe their methods.

These determinations seem more natural and go uncontested when certain ideas and practices become more legitimized. Increased legitimacy also prompts boundaries to shift from sharp and coherent to something complex that divorces the individual from the institution. When engaging in legitimizing practices, transparency eventually becomes the currency for mitigating problems (Colyvas and Powell 326-327). Revealing connections, experiences, and practices that are widely accepted is a strategy to silence any suspicion or dissent. Thus, we must view the laboratory, not as a place concerned with truth, but as a place concerned with justification. Colyvas and Powell also highlight taken-for-grantedness as a critical component of legitimacy.

They use Berger and Luckman's 1967 definition of taken-for-grantedness as "a means by which the social order is reproduced as human activity is shaped into patterns and shared meanings and becomes repeated, habitualized actions, which are subsequently externalized as objective reality" (Colyvas and Powell 327). In their book on the public nature of science, Jane Gregory and Steve Miller use Stanley Aronowitz's work on Marxist and post-Marxist attitudes towards science which critique the domination of nature and humans promoted by scientific practices. "'Science is a language of power,' Aronowitz argues, 'and those who bear legitimate claims, i.e. those who are involved in the ownership and control of its processes and results, have become a distinctive social category equipped with a distinctive ideology and position in the post-war world'" (as cited in Gregory and Miller 68). So, in this investigation of boundaries and strategies, what is really being investigated is power.

Religion, like science, selectively reveals and conceals information, a practice that this paper argues is central to the power of science as well as religion. Both are major societal influences and epistemologies, rely on authority figures, involve belief/faith, and are practiced out of specially designed locations. Hugh Urban's *Secrecy: Silence, Power, and Religion* frames secrecy as a strategy used in the construction of religious authority. Secrecy is inseparable from questions of power, being best understood as a strategy for "acquiring, enhancing, preserving, and/or protecting power" (Urban 10). Urban explains that the specific type of power being dealt with here is what Pierre Bourdieu calls symbolic power: a power granted by others to impose one's worldview and define taken-for-granted understandings of reality through status and authority (Urban 10). Symbolic power is not viewed as power, but rather legitimate reasons to be recognized, believed, and trusted. "Secretism," as defined by Paul C. Johnson, is the public display of hidden knowledge which serves to stake a claim to foundational knowledge that relies on the containment of the knowledge (Urban 11).

Secrecy is fundamental to “the maintenance and dismantling of religious power in relation to broader social, political, and historical interests,” particularly through vestment and adornment (Urban 4). Vestment is the concealment of knowledge, while adornment is the advertisement that knowledge is being hidden. In the context of the laboratory, adornment can be thought of as the obligation to be public-facing—to put distance between the lab’s work and ‘pre-science’ reclusiveness, to validate public funding, and to elevate the status of the scientist. Vestment can, then, be thought of as the acts involved in keeping the actual work private and the myriad of reasons scientists provide to justify their practices; many of these reasons are deemed highly legitimate, like physical safety or contamination concerns. Laboratory adornment practices mystify both the work being done and laboratory science in its entirety. As an example of adornment, consider the website of the Cornell University Biotechnology Building (a laboratory space explored later in this paper). The layout consists of several sections with many subsections, giving the appearance that much information is being revealed. However, the services and instruments included on the website are explained minimally in technical jargon, and one must be affiliated with particular universities and programs to make an account to reserve spaces and equipment. If one did not keep clicking, they could assume that this institution is being transparent, but they just haven’t reached the barrier to the public yet. Something that might seem like transparency instead serves to reinforce scientific authority and the inaccessibility to scientific practices and spaces. This can also be described as a form of mystification that amplifies scientific expertise through acts of concealment. Like Urban formulates, processes like this inherently creates an 'in' group and an 'out' group' that is crucial to the power of the secret.

The process of engaging with performativity, legitimization, and mystification requires attention to the myriad of forces acting upon and being enacted in the laboratory. In *Ghost Stories for Darwin*, which is becoming a foundational work in feminist science and technology studies, Subramaniam cites Isabelle Stengers' scholarship to explain that our challenge in analyzing the cultural, social, and historical context of science and technology "is not a pointless battle between the irreconcilable frames of objectivity and social construction, but how to better understand the tensions between objectivity and belief as a necessary part of science and as central to the practice of science" (as cited on Subramaniam 5). A grounding concept of this project is co-constitution—that a multitude of forces and entities are always involved in complex processes that shape how we make meaning. Subramaniam reminds us that invisible things, like what is made private as well as the boundary between public and private itself, are not necessarily "not-there." By investigating and writing about what can be thought of as invisible, we write about "permission and prohibitions, presence and absence…" (Subramaniam 22).

Co-production is foundational to examining the laboratory and the knowledge produced in it, particularly in that it allows us to see what might otherwise slip through the cracks.

> "Knowledge and its material embodiments are at once products of social work and constitutive of forms of social life; society cannot function without knowledge any more than knowledge can exist without appropriate social supports. Scientific knowledge, in particular, is not a transcendent mirror of reality. It both embeds and is embedded in social practices, identities, norms, conventions, discourses, instruments and institutions…" (Jasanoff 3).

Trying to fully attend to all of the complexity of devices used to exercise power has the potential to diffuse responsibility and depoliticize by rendering actions invisible (Jasanoff 17). Sociotechnical imaginaries are "'collectively held and performed visions of desirable futures… animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology'… collective, durable, capable of being performed… temporally situated and culturally particular" (Jasanoff 19). Jasanoff calls for a better balance to be struck between abstract idealism and deterministic materialism, a dichotomy one finds oneself pulled back and forth between when they engage with the constructivist nature of laboratory boundaries (Jasanoff 22).

History

The laboratory, as a sociotechnical imaginary, which calls attention to the thoroughly situated nature of the space's purpose and function, both reflects and reifies ideals of a particular time and place in history. It follows, then, that labs were presupposed by many different types of spaces. Tracing the concept of the lab from its inception demonstrates the highly co-produced, constructive nature of laboratory science and how public/private divisions have always been salient concerns of scientific authorities. Early laboratories were mainly associated with the practice of alchemy (Jackson 296). Often private domains of nobility, alchemical workspaces were not squarely scientific. Before around 1650, the knowledge the lab produced was more practical and based on manual labor (Jackson 297). Some of what we would now call laboratories had come to be sites of experiment and philosophical endeavors, but many were still host to more commercial, chemical operations like dyeing and distillation performed by those who were/are not considered scientists (Jackson 297). Thus, it is vital not to conflate the history of the laboratory with the history of experiment. Also, we must remember that the lab was only one of the potential places to do science, alongside private houses, anatomical theaters, kitchens, hospitals, and parlors. Many non-experimental things have always happened in labs, like teaching, testing, and analyzing (Jackson 297, Gooday 788). Alchemy is typically thought of as a hidden, secretive practice, but it was also commonly a spectacle in courts. Rudolph Werner Sokup argues that this performative function of alchemy served as a testament to the power of Emperor Leopolde I in the seventeenth century (Lang 23). Around this period of time, values shifted from worthiness and gentlemanliness towards particular methods (including using specifically defined spaces) and privileging of sight as markers of truth (Macdonald 8).

The term *laboratorium* did not become associated with scientific workshops until the sixteenth century (Hannaway 585). Gooday traces the origin of the word laboratory to a different source, "elaboratory," which encompassed at least three distinct types of activity: organic genesis, practical experimentation, and material manufacture—still mainly alchemical work (Gooday 788). Tycho Brahe's sixteenth-century astronomical research center, Uraniborg, and the chemical lab it contained are generally the chronological starting point of histories of the laboratory. Brahe, Danish noble and prominent early modern mathematical astronomer, is renowned for his commitment to systematic observation and accuracy (Hannaway 588). He was granted an island by Denmark's King Frederick II to build an observatory dedicated to his astronomical studies, one that provided the seclusion he desired (Hannaway 589, 591). Uraniborg consisted of an observatory, main residence, and a workshop for artisans who constructed some observatory instruments (Hannaway 591); the perfectly symmetrical main building held circular bays serving as the main work areas, the south one of which sat overtop Brahe's ground-level personal study. Underneath his study was the also circular main chemical laboratory which contained a worktable constructed around a central pillar and sixteen furnaces

(Hannaway 594). Circular layouts fell out of popularity, likely because it was difficult to maximize the space and because straight tables and benches were easier to acquire, as opposed to curved ones.

Brahe's work and workspace, as described above, reads as remarkably similar to newly built laboratories. Though, his chemistry is regarded as an earlier form of the science, one that assumed connections between events in the heavens and events on Earth—a remnant of classical antiquity (Hannaway 597). Also typical of early chemical practice is a secrecy complimentary to Brahe's instinct for seclusion in producing scientific knowledge. A form of reclusive devotion to science, this paper argues, is carried through to the present, but is intentionally obscured as a performance of legitimacy. Laboratories are only accessible by those authorized and are often in specially designed buildings, a development explored further later in this paper. Additionally, Brahe's research center is similar to today's labs in that they are funded by state/federal bodies. Throughout the history of the laboratory up to today, in order to execute precise, empirical science, one must appeal to powerful figures or organizations. Cosmological relationships, secrecy, and connections to the state are all ideologies from classical antiquity that are reflected in early modern science, and the latter two are still deeply woven into laboratory structure and culture today.

Andreas Libavius, one of the first 'chymists,' laid out his plans for a chemical house and laboratory in a 1606 appendix to the second edition of his textbook, though it was never built (Morris). His laboratory design starkly contrasts Brahe's, something noted by scholars to be obviously intentional on Libavius's part (see Hannaway, Schmidgen, Morris). They are similar, though, in that they are whole dwellings with certain spaces not designated for science where the scientist both lives and works. Libavius addresses his lack of patronage and wealth, a difference in circumstance to Brahe that he often makes not-so-subtle jabs at (Hannaway 590). He directly critiques Brahe's seclusion and pretension: "Thus we are not going to devise for him just a *chymeion* or laboratory to use as a private study and hideaway in order that his practice will be more distinguished than anyone else's…" Libavius recognizes seclusion as a performance of legitimacy and prestige. He also lays out his views of the chemist as having a civic duty; there is a public/private boundary, but it is always traversable—at the purview of the scientist (Hannaway 599). Additionally, rooms with particular functions including stores (storages) and processes requiring specialized equipment were central to his building design.

Keeping in mind that Libavius's chemical house was purely imagined, we can at least recognize that his design reflected shifting ideas about science in the seventeenth century and is seen in the layout of some subsequent laboratories, like the one at the University of Altdorf (see fig. 1). Peter J. T. Morris observes that Libavius, "saw his chemical house as being integrated into the town and hence in the public sphere in opposition to what he saw as the aristocratic isolation of Uraniborg. In that sense, his chemical house was perhaps one of the earliest attacks on the 'ivory tower' model of research" (Morris). This is a consistent critique of science and academia, one that can be seen in the formation of justice-oriented laboratories today. Libavius's model of specialized rooms is a key feature of laboratories today. He places emphasis on the doorways connecting the various parts of his chemical house, clearly marking them on his ground plan, as a representation of the chemist's duty to navigate the boundary between private and public (Hannaway 601). Libavius constructs the chemist as active rather than contemplative—a figure to contrast Tycho Brahe. Libavius also features light throughout his design, something symbolizing both the public nature of his science and a separation from antiquated ideas of celestial influence on earthly elements. Note that many of today's laboratories feature large, wall-to-wall windows when light does not inhibit any laboratory processes. The construction of the first recognized laboratories from the sixteenth and seventeenth centuries has been carried forward into subsequent laboratories in physical design as well as purpose/concept.

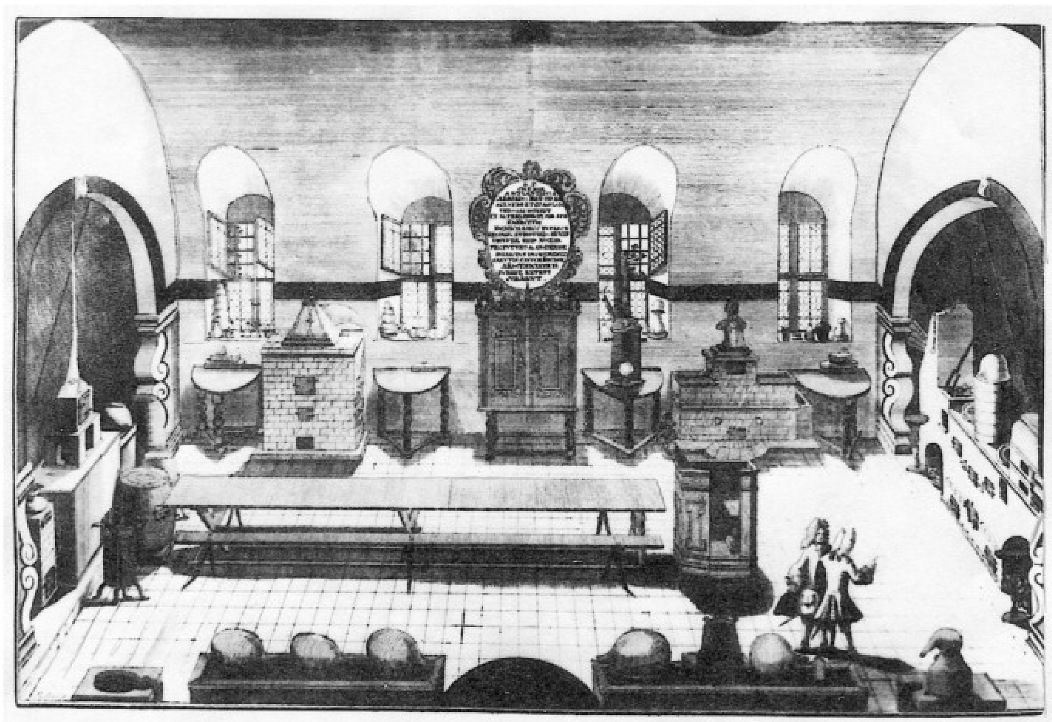

Fig. 1. University of Altdorf Laboratory and Lecture Room, 1682 “The History of Chemical Laboratories: A Thematic Approach.”

The lab came to be professionalized during the eighteenth century, contributing to our current understanding of the laboratory as a product and symbol of modern industrial society (Frank James cited on Lang 19). Also during the eighteenth century, focus shifted towards pneumatic (or gas) chemistry rather than heat, which was central to alchemy and early chemistry, changing laboratory equipment (Morris). Early chemist Antoine Lavoisier’s famous Arsenal lab, which he moved into in 1776, did not even contain a furnace (see fig. 2). Instead of the difficult-to-approximate temperatures of the furnace, Lavoisier preferred methods of heating like the burning lens, a curved disk of glass channeling sunlight to reach high temperatures (Baeretta and Brenni 34). One of rooms in his lab consisted of a *cabinet de physique*, prominent at the time and consisting of a central table whose walls are lined with shelves of physical apparatuses (Morris). The other two main rooms—each of which served a specialized function—of his famous lab at Arsenal were for chemical experiments (Beretta and Brenni 68). This three-room model was very close to the ideal laboratory described by Antoine-Francois Fourcroy, who worked in Lavoisier's lab for years. However, Beretta concludes that Lavoisier's lab was not as exceptional as scholars often make it out to be (Beretta and Brenni 70-71). Little is known about the specifics of Lavoisier's space, as the buildings were abandoned and several were destroyed in the Franco-Prussian War (Beretta and Brenni 63). Other important features that are known about, however, are a cellar that served as a glassware warehouse and a library, commonly associated with labs at the time (Beretta and Brenni 68). Developments in equipment, particularly glass apparatuses, drove rapid changes in the interior arrangement of the laboratory.

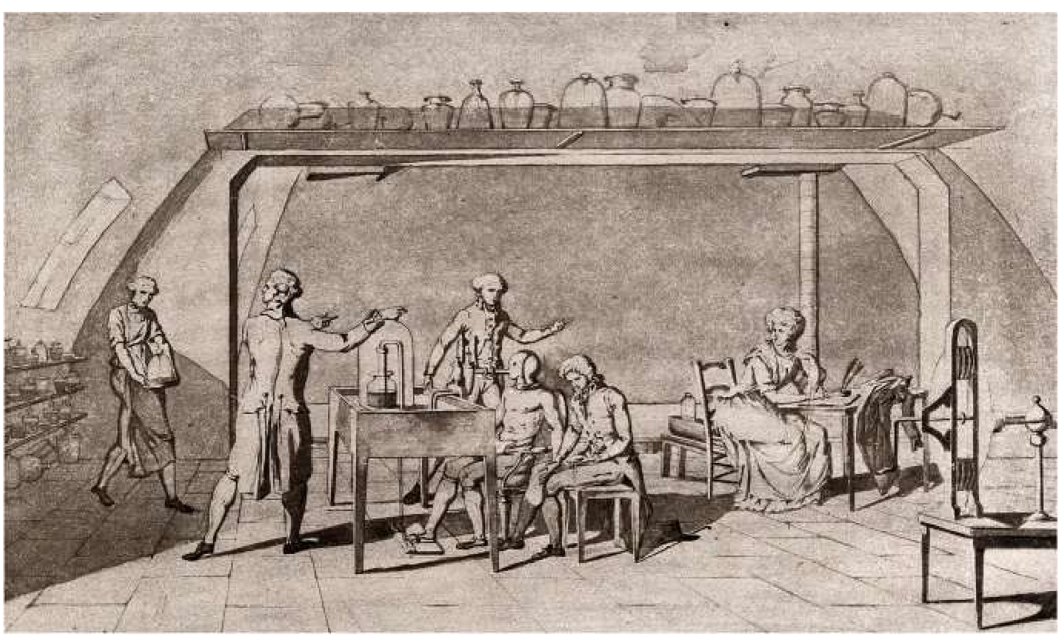

Fig. 2. Antoine Lavoisier's Arsenal lab in Paris, 1790 "The History of Chemical Laboratories: A Thematic Approach."

The Arsenal lab had a strong relationship with the Académie des sciences; they would perform experiments in the facility and Lavoisier, with his team, would bring instruments to perform public experiments at the Académie's official meetings (Beretta and Brenni 3). They also performed these experiments in the Arsenal's garden, and Lavoisier was known to travel and conduct experiments in agricultural settings and portable setups (Beretta and Brenni 57, 67). Lavoisier's places of work seem to be based on a less rigid idea of what the laboratory is. According to Fourcray, Lavoisier held meetings with "the best informed men in Europe," including rival Joseph Priestly (Beretta and Brenni 68). The discourse around the Arsenal lab seems more focused on apparatuses and instruments rather than particular features of rooms or buildings, likely because the use and meaning of the term "laboratory" was still being formed at this period in time.

The early nineteenth century saw major developments in the laboratory, largely due to the growth and reform of universities, the success of private teaching and research labs, and the increase in people receiving scientific training (Schmidgen). The classical chemistry laboratory has its roots in Justus Liebig's work at the university in Giessen. By the 1840s, it had benches, bottle racks, and fume cupboards. As this model expanded, washbasins, piped gas, running water, drainage systems, forced ventilation and more fume hoods came to define the design we are familiar with today (Morris). A vital innovation of Liebig's model is the arrangement of tables around the room, rather than against the wall, which facilitated more simultaneous experiments and accommodated more students. This version of the laboratory was depicted as space where students and teachers worked together collectively—a place of discourse between science and technology—in addition to a workshop/factory focused on craft (Schmidgen). Modern physics labs also emerged in the nineteenth century; before 1833, only "cabinets"—isolated rooms that housed collections of instruments—had existed. Both Wilhelm Weber's 1833 lab in Gottingen and Heinrich Gustav Magnus's 1843 lab in Berlin were private, only accessible to those given special permission by the founders (Schmidgen). Physiology laboratories came later in the century after teaching and equipment became more accessible. Carl Ludwig's physiological institute in Leipzig divided workspaces to save the time of configuring different instruments; already efficiency emerges as central to the laboratory (Schmidgen). These developments occurred largely in the German-speaking territories.

Note that the laboratories of the nineteenth century were different from earlier laboratories in that they were mainly associated with universities as they grew in number and size, which reflects an increased focus in knowledge production in academic spaces. Science was taking up the largest amount of new university space (Forgan 411). Throughout the century, popular institution plans moved from lecture-based quadrangles to 'integrated museums' centering research, collections, and laboratories to a form of quadrangle with logical, differentiated order. The shift to valuing order meant that scientists were consulted about what they wanted and needed. With this opportunity to shape their spaces, European scientists often traveled to observe different universities, bringing some designs back with them. Many turned to Germany as a model. British scientists noted their emphasis on laboratories, with more space allocated for personal research, more emphasis on personal teaching rather than lecturing, and more order and division (Forgan 422). A concern for order, discipline, and efficiency is evident in the facilities built in the late nineteenth century through the designation of subjects to specific areas and spatial arrangement in labs (see fig. 3). The free-standing bench, courtesy of Liebig, allowed German professors to make rounds, representing an emphasis in tutorial methods. Labs also took on similarities to school designs, with benches arranged in rows and reserved for individual students; lockable drawers/cupboards also became a part of bench design (Forgan 425). These features are still present in laboratories even though many labs today are not involved in teaching like that which occurs at a university.

Fig. 3. 1905 Chemical Laboratory in Zurich "The History of Chemical Laboratories: A Thematic Approach."

Shifting Concerns

Several specific cases in the latter half of the twentieth century—which saw major laboratory industrialization that created complex tensions and administrative structures between government, big business, and universities as stakeholders in the lab—are useful to discuss differently-legitimized privacy practices. The model of the ultra-clean lab was constructed at Caltech in 1953 after Clair Patterson grew concerned about lead contamination in his doctoral research (Gieryn, “Ultra Clean Lab” 158-159). His practices spread as he invited scientists to his lab to train—though his reason for doing so was mostly to make people trust his data and avoid being viewed as hermetically secretive (Gieryn, “Ultra Clean Lab” 164). Similarity across ultra-clean labs eases the burden of those who move between different locations. However, the head of today’s most prominent clean lab, Laura Wasylenki, questions their protocols. At some points in processing samples, they are so careful that it seems like overkill, but at other points, it seems that procedures deemed less rigorous could lead to contamination: “We are now going to walk into the mass spec lab which has six machines in it, and isn’t a clean room at all. We don’t take our street shoes off and we don’t change our clothes. … And you carry them through plain old air. … That’s what seems funny to me: we’ve been so damned careful up here but then at the moment we are going to measure the thing, we are not so rigorous” (as cited in Gieryn, “Ultra Clean Lab” 154). She also explains that the main reason they have a clean lab is because that’s how things are done, that’s how you get “in the game” (Gieryn, “Ultra Clean Lab” 151). Even remotely detailed descriptions of these spaces are almost entirely absent from scientific papers, making this knowledge tacit. One must be permitted access to existing labs if they wish to design a clean space of their own that will be accepted as legitimate (Gieryn, “Ultra Clean Lab” 169). Avoiding/limiting potential contaminants does reasonably explain restricting access to clean labs. However, most labs are selective about who they are accessible to and will construct a similarly legitimized reason to do so.

By focusing on the desires and intentions imbued in designs of contemporary laboratory spaces, we can understand how/if ideas about the role of private/public boundaries in legitimizing laboratories have changed. "Biotechnology's Private Parts (and Some Public Ones)" by Thomas Gieryn explores public/private distinctions to account for biotechnology as an instance of contemporary science. The process of designing and constructing the Cornell University Biotechnology Building (CUBB), which began in 1983, reflects collaboration of architects and engineers, faculty scientists and their staff, and university administrators—a continuation of the practice of constructing new scientific spaces born in the late nineteenth century (Gieryn, "Biotechnology's Private Parts (and Some Public Ones)" 284). Public service was established as a key element in selecting a site for the Biotechnology Program alongside research and teaching, following the pattern of public obligation described by Libavius and woven into nineteenth century university models. However, this is revealed to mean involving corporate scientists and officials with the university campus as well as "state and university officials." Undergraduate teaching is intentionally left out of the CUBB. Thus, the use of 'public' is strategic, simultaneously expanding some publics while actively excluding others (Gieryn, "Biotechnology's Private Parts (and Some Public Ones)" 288-289).

Two diagrams by the architecture company have a few interesting conceptual features, namely arrows and a bar separating the words 'private' and 'public' (see fig. 4 and fig. 5). The meanings of these marks are never elaborated on in any documents. However, knowing who the public is intended to be clarifies that the top arrows steer certain members of the laity to the public administrative and seminar facilities. People are invited to the edge of the space, but actively kept from the interior, and the diagrams reflect the salience of this boundary by those involved in the building's design. There is a need to be seen and bring the public to the perimeter to an extent; labs must not come off as reclusive workspaces—like Tycho Brahe's. Laboratories must also justify the spending of taxpayer money; New York State contributed $32.5 million to the construction of the CUBB ("Our History"). The three floors of the building add more layers to the complex public/private divide. One must go through a secretary by the stairs and elevators to pass from conference rooms and offices to the biotechnology facilities. Those who occupy the building do not agree on the method and success of the public/private separation; one scientist praises the capacity to host large parties in the lobby while not disturbing the upper floors, while another complained that the 'research part' was poorly isolated, and a third commented on the waste of money on the non-functional public spaces (Gieryn, "Biotechnology's Private Parts (and Some Public Ones)" 297). Scientists have different perspectives on appropriate public and private activities proximal to the laboratory but outside of their perception of its physical boundaries.

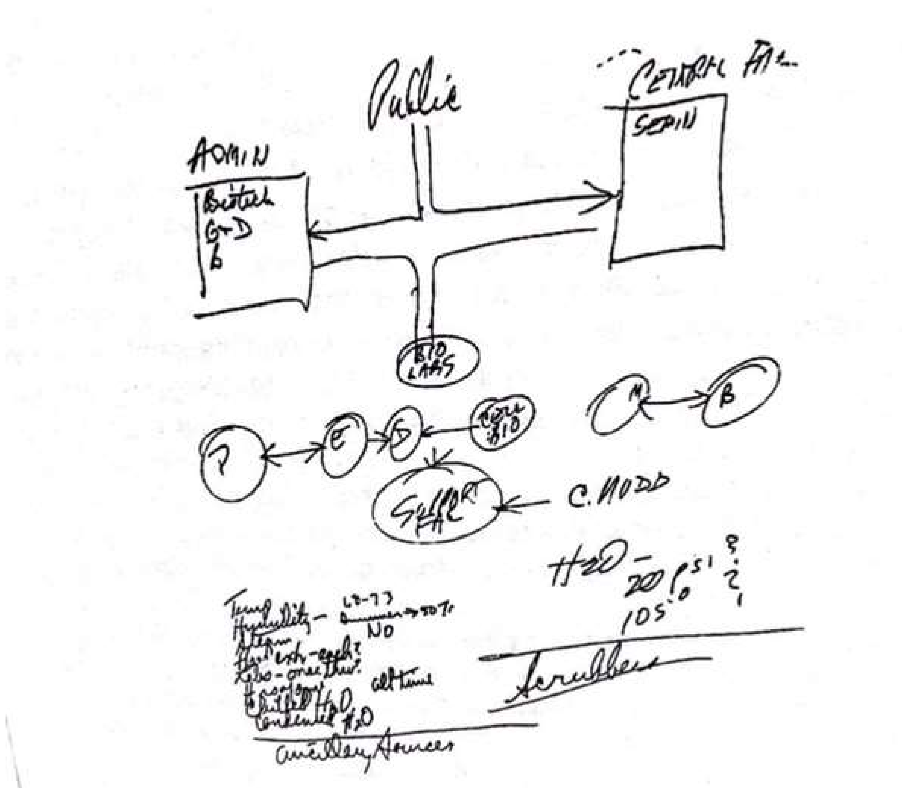

Fig. 4. Early Sketch "Biotechnology's Private Parts (and Some Public Ones)"

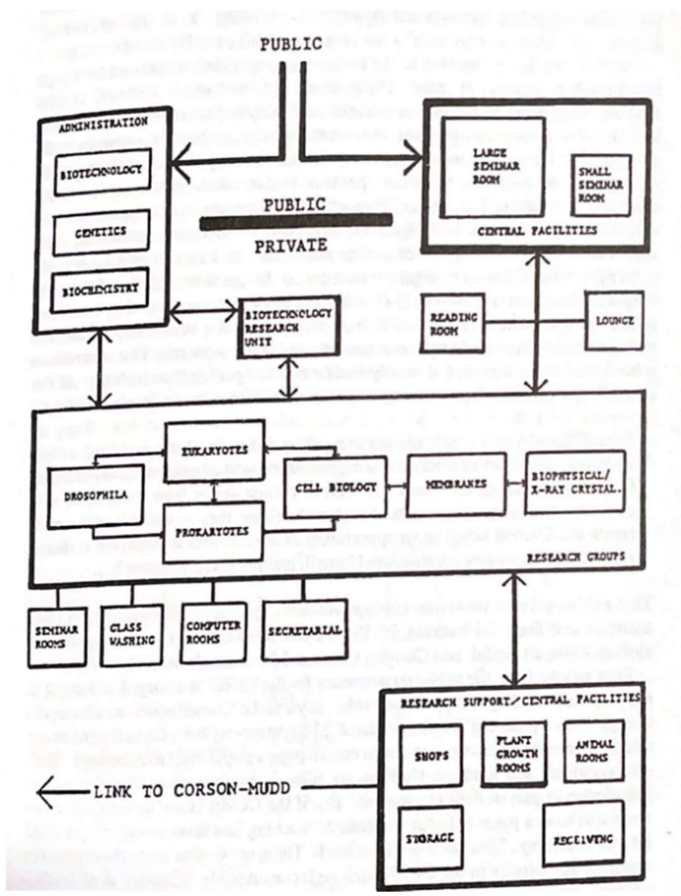

Fig. 5. Bubble Diagram (Davis, Brody, and Associates, Architects) "Biotechnology's Private Parts (and Some Public Ones)"

At Stanford University, the Clark Center, a biomedical engineering and sciences laboratory building, was voted *R&D Magazine*'s "Laboratory of the Year" in 2004. The layout of the interior is startlingly open. Working areas of the lab are entirely undivided, essentially free of any fixed partitions (see fig. 6). All equipment is on wheels and utilities drop down from ports in the ceiling, allowing for easy rearrangement and collaboration (Gieryn, "Laboratory Design for Post-Fordist Science" 797). This is a break from the stationary, permanent arrangements in most labs, both past and present. Balconies surrounding the interior even allow the public to look in. Like with the CUBB, the design brings people to the periphery of the lab, but not inside.

However, in the Clark Center, labs are separated from the public by the most visually surprising element of the building: glass walls. This creates transparency and a divide at the same time (see fig. 7). The transparency comes off as performative—a recognition of divisions between the public and the private of the laboratory without deconstructing them. The laboratory strives for decontextualization and universalization, as trustworthy scientific knowledge production is associated with purified spaces; the knowledge come from nowhere. Only qualified experts are allowed inside the laboratory while potential sources of damage are filtered out (Gieryn, "Laboratory Design for Post-Fordist Science" 798). Expectations and enforcement of who is (authorized experts) and isn't (everyone else) allowed inside its physical walls is a legitimizing practice to keep the knowledge produced "pure." Placelessness is in part constructed by the layout and architectural design of labs. Signs of the local affect credibility of the claims coming from the space, so sticking close to the architectural norm legitimizes the work done in it.

Fig. 6. James H. Clark Center, Stanford

https://www.fosterandpartners.com/projects/james-h-clark-center-stanford-university

Fig. 7. Clark Center, Stanford University "Laboratory Design for Post-Fordist Science"

Laboratory buildings, like the CUBB and the Clark Center, reflect the needs of scientists and their equipment while the science itself reflects various elements of society, so how do we delineate where design begins and ends? Design is also pragmatic and performative; floor plans are representational devices serving a specific purpose. Private/public are used flexibly and inconsistently. Delineating the social from the technical, like delineating the public from the private, is limiting to the study of knowledge-producing sites. Laboratories are constructed with a multitude of (sometimes competing) interests that dictate everyday procedure, organizational structure, and levels of access/restriction. In this way, the laboratory is no different from any other space, though sociology of science can paint a story of social factors 'intruding upon' science. Over time, a "normal scientific process" has been established, and elements of this process, like secrecy, are resisted as objects of study by outsiders (Latour, *Laboratory Life* 22). Lab designs, like that of airports, suburbs, and shopping malls, are often meant to seem placeless. "Manuel Castells suggests that 'the global city is not a place, but a process,' and this may be true of laboratories too. Capitalist production once happened in a 'space of places'; now it exists in a 'space of flows'" (as cited in Gieryn, "Laboratory Design for Post-Fordist Science" 801). However, there are easily understood reasons for these places to be laid out like they are: ease of use, flow of foot traffic, and creating a less jarring experience. We must reckon with this mangle of influences and validation—a difficult task.

Laboratories can and often do perform transparency as part of a strategy to bolster their scientific authority. What would a lab look like if it actively worked to subvert typical private/public boundaries rather than perform them? CLEAR—the Civic Laboratory for Environmental Action Research—does not actually have clear walls like the Clark Center. CLEAR is a feminist and anti-colonial space for both natural and social science. Much of the knowledge they produce is environmental, mainly concerning plastic pollution, but they also work heavily on topics of colonialism and power dynamics in research. Their website engages in an open dialogue about the lab's values and how it's structured, also hosting a public version of their lab book (though there is mention of a private version that the uninitiated don't have access to). Unlike the aforementioned labs, CLEAR's website has an extensive guest protocol section. Interestingly, screening guests is framed as protective for the lab, and there is emphasis on the guests agreeing with protocol ("Methodological Projects"). Guests are considered full collaborators in any meetings they attend; sharing food/tea and resources is centralized in the introduction process. They have access to the private lab book, but not the Google drive or the lab's listserv, only receiving materials that the lab deems relevant ("Methodological Projects").

There are barriers here, but they are not like those of the labs considered above. The boundaries are rooted in valuing a community's right to self-determination, a completely different foundation from the CUBB and Clark Center which seems to reinforcing authority and performing legitimacy.

CLEAR's Max Liboiron gave a powerful presentation on power and citizen science in 2019. Researching with those who don't have science degrees is not merely a gesture to increase diversity; rather, they emphasize that the work belongs to those people and the lab is there to facilitate, not take ownership (Liboiron). Power is everywhere in the lab; all research questions, grants, and communications align with values that naturalize certain things but not others. Power is more so an infrastructure than just decisions or behaviors. By this, I mean that the situations and systems of power we encounter are attributable to long-term, political forces rather than particular people and places alone, though this does not mean that we can ignore those particulars. This is reflected in the mixed and slightly confused attitudes of scientists towards private/public boundaries, like those who reflected on the CUBB's public functions. CLEAR's technology has specific guidelines to be truly accessible, free, and available, with instructions to make them out of affordable materials (Liboiron). Instead of questioning the capacities of those who aren't deemed scientists to fit into the category of an accredited scientific expert, we must accept the benefits that they do provide. Regarding AIDS discourse and activism, Steven Epstein examines the nuance of how survivors and activists were afforded credibility because they "knew their science," the markers of their credibility as "lay experts" inscribed in their own bodies (Epstein 333). Citizen science does not have to fit the rigid molds of "good," "regular," or "elegant" science, and this does not make it lesser. As Liboiron discussed in the context authorship and credit, nothing is lost in acknowledging all sources of influence.

Exiting the Laboratory

The previous section focused on the inside of the lab, but to understand the constructed public/private divisions around the lab, we need to examine how things leave its physical walls. How are different forms of information handled when they are released to those outside of the laboratory space? How is the lab's authority constructed in these interactions? Ludwik Fleck considers how facts are formed after they leave the laboratory and the vast, stylized systems experts enact to get them out there (Fleck). Open science is a growing practice that promotes sharing of all stages of research: plans, materials, procedures, data, and papers (Tay 841). An article in *Nature* magazine explores both the attitudes of scientists towards open science and the behavioral realities. They explain that while open-access publishing is embraced, with 90% of one survey's respondents participating in "at least one open-science practice like sharing data and code," sharing laboratory materials and protocols is viewed more skeptically, mostly due to a lack of incentives and awareness for procedures to do so (Tay 842). This project reveals that there are much more complex power dynamics involved in the apprehension to share more details of laboratory practices. However, the article fails to mention that this study was only of social scientists: sociologists, psychologists, economists, and political scientists (Ferguson et al.). It is interesting, then, that they transition to discuss the open practices of the CRISPR gene-editing tool, like the field and type of science has no effect on perceptions of legitimate laboratory practices. Looking at a particular field, Steven Epstein explores why AIDS research is so "unusually public and porous," questioning how scientific beliefs and spokespeople become authoritative and how certainty is constructed. "Good science" or "elegant science" are often pushed back against as not conducive to progress or facilitating wellbeing (Epstein 2). What exactly are these dissenters critiquing? What possibilities are they imagining?

A National Research Council symposium on scientific and technical data made up of private and public sector experts/managers addressed, in part, open science in economic terms. A conflict is presented between the apparent norms of cooperation and incentives for cooperation in research, particularly when considering the rewards system around open science (David 19). Competitive markets, like our current knowledge economy, do not handle the allocation of resources around public goods. Ideas are often considered "non-rival" in that they can be spread without depleting the resources of the one disseminating an idea (David 20). Though, this does not mean the power of information is not affected; concealing and selectively revealing knowledge as a strategy is laid out in the introduction of this paper. Exclusivity of possession of both the knowledge itself and the economic benefits of the knowledge are necessary for success under a capitalist market system. Openness, which is not compatible with competitive market ideas inherent to our form of capitalism, is beneficial in that it allows for rapid validation and reduces duplication of research (David 21). Intellectual property regimes, which have become increasingly enforced with time in the forms of patents and copyright, "convey a monopoly right to the beneficial economic exploitation of an idea… or of a particular expression of an idea…" (David 30). Importantly, not any system that assigns personal credit monopolizes benefit from the knowledge. Remember that CLEAR still centers authorship and naming collaborators in their methodology. This symposium is hopeful for forms of intellectual property "designed to make it easier for many to 'see farther by standing on the shoulders of giants'" rather than those that make it difficult to even attempt to climb onto those shoulders (as cited in David 30). Privatization turns knowledge into property, a necessary step in the functioning of our knowledge economy. The strategy of appealing to both common and private property is often used to legitimize "contemporary western-indigenous relations," particularly those involving land (Whitt 11). Material, cultural, and genetic resources are first declared common property, freely available, just to then privatize and commodify the resource (Whitt 12).

The CRISPR gene-editing technology was first, as would be expected, circulated in well-known, accessible scientific journals as well as U.S. patent applications that were later made public. The most interesting publication, though, is of their plasmids: preserved DNA sequences that can be used for further research. Addgene, a non-profit that accepts and distributes plasmids among researchers, is the main repository for CRISPR (Thompson and Zyontz 16). Of course, only those who are connected to certain institutions under certain projects can even create an account to access the plasmids. The CRISPR tool was first introduced to the public in 2012 and 2013 in scientific papers by its co-inventors. One of them explains that the reason he gave plasmids to Addgene was because the sheer number of requests they would receive would take so much time that they wouldn't be able to do science—a concern for efficiency and productivity (Thompson and Zyontz 17). Scientific research, Epstein suggests, is likely to become controversy and subsequently demanded into the public when it is relevant to a politicized issue, related to a social movement, or is in competition for scarce resources (Epstein 5). Despite the increased popularity of attitudes embracing open science, actual practices reflect greater concern for "normal science." The mentioned forms of circulated knowledge can be considered codified, as in explicitly organized into a tool, rather than tacit, as in unstated. Thompson and Zyontz argue that codification solves the problem of access but does not solve issues converting those accessed tools into published science, particularly when considering geographical differences. They refer to this as the "tacit knowledge problem" (Thompson and Zyontz 2). Distinguishing these different forms of knowledge reveals a nuance regarding access. Perhaps the way scientists publish information retains a barrier to the public, which is not surprising considering that dividing the public and the private is ingrained in the very concept of the laboratory.

Continuous cell lines—samples, often from carcinogenic cells, used in biotechnology research for their quick growth and easy reproduction and distribution—are tools that extend the lab from one physical place. Seemingly sensational accounts of the origin on the HeLa cell line, one of the most popular continuous cell lines, are abundant, immortalizing the woman along with the cells. Freezing, which is essential to enabling cell lines like HeLa, prompted novel comparisons of different points in biological time of the same individual, constructing a new reality within the lab that abolished space and time (Landecker 157). This is a form of boundary work not so different from strategies to restrict access to knowledge production within the laboratory. One can think of space and time as boundaries—ones less material than the physical construction of a building—that are traversable only by those deemed acceptable to inhabit the laboratory. George Gey never worked to patent or restrict the distribution of HeLa cells, not anticipating their explosive growth (Landecker 162). Just like with CRISPR and AIDS research, politicization—here regarding the national interest in polio—brought science normally done in private into the public (Landecker 163). HeLa cells had come to be invisiblized as a "standard reference cell" until 1967 when it was politicized by the announcement that HeLa had "overgrown" and "contaminated" other immortal human cell cultures, communication about which was rife with racial metaphors (Landecker 168). Narratives of HeLa as an embodiment of scientific knowledge are often preoccupied with mass, "What would she weigh now?" (Landecker 179). These narratives seem to be reckoning with the construction of samples as immaterial and the recognition that they are very much material extensions of the laboratory and the translations that occur inside its tangible walls.

The Politics of Display: Museums, Science, Culture explores how museums, particularly those that display science, tend to present themselves as outside/above politics, nested within the increasingly common critique of technologies of truth production. "The assumptions, rationales, compromises and accidents that lead to a finished exhibition are generally hidden from public view: they are tidied away along with the cleaning equipment, the early drafts of text and the artefacts for which no place can be found" (Macdonald 2). Museums, like laboratories, create particular sciences for the public that reify the grounds they are built upon and have varied and leveled agents involved in defining their work: state interests, exhibition-makers, curators, visitors etc. Unlike most labs, however, display is a more obvious and necessary task central to the museum's function and purpose. Science museums, particularly, are endowed with the cultural authority of trustworthy scientific witnesses and must engage with rhetorics of political impartiality (Macdonald 5). Are laboratories obligated to do the same? Is there a difference because the public is more aware/critical of the constructive nature of museums? Many exhibits in science museums are reliant on laboratories and laboratory results. So, why doesn't discourse around these exhibits extend back to the lab?

Adding these ideas about science museums to the above discussion of open science practices, CRISPR plasmids, and the HeLa cell line reveals some sort of aversion to or ignorance of going back to unpack and reveal the laboratory. Is it merely because, like Bruno Latour formulates, the lab itself has become a black box? A complicated process of distancing and legitimizing has become necessary for how labs interact with the public. There seems to be, in the cases outlined above, a sort of confusion about how to engage with what comes out of the lab, particularly when it is material. This likely results from interplay of concealment and public engagement, the strategic performance of transparency that serves to mystify the lab and reinforce its authority as a production site of scientific knowledge.

Conclusion

Why is it important to ground this investigation of the power of the laboratory in interdisciplinarity? Jurgen Habermas considers the difficulties of studying the "public sphere," stating that it must be investigated broadly to prevent its disintegration within the confines of a discipline (Habermas xvii). Sheila Jasanoff cites comparison as an incredibly valuable method for studying sociotechnical imaginaries, allowing us to map the contours, but avoid generalizing the situated and particular (Jasanoff 24). Thomas Gieryn points out a paradox in the constructivist nature of studies of scientific knowledge and the level of cognitive authority it is often assigned (Gieryn, "Boundaries of Science" 405). Attending to the boundaries of what science is, who does science, and where science is done cannot be done with a limited set of frameworks. Thus, it is necessary that this project is interdisciplinary, drawing mostly from history, sociology, science and technology studies, and religious studies in order to see the dynamics and histories that might otherwise go unseen.

This paper merely scratches the surface of public/private divides in the laboratory. As discussed at the beginning of the historical section, laboratory spaces were born most directly out of early chemistry practices. Thus, this project focuses on sciences in a similar vein, mainly chemistry and biotechnology, to keep a narrow scope fitting of a 30-page paper. Future work could extend to physics labs and scientific spaces less associated with chemistry and biology. Graeme Gooday, like Catherine Jackson, calls for future work on less formally recognized spaces of knowledge production as well as how knowledge coming out of laboratories travels while, like Jackson wants us to, focusing on the ubiquitous, not placeless nature of the laboratory

(Gooday 795). Other potential projects might use rhetoric in various contexts—like news sources, academic papers, and popular science communications—as a secondary site to examine how the lab is conceptualized by wider audiences. Another path could dive into the science-religion comparison, particularly relating physical places of worship to scientific spaces or exploring devotion/commitment/belief in both contexts.

The laboratory is a site to analyze the production of scientific knowledge, particularly in how it constructs and reinforces its scientific authority through the boundaries it sets. After considering a brief history of the lab in the West, dynamics of designing contemporary lab spaces, and how things exit the lab, it is clear that laboratories are political spaces operating firmly within their historical, social, and cultural context. To reach this conclusion, however, requires unpacking performances of transparency that serve to legitimize and mystify the lab in order to build up symbolic power. This form of power actively conceals the various factors that co-produce the laboratories and the knowledge that they generate. Experts and 'scientific spaces' are further distinguished from 'the laity' and public spaces. A veil is placed between the workings of the lab and those not in the 'in group' of authorities—which includes scientists as well as invited administrator, officials, and businesses. Divisions of public and private in and around the laboratory ultimately promote a lack of critical engagement with scientific knowledge production. By calling out and dismantling this veil and the forces that construct it, we can question barriers to access, understand the role of "laypeople" in science, and work to create more just systems of knowing.

Bibliography

Beretta, Marco, and Paolo Brenni. "The arsenal of eighteenth-century chemistry: the laboratories of Antoine Laurent Lavoisier (1743-1794)." *The Arsenal of Eighteenth-Century Chemistry*. Brill, 2022.

Cetina, Karin Knorr. "Laboratory Studies: The Cultural Approach to the Study of Science." *Handbook of Science and Technology Studies.* Edited by: SAGE Publications, Inc., 1995, pp. 140-66. *Sage Research Methods*, https://doi.org/10.4135/9781412990127.

Colyvas, Jeannette A., and Walter W. Powell. "Roads to institutionalization: The remaking of boundaries between public and private science." *Research in Organizational Behavior*, vol. 27, Jan. 2006, pp. 305–353, https://doi.org/10.1016/s0191-3085(06)27008-4.

David, Paul, et al. "The Economic Logic of 'Open Science' and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information: A Primer." *The Role of Scientific and Technical Data and Information in the Public Domain: Proceedings of a Symposium*, National Academies Press, 2003, pp. 19–34.

Epstein, Steven. *Impure Science AIDS, Activism, and the Politics of Knowledge*. University of California Press, 1998.

Ferguson, Joel, et al. "Survey of Open Science Practices and Attitudes in the Social Sciences." Nature News, Nature Publishing Group, 5 Sept. 2023, www.nature.com/articles/s41467-023-41111-1#citeas.

Fleck, Ludwik. *Genesis and Development of a Scientific Fact*. The University of Chicago Press, 1979.

Forgan, Sophie. "The Architecture of Science and the Idea of a University." *Studies in History and Philosophy of Science*, vol. 20, no. 4, Dec. 1989, pp. 405–434. Science Direct, https://doi.org/10.1016/0039-3681(89)90017-4.

Gieryn, Thomas F. "Biotechnology's Private Parts (and Some Public Ones)." *Making Space for Science: Territorial Themes in the Shaping of Knowledge*. Edited by Crosbie Smith and Jon Agar, St. Martin's Press, New York, NY, 1998, pp. 281–312.

Gieryn, Thomas F. "Boundaries of Science." *Handbook of Science and Technology Studies*. Edited by Sheila Jasanoff et al., SAGE Publications, 1995, pp. 393-443.

Gieryn, Thomas F. "Laboratory design for Post-Fordist Science." *Isis*, vol. 99, no. 4, Dec. 2008, pp. 796–802, https://doi.org/10.1086/595773.

Gieryn, Thomas F. "Ultra Clean Lab." *Truth-Spots: How Places Make People Believe*, The University of Chicago Press, Chicago, 2018, pp. 148-170, https://academic.oup.com/chicago-scholarship-online/book/17841/chapter-abstract/175614503?redirectedFrom=fulltext. Accessed 25 Oct. 2023.

Gooday, Graeme. "Placing or replacing the laboratory in the history of science?" *Isis*, vol. 99, no. 4, Dec. 2008, pp. 783–795, https://doi.org/10.1086/595772.

Gregory, Jane, and Steve Miller. *Science in Public: Communication, Culture, and Credibility*. Plenum Press, 1998.

Habermas, Jürgen. *The Structural Transformation of the Public Sphere: An Inquiry Into a Category of Bourgeois Society*. MIT Press, 1991. EBSCOhost, https://web-p-ebscohost-com.proxy.lib.ohio-state.edu/ehost/ebookviewer/ebook/bmxlYmtfXzMyNjQ2X19BTg2?sid=f16ec39b-3d55-4677-854b-992d94e3cf1a@redis&vid=0&format=EB&rid=1.

Hannaway, Owen. "Laboratory Design and the Aim of Science: Andreas Libavius versus Tycho Brahe." Isis, vol. 77, no. 4, 1986, pp. 585-610. JSTOR, http://www.jstor.org/stable/233163. Accessed 8 Oct. 2023.

Jackson, Catherine M. "The Laboratory." *A Companion to the History of Science*, 9 Mar. 2016, pp. 296–309, https://doi.org/10.1002/9781118620762.ch21.

Jasanoff, Sheila. "Future Imperfect: Science, Technology, and the Imaginations of Modernity." *Dreamscapes of Modernity*, Edited by Sheila Jasanoff and Sang-Hyun Kim, The University of Chicago Press, 2015, pp. 1-33.

Landecker, Hannah. *Culturing Life: How Cells Became Technologies*. Harvard University Press, 2010.

Lang, Sarah. "Alchemical Laboratories: Texts, Practices, Material Relics."

Latour, Bruno, et al. *Laboratory Life: The Construction of Scientific Facts.* Course Book ed. Princeton University Press, 2013. Project MUSE, muse.jhu.edu/book/57399. Accessed 26 Sept. 2023.

Latour, Bruno. *Science in Action: How to Follow Scientists and Engineers through Society*. Harvard Univ. Press, 1987.

Liboiron, Max. “The Power (Relations) of Citizen Science.” *CLEAR*, 21 Mar. 2019, civiclaboratory.nl/2019/03/19/the-power-relations-of-citizen-science/.

Macdonald, Sharon. “Exhibitions of Power and Powers of Exhibition.” *The Politics of Display: Museums, Science, Culture*. Edited by Sharon Macdonald, Routledge, 1998.

“Methodological Projects.” *CLEAR*, 8 May 2023, civiclaboratory.nl/methodological-projects/.

Morris, Peter J. T. “The History of Chemical Laboratories: A Thematic Approach.” *ChemTexts*, vol. 7, no. 21, 22 June 2021, https://doi.org/10.1007/s40828-021-00146-x. Accessed 26 Sept. 2023.

“Our History: Cornell Institute of Biotechnology: Cornell University.” *Cornell Institute of Biotechnology | Cornell University*, www.biotech.cornell.edu/about-us/our-history. Accessed 27 Nov. 2023.

Schmidgen, Henning. “Laboratory.” *Encyclopedia of the History of Science*, Carnegie Mellon University, 9 Apr. 2021, ethos.lps.library.cmu.edu/article/id/450/#fn4. Accessed 26 Sept. 2023.

Subramaniam, Banu. *Ghost Stories for Darwin: The Science of Variation and the Politics of Diversity*. University of Illinois Press, 2014.

Tay, Andy. “The open-science movement for sharing laboratory materials gains momentum.” *Nature*, vol. 625, 22 Jan. 2024, pp. 841–843, https://doi.org/10.1038/d41586-024-00172-y.

Thompson, Neil and Zyontz, Samantha, "Decomposing the 'Tacit Knowledge Problem:' Codification of Knowledge and Access in CRISPR Gene-Editing." 17 Nov. 2017, http://dx.doi.org/10.2139/ssrn.3073227

Urban, Hugh B. *Secrecy: Silence, Power, and Religion*. The University of Chicago Press, Chicago, 2021.

Whitt, Laurelyn. *Science, Colonialism, and Indigenous Peoples: The Cultural Politics of Law and Knowledge*. Cambridge University Press, New York, 2009.