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HERMES & THE VEIL
***ESSAIS* BETWEEN ART, FEMINISM**
AND PHYSICS

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PhD
2021

**A THESIS SUBMITTED TO
NORTHUMBRIA UNIVERSITY IN
PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF
PHILOSOPHY IN THE FACULTY OF
ARTS, DESIGN AND SOCIAL SCIENCES**

**DECEMBER 13, 2021
CRYSTAL BENNES**

ABSTRACT

This thesis explores the ways in which visual art practices can engage with the sciences; or, more precisely, how my artistic practice engages with the field of physics. Rather than define itself as interdisciplinary ‘sciart’ or ‘art-science’, the thesis argues for an innovative approach. Informed by the feminist works of writers and thinkers such as Sandra Harding, Sharon Trawick, Lauren Chambers and Chanda Prescod-Weinstein, this approach draws from a diverse set of practices including artistic research, ethnography, science and technology studies, and feminist theory. Less interested in participating in longstanding ‘two cultures’ debates in which arts and sciences are defined either as oppositional or complementary forms of knowledge creation, the thesis argues for a novel way forward. Adapted from the field of cultural translation, particularly the work of Sarah Maitland and Michel Serres—in which methods of interpretation, distancing, and appropriation are key—the thesis argues for an innovative method of negotiation between two otherwise specialist domains. Here, the artist self-consciously acts as a Hermes-like figure, moving between two worlds, occupying a position that Serres refers to as ‘the Northwest Passage’, the treacherous in-between. The thesis further moves the conversation away from ongoing debates around ‘two cultures’—and from discussions of possible disciplinary commonalities such as ‘creativity’, ‘curiosity’, and ‘experimentation’—by asking whether it might not be more constructive for artists to differentiate based on concepts of ethics and values. Borrowing Hester Reeve’s idea of the artist as a moral agent, questions of ethical agency, in both art and science, are central to the practice. While the thesis endeavours to move on from existing ‘two cultures’ binaries, it nevertheless acknowledges the challenges and inherent contradictions present in any attempt to do so.

Although the art practice critically accounted for in this dissertation is ambivalent about the production of material art objects, it nevertheless engages in such production using lens based media, installation, and writing. Crucially, however, it is a practice committed to thinking as both a type of making and a type of writing, and the thesis demonstrates an important reflexive relationship between the writing/thinking and the practice/thinking. This dissertation is also underpinned by a commitment to making knowledge structures manifest. Namely, through the considered use of the essay form, the writing reveals artistic (and indeed scientific) knowledge production to be fragmented, contested, situated, contingent, subjective, and in constant negotiation. Here, essay refers not to traditional conventions of academic writing, but instead to the *essai* (n, French: try, attempt, trial) of Montaigne, Virginia Woolf, Maggie Nelson, and Sven Lindqvist, and offers up writing as a mode of thinking and making. Furthermore, use of the *essai* form is a critical device that appropriates and subverts the institutionalised

conventions through which both academic and scientific knowledge production is legitimised—the practice is described ‘in real time’, accompanied by attendant failures and changes of direction, rather than as a finished account of a completed project.

Stemming in part from the thesis’s interest in the artist as a moral agent, the writing also appropriates certain formal conventions of academic writing, chiefly footnotes, for its own aims. Here, drawing on feminist citation and bibliographic practices, but especially the work of Katherine McKittrick, the writing complicates the first-person position of the *essai* by revealing its own situatedness through a complex web of influences and references beyond conventionally-accepted citational practices. Footnotes are also used throughout as a secondary structure, for additional commentary or reflection on processes, experiences and practice. Despite personal ambivalence about the usefulness or necessity of an artistic practice predicated on the production of ‘stuff’, an ambivalence which intensified over the course of the PhD project, the practice nevertheless explores and (perhaps unwillingly) argues for the importance of making as a unique form of knowledge production. Finally, the thesis further enacts the situatedness and contingency of its knowledge production through a chapter simply entitled ‘Interruption’. The Covid-19 pandemic began almost precisely at the mid-way point of this PhD. Acknowledging the challenges and difficulties this event presented to research, ‘Interruption’ claims this disruption as an important aspect of the practice.

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**HERMIES
& THE
VEIL**

***ESSAIS BETWEEN
ART, FEMINISM &
PHYSICS***

CRYSTAL BENNES

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BOOK ONE

Essay/*Essai* (All men by nature desire to know)

‘It goes back to the very understanding of the word essay, which is not to write, but to make sense of things’.¹ Artist John Akomfrah, speaking to an invisible interlocutor in a 2014 video interview for *Frieze*, is responding to questions about his project on the Black Audio Film collective. Akomfrah talks about the idea of the film essay on television and in the art gallery as a kind of ‘pariah space’. The short film closes with the phrase that opens this paragraph. It’s a definition that appeals to me; the essay as a form for figuring things out.

Akomfrah’s definition draws on an old English meaning of the word ‘essay’ which in turn derives from Montaigne’s use of *essais* as a title for his idiosyncratic musings on everything from smells to sadness. In English, ‘essay’ has lost much of its symbolic weight; in part, thanks to the introduction of the divergent spelling ‘assay’ for certain meanings, and in part thanks to generations of students who have been compelled to write formulaic and structured essays as part of their coursework. While the French *essai* retains its full complexity of meanings—try, attempt, test, trial, assay, and practice—such connotations have largely withered from the diminished English ‘essay’.

Despite the fact that the word is a noun, as Thomas Karshan and Kathryn Murphy write in their introduction to *On Essays: Montaigne to the Present*, Montaigne’s approach centred on a more active process; *essai* as verb, not noun. ‘Montaigne plays on the full range of [the word’s] possible meanings, to propose essayistic writing as a tentative, risky, and experimental way of rejecting authority and exercising the free-thinking of the author: rather a style and attitude than a form, more frequently a verb than a noun’.²

Although there are and have been many essayists, there is far less writing on the essay as a form or on the essay as a mode of practice. By which I mean writing practice. No writing exists that I can find on the essay/*essai* as a mode of artistic practice. Although not everyone who has written on the essay as form agrees on definitions, there are nevertheless certain commonalities: Adorno suggested that the knowledge offered by the essay is not that of definition, but experience. For Rachel Blau DuPlessis, ‘given that the essay is all margin, marginalia, and interstitial writing, it rearranges, compounds, en-

¹ ‘John Akomfrah: On Essays, Identities and Stuart Hall.’ *Frieze*, February 7, 2014. Accessed 15 July, 2019. <https://frieze.com/media/john-akomfrah-essays-identities-and-stuart-hall>.

² Thomas Karshan and Kathryn Murphy, *On Essays: Montaigne to the Present* (Oxford: Oxford University Press, 2020), 4.

folds, and erodes the notion of the centre in textually fruitful ways'.³ Karshan and Murphy note that the essay's key features, 'remarked by everyone from Montaigne to Adorno' include the 'detachment of their separate considerations, their shortness, and their freedom of form to begin and leave off at will'.⁴ Other general characteristics include the appropriation of quotation, so that what another author said becomes the utterance of the essayist's own voice.⁵ Another commonplace is the idea of the essay as a kind of mosaic—or, my preference, a woven textile (similar to Adorno's carpet mentioned below)—'an intricate tessellation of material in which the originality and [the] beautiful consists both in the appeal of the individual segments, and the intricacy of their patterning'.⁶ There is much irony in the fact that essays—writing understood as orderly, structured, clear, well-defined, argumentative, evidential, summative, complete and coherent, without digression—are prevalent as a common form of instruction and assessment in school and undergraduate writing, particularly in the humanities. By definition, however, the essay/*essai* resists and rejects precisely such tropes—its *raison d'être* is digression, marginality, lack of authority, individuality, tentativeness.

'Politicised poetic prose' is another conceptualisation offered by DuPlessis, or 'a protest against all the "rules" of method codified by Descartes, all claims of totality and continuity, of universality, all claims that the mind is a tabula rasa independent of language, independent of its materiality.'⁷ Given the importance DuPlessis ascribes to the essayist's making visible their struggle not to separate out the essay's message from its medium so as, in particular, to avoid 'sidelining deeply imbedded metaphors of gender, sexuality and race', she also emphasises the essay as a form underpinned by self-criticism. This is not to say, DuPlessis argues, that the essay is self-absorbed. Rather, that it is *implicated*. 'Writing an essay does not imply a proper (meaning objective) distance from something,' she writes, 'but a significant proximity to it'.⁸

When bell hooks says that the essay writes at and 'about the points where the public and the private meet'⁹, this feels again like an acknowledgement of the importance of understanding the essay as a form in which the essayist *essais* to foreground the

³ Rachel Blau DuPlessis, 'f-Words: An Essay on the Essay,' *American Literature* Vol. 68 no. 1 (1996): 15–45, 20.

⁴ Karshan and Murphy, *On Essays*, 10.

⁵ *Ibid.*, 12.

⁶ *Ibid.*

⁷ DuPlessis, 'f-Words,' 28.

⁸ *Ibid.*

⁹ *Ibid.*, 32.

reality of their own implication. ‘In the essay, I study myself more than any other subject’.¹⁰ In part because of such open acknowledgement of the role of the self in its construction of meaning, perhaps more than any other form of writing, the essay, again as DuPlessis argues, can claim a feminist space. This claiming can take a number of forms: ‘through interruption, through beginning again and again, through fragmentation and discontinuities, but most of all through its distrust of system, its playful skepticism about generalization...skepticism even about one’s own self-interested position’.¹¹

As Adorno insisted, the essay is not interested in following the rules or logic of the sciences. ‘Since the airtight order of concepts is not identical with existence, the essay does not strive for closed, deductive or inductive, construction,’ Adorno writes. ‘It revolts above all against the doctrine - deeply rooted since Plato - that the changing and ephemeral is unworthy of philosophy’.¹² Relatedly, the essay does not attempt to build a linear continuum of thought (and/or practice) that advances in a single direction. Adorno uses a carpet as a symbol for the way the aspects of arguments interweave in an essay. The fruitfulness of the thoughts depends, he says, on the density of the carpet’s texture.¹³ The implication, of course, being that greater density equals more fruitful thought.

Another interview. Oxford Professor of English, David Russell, is being interviewed by Stephanie Kelley for the website *Five Books*.¹⁴ Russell has been asked to discuss the Victorian essay and suggest five exemplary, or otherwise meaningful, texts. Although Russell reads the essay in the Victorian period as a means for publicly thinking through new ideas about social relations, which is of less interest to my own practice, his emphasis on play and on the essay format as ‘less invested in system and final knowledge’ is much more appealing. For Russell, the essay ‘allows for play; it allows for the tentative; it allows for not quite knowing where you’re going’.¹⁵ By so doing, Russell argues, the essay provides a home for forms of writing that might otherwise be homeless. ‘The essay form *should* be relatively uncategorisable, or keep us on our toes. That’s how it keeps us interested’.¹⁶

¹⁰ Michel Montaigne, *The Complete Essays*, trans. M. A. Screech (London: Penguin Books, 1991), 1217.

¹¹ Duplessis, ‘f-Words,’ 34.

¹² T. W. Adorno, Bob Hullot-Kentor, and Frederic Will, ‘The Essay as Form,’ *New German Critique* No. 32. (Spring-Summer, 1984): 151-171, 158.

¹³ *Ibid.*, 160.

¹⁴ Stephanie Kelley, ‘The Best Books on The Victorian Essay: A Five Books Interview.’ *Five Books*. Accessed August 4, 2019. <https://five-books.com/best-books/victorian-essay-david-russell/>. *Five Books* is a website that combines the form of a list of five book recommendations with an interview, typically with an academic or professional expert in a particular field.

¹⁵ *Ibid.*

¹⁶ *Ibid.*

Each of the above attempts at definition and explanation are useful in beginning to build an understanding and appreciation of the essay/*essai* as a form that defies easy categorisation and embraces uncertainty, skepticism, reading, political situatedness, feminism, self-criticism, digression and tentativeness as part of its process of creation. The *essai* as a form with which one can further develop or construct an artistic practice (an artistic practice that includes these words and those words to come). ‘A celebration of variety, changeableness and partiality as a more authentic kind of knowledge...the essay not just a substitute for experience, but an experience in itself.’¹⁷ The essay as a place to test, to attempt, to try and make sense of things.¹⁸

On CERN (part 1, 2018)

In June 2018, I’m contacted by a physicist from the ATLAS collaboration at CERN, Europe’s centre for particle physics research.¹⁹ Like many people at CERN, the physicist had seen photographs of my stained glass window²⁰ on social media. Alongside a colleague, the physicist was then in the process of setting up a new arts programme hosted by the ATLAS experiment (separate from the ‘official’ artist-in-residence programme, arts@CERN), and was hoping that I might be interested in participating. An initial week-long visit was organised for October 2018, just a month after I started this PhD.²¹

At the time, I thought that processes of data capture and analysis in particle physics experiments would form the core of my PhD research subject, and so many meetings at CERN were scheduled with people working in related areas. Given that CERN’s detectors capture exponentially more data than its computers can store or its physicists can process, for example, I was particularly interested to learn more about the bespoke systems for filtering data; for making decisions about what to save and what to destroy. To-

¹⁷ Kathryn Murphy, ‘Of Sticks and Stones: The Essay, Experience, and Experiment,’ *On Essays*, 96.

¹⁸ By ‘things’ I mean thoughts, ideas, concepts, methods, modes, practices, primary sources, secondary sources, nature, sciences, art institutions, political structures, etc. etc. etc.

¹⁹ ‘We (ATLAS experiment) are moving towards a better collaboration with artists, in partnership with <http://artcms.web.cern.ch/artcms/> and others. Given that your portfolio contains a lot of potentially interesting material, I’m wondering if you’d be interested in some kind of follow up or if you have moved to something else. We could maybe skype?’

²⁰ This artwork resulted following a prolonged period of research into the visual culture of science. Namely, the reoccurrence of circular geometric shapes in the visual communication of scientific thought past and present. With reference to this research, a data visualisation from the ATLAS experiment at CERN was translated into a Medieval-type circular stained glass panel. The artwork was made by hand over a one year period: a cartoon drawing, 650 pieces of glass, 150m of lead came fit between each glass piece, the glass was “cemented” and stabilised with a steel frame and ferramenta framework (created with the help of a metalworker and fellow student at Aalto University, where I was studying when I made it).

²¹ Although I later started keeping a daily diary during my fieldwork visits, I hadn’t yet started this practice and so my recollections of this trip are pieced together from memories, emails and photographs.

gether with my host, I visited the main CERN control room and the ATLAS control room. As the beam was in continuous operation throughout the duration of my visit, I was unable to visit any of the four underground detectors. But visits to various data centres, numerous other experiments, technical spaces where parts were under construction for future detector upgrades made up for any potential disappointment at not being able to go below-ground.

One fairly depressing aspect of the visit was that, in terms of gender balance, I met far more men than women. Most of the women I met were not physicists, but archivists, other artists, or communications directors. With one exception, everyone I met was enthusiastic, courteous, and interesting. However, they were almost entirely uninterested in me or my work. In a pattern that was to be repeated on nearly all of my subsequent PhD fieldwork trips, most meetings were one-sided; the physicists implicitly assumed I was there to learn from them and to act as a vessel to receive and then transmit their knowledge to an unspecified ‘wider public’. There was little to no appreciation of the fact that I might have my own knowledge to transmit, or my own lines of inquiry or interest in physics which diverged from theirs.

Another oddity was that everyone wanted to meet in the cafeteria or R1, as they called it. Initially I wondered if this was about a division of space, that people didn’t want me to intrude on their private office spaces. Eventually I asked my host about it and she said that meetings in R1 gave people an opportunity to get out of their offices—many of which were small and shared with others.

Although I found certain aspects of the visit stimulating and interesting, overall I was surprised by how little I liked being at CERN. Most surprising, though, was what happened after the visit. My host followed up about whether I had any ideas for artworks that could be created as part of the brand new arts + ATLAS programme. When I asked about budget, I was informed that all that was on offer was time and support. My host, one of the instigators of the art + ATLAS collaboration, seemed frustrated by the lack of support from the ATLAS management, but as I was later to learn, CERN—despite outward evidence suggesting otherwise—is wholly uninterested in committing money to projects which are not perceived as having scientific relevance.

Despite the lack of any financial support from CERN, a little over a month later, I submitted an informal proposal for a new artwork inspired by my visit—a moving-image piece on the women of CERN, mainly the administrators, cafeteria workers and

cleaning staff, but also women physicists. Not only would the work need to be funded independently through financing which I would have to source and secure, but the proposal would also need to be approved by the ATLAS secretariat in order for permission to be given to return to CERN to create the artwork. My host emailed one of CERN's most well-known, high-profile woman physicists, who had also recently been appointed the next outreach co-ordinator of the ATLAS experiment, about my project to gauge her interest and willingness to support the project through administrative and bureaucratic channels. She never replied.²²

I submitted a more concrete proposal document in February 2019. A month later, I was informed that my proposal—because the film I wanted to make had largely settled on the idea of foregrounding the non-scientific, non-technical labour that makes it possible for CERN to function relatively frictionlessly for physics research—would need to be approved by the 'Exhibition and global engagement' team. This resulted in large part from the fact that CERN staff expressed their puzzlement at my lack of interest in featuring technical or scientific workers in my artwork. Their response stated confusion as to why I would want to make such a film at CERN because, in that case, I might as well make an artwork about 'any other big working place', i.e. my film would not present a depiction of CERN as somewhere special and unique. Not only did the exhibition and

²² I think about this when I read the following quote by Sookie Stambler cited in bell hooks's *Feminist Theory*:

'Movement women have always been turned off by the media's necessity to create celebrities and superstars. This goes against our basic philosophy. We cannot relate to women in our ranks towering over us with prestige and fame. We are not struggling for the benefit of the one woman or for one group of women. We are dealing with issues that concern all women.'

I think about this in relation to a conversation I had with a woman physicist at CERN when asking about why, for example, the lab had an activist group for the LGBTQ community but not one for women, she talked about her experiences with a few "famous" women physicists who were content to make use of feminist rhetoric for their own personal or professional gain, but were unwilling to join collective action for the benefit of all women in physics.

global engagement committee reject my proposal, but they refused to even consider it in the first place.²³

Despite having been *invited* to visit CERN for the express purpose of creating a new artwork, I was now informed that my proposal was not even going to receive consideration. That particular committee, I was told, only considered proposals for artworks via the art@CERN competition held once a year through an international open call. The art + ATLAS programme would only allow for artistic collaborations that focused on scientific and technical endeavours. It felt like a very elaborate, and wonderfully bureaucratic, way of controlling the narrative about and around CERN. We would love to invite you to visit our institution and create a new artwork, but only if we approve the message and you pay for it. Message not approved. Proposal rejected.

Beamtimes and Lifetimes

It is easy to distinguish between the groups at the cafeteria [at the Stanford Linear Accelerator Complex in Berkley, California]. The physicists are dressed most casually, in shirts with rolled sleeves and jeans or nondescript slacks. They disdain any clothing that would distinguish them from each other. The style to which they conform, furthermore, maintains a carefully calibrated distance from fashion, quality, or fit... Usually the physicists from each experimental research group will walk as a body to the cafeteria and then sit together, pulling a few tables end to end and making room for late arrivals. Sometimes senior physicists from different groups have lunch to discuss lab business. Theorists eat in smaller

²³ 1 March, 2019 email: 'If you agreed to restrict your searches to that area, then the yes/no would depend entirely on ATLAS Technical Coordination, and the fact that we work together fully justified. It really is "ours" so to say. If you do not agree, or if you do and the ATLAS TC (= Technical Coordination) doesn't ... then I'll mention the project to the head of CERN ECO on March 14 (when I meet her) and cross fingers, as it is "their land".'

13 March, 2019 email: 'Now that the web@30 celebration is over, the head of the CERN ECO group [<https://communications.web.cern.ch/>] replied. She told me to forward the file to the "Exhibition and global engagement" team, which includes Monica Bello's art@CERN activities but not only...FYI, she is (just like me) puzzled by the fact that you do not want any technical or science person at all, because in that case CERN becomes "any other big working place". You may want to think about what you're going to answer, as it is a decision that may close many doors and the answer you gave me ("I do not want to mix with my PhD on data") is not easy to catch or follow for us.'

13 March, 2019 email: 'OK, let me play the "CERN guys part" ... They will buy the idea to expose other aspects & people of their place, for sure. But the question is then: If you shoot non "gee whiz" people's labour in a non narrative piece, what will make the spectator understand that they are a specific place (CERN, not any large semi rotten campus) and that they are "making big science possible"?'

13 March, 2019 email: 'They were quick: No, the CERN ECO guys do not want to get in touch with you, as their only entry door is the art@CERN program competition procedure. I cannot say that I am surprised, as it's been their policy for long. We (art@CMS and its extension ORIGIN) work on/with collaborations, that is to say our institutes & people, and on the scientific & technical endeavour. So that does not fit either. I do hope that there will be other occasions.'

clusters. While eating, people scan the room frequently, noting who is or is not eating with whom. Almost no one eats alone.²⁴

About a month after returning from CERN, I read *Beamtimes and Lifetimes*, anthropologist Sharon Traweek's pathbreaking study of communities of high energy particle physicists in the United States and Japan. So many things that perplexed me during my CERN visit, cultural behaviours in particular, suddenly started to make sense. For example, Traweek's observation that knowledge transmission among professional physicists is largely verbal.²⁵ And that culturally, outside of a few, individual white male 'geniuses' who serve as (unattainable) role models, physicists display a marked lack of interest in the history of their field.²⁶ Or that physicists are members of a community which, mainly in the Anglo-American-European context, values conformity as well as a certain degree of showmanship from its leaders.²⁷ Perhaps most harmful of all, Traweek traces the ways in which physicists have and continue to regard themselves as a meritocracy, despite the fact that the field is (and has historically been) dominated by white men to the exclusion of all others. Concern with these and related matters, Traweek emphasises, such as how to get along with other members of the community, is considered to be un-scientist-like. 'Social eccentricity and childlike egoism are cultivated displays of commitment to rationality, objectivity, and science,' she writes. 'Young scientists often assert their ignorance of human motives, of everything "subjective," as if that confirms their vocation'.²⁸

Traweek also speculates on the interesting relationship which developed between physicists and the public following the end of the Second World War when the discipline occupied an elevated status for its role in developing the atomic weapons which 'won the war'. Although physicists, she argues, do not see themselves as involved in creating religious meaning, 'they do see their own profession as the revelation and custody of fundamental truth'.²⁹ More importantly, however, physicists and astronomers in particu-

²⁴ Sharon Traweek, *Beamtimes and Lifetimes* (Cambridge: Harvard University Press, 2009), 25.

²⁵ Ibid., 75. 'Self-assertion and bravado must be added in the third stage, when the "students"-having earned their Ph.D.'s-become research associates. This desired ethos stands in counterpoint to, yet must include, the meticulousness and patience of the earlier phase. The "postdocs" begin to learn 'and communicate about physics orally, rather than through books and articles. They cultivate competitive and acerbic conversation to display independence and a contempt for mediocrity. They learn stories about those in recent generations who have "made it"; from these stories they realize how important it is to anticipate the future. Only at the completion of these first three stages. can a postdoc become a full-fledged member of the particle physics community. Even so, about 75 percent leave the field after this fifteen-year training period.'

²⁶ Ibid., 86.

²⁷ Ibid., 87-88, especially where Traweek writes of how you need to be a 'son of a bitch' to gain respect from peers and develop interest in your work among the community.

²⁸ Ibid., 91.

²⁹ Ibid., 2.

lar have become aware of the public's fascination with their subjects of study and feed such fascination by providing regular news stories and books that speak to the 'gee whizz, science!' phenomena. Of this relationship, Traweek observes that 'Western culture confirms them in this privileged role. [The physicists] bring news of another world: hidden but stable, coherent, and incorruptible. In times of bewildering and threatening change, this gospel, however esoteric, has a very deep appeal'.³⁰

Having felt at CERN that I was perhaps attempting to borrow from the toolbox of a science studies researcher or an ethnographer, but without the theoretical foundations or sufficient practical experience to draw appropriate conclusions from my observations, Traweek's text enabled me to begin to map my own observations onto possible explanations. Moreover, Traweek's reflections on developing methods and strategies for working among physicists were useful as I worked out my own approaches for talking about physics with physicists, many of whom (unconsciously or consciously) perceive their discipline as a 'culture of no culture' as Traweek so memorably put it.³¹ Although such considerations are only briefly mentioned in *Beamtimes and Lifetimes*, Traweek writes of the power differences between her own field of anthropology and that of the physicists she studies, power differences which are very much applicable to disciplinary contact between art and science. She mentions that the physicists she engages with are shocked at the small research grants awarded to anthropologists (compared to their own), for example, and frequently advise her how to better make use of the grant system.³²

Given the similarities between our experiences as individual women working with collectives of male physicists who are much better funded and resourced, I was particularly struck by Traweek's comments on how to do good fieldwork. I recognised a great deal of myself in the following comment:

My first task was to suppress my own conditioned impulse to show myself a good student-which they elicited so well. They liked my persistent inquisitiveness, although they did not like me to pursue questions they had decided were unimportant.³³

³⁰ Ibid.

³¹ Ibid., 162.

³² Ibid., 5.

³³ Ibid., 5.

While I wanted to ensure that I understood scientific or technical concepts as clearly and correctly as possible, I was often more interested in various social or political structures. As Traweek states, many physicists attempt to shut down certain lines of questioning which they do not like or which they feel are unimportant. One of the most frequently deployed techniques, in my experience, was that a physicist might insist I was wrong, or that I didn't have the requisite scientific training, in order to be able to authoritatively comment on certain issues. Regardless of whether or not I was, in fact, correct, my status as a 'community outsider' often meant that my criticisms or even certain lines of questioning were aggressively refuted or simply dismissed. By contrast, when I was performing the role of a 'good student', asking appropriate questions and demonstrating my understanding, I was treated with benign acceptance. Interestingly, when I demonstrated levels of more advanced or professional knowledge—for example, when I revealed to a group of physicists at a specialist physics conference in Germany that I had been learning how to use Root, a software package ubiquitous in high energy physics data analysis, to better understand their tools, this was met with confusion, bafflement and even a degree of suspicion.

While, as Lauren Chambers points out, in feminist terms, Traweek's work is imperfect and only barely feminist, *Beamtimes and Lifetimes* nevertheless 'laid the foundation for all subsequent "feminist" studies of physics'.³⁴ While Traweek spoke of the gender disparity in high energy physics, noting in particular the fact that, while women were excluded from doing physics, they were present in large numbers in purely administrative roles or low-status work such as 'scanners'.³⁵ Traweek also writes of the role of undergraduate physics textbooks in the United States, and their role in subliminally enforcing the message that 'science is the product of individual great men; that this product is independent of all social or political contexts; that all knowledge is dependent upon or derivative from physics; that only a very few physicists will be invited into the community of particle physics; and that the boundaries of particle physics are rigidly defined'.³⁶ One of Traweek's more important observations on gender and physics is that women are excluded from high energy research communities in both Japan and the

³⁴ Lauren Chambers, 'A Different Kind of Dark Energy: Placing Race and Gender in Physics' (BA thesis, Yale University, 2017), 30.

³⁵ Traweek, *Beamtimes*, 28-29: 'Nine of the thirteen scanners at SLAC are women, some young, some middle-aged; six are black and one is Asian-American... It is now realized that one need not know anything about physics to do the work well, and its status has declined accordingly'.

³⁶ *Ibid.*, 78. Such subliminal messages are often reinforced in other ways. For example, at CERN, in one of the larger conference rooms in the main building, the walls are lined with large black and white photographs of past Nobel prize winners. Every single one of the past winners is a white, middle-age man.

United States, but that the justifications given in each country are based on opposing stereotypes.

On Becoming an Advocate for Feminism³⁷

I'm in southern Sweden on a photography residency. It's August 2021 and I'm reading bell hooks's *Feminist Theory: From Margin to Center*. I turn down the corner of nearly every single page. I nod my head after so many sentences. But there's this one bit in particular that makes my heart stop beating for a millisecond: 'To emphasize that engagement with feminist struggle as political commitment, we could avoid using the phrase "I am a feminist" (a linguistic structure designed to refer to some personal aspect of identity and self-definition) and could state, "I advocate feminism"'.³⁸ I'm a few months away from turning forty, and I'm only now encountering the feminist texts I wish I knew existed in my late teens and early twenties. Although a small part of me feels melancholic at how long it's taken me to come to the writings of bell hooks and Angela Davis and Katherine McKittrick, I mostly feel elated, completely invigorated.

Many aspects of conventional feminism of the kind espoused by white, middle-class women in the West, particularly since the 1970s, have pushed me away from rather than drawn me towards self-identifying as feminist even though this is the same demographic from which I hail. I don't want to use space here to list all my grievances with white, middle-class Western feminism. Rather, I want to note the extent to which, unlike Sharon Traweek, who was only marginally interested in feminist questions, this PhD has become a feminist project, and indeed the extent to which my practice has become feminist praxis. Or, rather, a praxis that advocates for feminism.

One of the key ways in which this thesis enacts the notion of feminist praxis is through citation. While, for example, Donna Haraway's conception of situated knowledge purports to counter bias in the 'objective' sciences by acknowledging the position of the researcher, a more generous version of this notion can be found in the idea of citation as a feminist praxis. The particular phrase 'citation is feminist praxis' is largely at-

³⁷ The title of this essay is taken a line in bell hooks's *Feminist Theory: From Margin to Center*.

³⁸ bell hooks, *Feminist Theory: From Margin to Center* (London: Pluto Press, 2000), 31.

tributed to writer Sara Ahmed³⁹, but the broader idea has emerged from Black feminist and other women of colour writers, many of whom are based in North America. Drawing the two ideas together, one could argue that situated knowledge is not only about locating the researcher or scientist within their local peer networks—networks which might influence hiring, funding, and other research practices—but about locating the researcher in an expanded network of solidarity, support, and respect. In this way citation-al practices—for example, who is referenced, who is discussed, who is added to syllabi, and with what frequency?—are able to become feminist, anticolonial, and antiracist praxis. As Katherine McKittrick emphasises, ‘Perhaps the function of communication, referencing, citation, is not to master knowing and centralize our knowingness, but to share how we know [...] Citing is not easy. Referencing is hard.’⁴⁰ And while McKittrick, Ahmed and others take pains to emphasise the need to rewrite existing citational systems which perpetuate the marginalisation of women and people of colour from academia, they also stress the importance of citation as a form of solidarity and a demonstration of love and respect.

On the Possibility of a Feminist Physics, part I

Demographics is arguably the most frequently discussed topic in relation to gender and/or race and physics. Physics as a discipline seems to agree that there are not enough women and people of colour in the field, or acknowledges that there exists a ‘leaky pipeline’ in which women start university as physics majors but drop out somewhere between graduate studies and employment as professional physicists.⁴¹ Historically, much of the rhetoric has revolved around the question of making physics more attractive to girls and women, rather than in making the cultures of physics more welcoming to people who aren’t white men. Relatedly, a number of feminist science studies scholars

³⁹ Sara Ahmed, ‘Making Feminist Points’, *feministkilljoys*, 11 September, 2013. <https://feministkilljoys.com/2013/09/11/making-feminist-points/>. Also Sara Ahmed, *Living a Feminist Life*, Duke University Press (2017), 17: ‘Citation is how we acknowledge our debt to those who came before; those who helped us find our way when the way was obscured because we deviated from the paths we were told to follow.’

⁴⁰ Katherine McKittrick, ‘Footnotes (Books and Papers Scattered about the Floor),’ in *Dear Science and Other Stories* (Durham: Duke University Press, 2021), 17. It was listening to a podcast conversation between Chanda Prescod-Weinstein and Cite Black Women podcast host Christen Smith that first made me want to read Katherine McKittrick and drew my attention to this particular book.

⁴¹ For example, Jess Wade, ‘Why we need to keep talking about equality in physics’, *PhysicsWorld* (August 2019) <https://physicsworld.com/a/why-we-need-to-keep-talking-about-equality-in-physics> and Aditya Gupta, Ninareh Mehrabi, Goran Muric, and Kristina Lerman, ‘The Leaky Pipeline in Physics Publishing’, *Physics and Society*, Vol 1 (18 October, 2020) <https://arxiv.org/abs/2010.08912>.

have equated the paucity of women in the field with the dearth of feminist critique of physics, compared to biology or chemistry. One of the difficulties with demographics as a focus seems to be a false equivalence between high numbers of women in a field and feminist critiques of that field. As many feminist theorists have argued, not all women are feminists and not all feminists support all women.⁴² Moreover, a crucial issue identified by Banu Subramaniam and Mary Weyer is that, in the sciences, women are educated in a professional culture that encourages them to distance themselves from their identity as women for professional advancement. Their term for this is 'dementoring'—the training of women in STEM by 'untraining them as women' and assimilating them as scientists.⁴³

In *Has Feminism Changed Science?*, Londa Schiebinger suggests that the scarcity of women in physics has insulated the discipline from feminist critique and bolstered calls by Evelyn Fox Keller and Helen Longino for further work in gender and the physical sciences.⁴⁴ Schiebinger suggests that the field's associations with positivist epistemologies is one key reason why feminist critique has not made significant inroads in physics, compared to biology or the social sciences. However, Schiebinger is in danger of reproducing the conflation between demographics and feminism, and her argument that a lack of women *as* physicists has contributed to a lack of feminist criticism feels somewhat misplaced. One does not need to be a professional physicist or even trained as a physicist to be able to legitimately criticise physics on feminist grounds. Schiebinger herself acknowledges that 'questions of meaning, consequences, or social responsibility are not considered to be part of physics proper, but belong to other realms, such as philosophy, ethics or history'.⁴⁵ It is not necessarily the literal absence of women physicists that is a problem with physics, but the way the discipline understands itself (and has historically understood itself) as a field utterly decoupled from any sense of social or political realities. As Margaret Wertheim has argued, 'To put it bluntly: It is not just a matter of helping women to change so they will be comfortable with the culture of physics, we also need to consciously work on changing that culture itself'.⁴⁶

⁴² Angela Davis's book, *Women, Race and Class*, offers many powerful examples in support of this point, but especially in terms of highlighting the racism and classism underlying many of the key figures in the American suffragette movement.

⁴³ Banu Subramaniam and Mary Weyer, 'Assimilating the "culture of No Culture" in Science: Feminist Interventions in (De)mentoring Graduate Women,' *Feminist Teacher*, Vol. 12, 1 (1998), 12-28.

⁴⁴ Londa Schiebinger, *Has Feminism Changed Science?* (Cambridge: Harvard University Press, 1999), 160.

⁴⁵ *Ibid.*, 163-64.

⁴⁶ Margaret Wertheim, *Pythagoras' Trousers: God, Physics, and The Gender Wars* (London: Fourth Estate, 1997), 246.

As an aside, an interesting example of the problem of demographics and representation is provided by atomic weapons research programmes carried out both during and after the Second World War in the United States. Although conventional histories of these events focus, like most popular scientific histories, on a handful of hero figures—almost without exception well-educated white men—a great many women participated in these programmes. Women ‘computers’ were hired by the Army to carry out firing table calculations, before later becoming hired operators and programmers of the first modern computers. Women mathematicians and wives of physicists worked on figuring out calculations for atomic bomb shock waves to improve understanding and performance of implosion detonation mechanisms. A more comprehensive history would feature the many women who were involved in this advanced physics research.⁴⁷ While some of these women were later lionised for their participation as early computer programmers, I question whether the simple fact of greater visibility and representation of women in the development of atomic weapons is in any way feminist. What good is it to have visible representation of women working in physics when what they worked to create were genocidal weapons that caused immense suffering?⁴⁸ As anthropologist Hugh Gusterson has noted, while many atomic weapons makers were situated across a broad spectrum of political affiliation, the socialisation of scientists into the laboratory is ‘a process whereby political questions [are] transformed into technocratic questions’.⁴⁹ Representation is one tool among many. It is an important one, but it is not the most important.

Inasmuch as there exists a plurality of views in physics, there exists a plurality of views in feminist analyses of science. In *The Science Question in Feminism*, Sandra Harding is careful to emphasise the importance of tensions between three broad epistemological feminist programmes:

⁴⁷ For example, Richard Rhodes’s history of the making of the atomic bomb, which clocks in at nearly 900 pages and includes many women who were involved in the project.

⁴⁸ This makes me think of another citation in bell hooks, that of French feminist Antoinette Fouque, in which she states that it’s not enough for women to aim at equality with men under the current system, but for a completely new system constructed around ending oppression:

The feminists claim that they do not seek equality with men, but their practice proves the contrary to be true. Feminists are a bourgeois avant-garde that maintains, in an inverted form, the dominant values. Inversion does not facilitate the passage to another kind of structure. Reformism suits everyone! Bourgeois order, capitalism, phallocentrism are ready to integrate as many feminists as will be necessary. Since these women are becoming men, in the end it will only mean a few more men. The difference between the sexes is not whether one does or doesn’t have a penis, it is whether or not one is an integral part of a phallic masculine economy.’

⁴⁹ Hugh Gusterson, ‘Becoming a Weapons Scientist,’ in *Technoscientific Imaginaries*, ed. George Marcus (Chicago: University of Chicago Press, 1995), 262. Cited in Wertheim, *Pythagoras*, 168.

Feminist empiricist philosophy, which aims to correct ‘bad science’; feminist standpoint theory, which tries to construct knowledge from the perspective of women’s lives; and feminist postmodernism, which is suspicious of the Enlightenment loyalties inherent in such scientific and epistemological projects.⁵⁰

For Harding, as for many feminist critics of the sciences, ‘modern Western science contains both progressive and regressive tendencies’ and she views her task to ‘advance the former and block the latter’.⁵¹ Although, for reasons I have set out previously and will reiterate shortly, I find it difficult to agree with this somewhat simplistic analysis, Harding’s emphasis on the need to socially locate our research—in particular in the race, gender and class relations from which it originates—holds substantially greater appeal.⁵² One outcome of reflecting on the argument that our research ought to be socially-located is that, as Harding claims, we begin to understand how ‘humans construct themselves as possible objects of knowledge and have also constructed inanimate nature as a possible object of knowledge’.⁵³ Drawing on the prevalent theme of unveiling nature, Harding continues:

We cannot ‘strip nature bare’ to ‘reveal her secrets’, as conventional views have held, for no matter how long the striptease continues or how rigorous its choreography, we will always find under each ‘veil’ only nature-as-conceptualized-within-cultural projects; we will always (but not only) find more veils. Moreover, the very attempt to strip nature bare weaves more veils, it turns out. Nature-as-an-object-of-knowledge simulates culture, and science is part of the cultural activity that continually produces nature-as-an-object-of-knowledge in culturally specific forms.⁵⁴

More importantly, Harding is adamant that the discussions and practices of feminist science and technology studies must ‘decenter the preoccupations of white, economically advantaged, heterosexual, and Western feminists in the thinking and politics of feminists with these characteristics’.⁵⁵ Too often white Western feminists unthinkingly set the agendas of feminist discourse and priorities without appreciating the desires, needs, vis-

⁵⁰ Sandra Harding, *Whose Science? Whose Knowledge? Thinking from Women’s Lives* (Ithaca: Cornell University Press, 1991), vii.

⁵¹ *Ibid.*, 3.

⁵² *Ibid.*, 12.

⁵³ *Ibid.*

⁵⁴ *Ibid.*

⁵⁵ *Ibid.*, 13.

ions and lived experiences that differ between different groups of women around the world. This is one reason why an isolated insistence on representation can become problematic; to borrow from another Harding title: whose representation?

An important project of feminist science criticism has been to demonstrate the extent to which Western elites have insisted, as Harding puts it, on the ‘separation between the work of pure scientific inquiry and the work of technology and applied science’ in order to ‘avoid taking responsibility for the origins and consequences of the sciences and their technologies or for the interests, desires, and values they promote’.⁵⁶ Given the fact that many scientific disciplines receive vast sums of public funding⁵⁷, it is easy to understand why strategies that insist on a separation between ‘pure’ and ‘applied’ research have prevailed. One of Harding’s broader interests is to ask why society should be expected to, particularly ‘in the face of competing social needs, provide massive resources for an enterprise that claims in itself to have no social consequences?’⁵⁸

From a methodological point of view, Harding makes note of the interesting relationships between feminist critiques of science and techniques borrowed from literary criticism, historical interpretation and psychoanalysis that enable the former to “‘read science as a text’...its formal statements, intellectual traditions, research practices, social formations, the scientific and popular beliefs about it, and so on’.⁵⁹ In borrowing and appropriating these and related techniques for application in feminist analyses, Harding also emphasises that the focus should be on cultural rather than individual. By way of example, she returns to the use of sexist language and imagery so prevalent throughout the history of Western sciences. It is important, she claims, not to simply identify certain individuals as sexist. Rather, ‘the point is that the sexual meanings of nature and inquiry are used to express the anxieties of whole societies—or, at least, of the groups whose interests science was intended to advance’.⁶⁰ Harding echoes Fox Keller’s insistence that sexist images, metaphors and rhetoric are not simply ‘ornamental images on the surface

⁵⁶ Ibid., 2.

⁵⁷ In 2017, the UK government’s expenditure on science, engineering and technology (SET) relating to research and development grew by £0.7 billion to £12.2 billion in 2017, an increase of 6.4%. <https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgovernmentexpenditureonscienceengineeringandtechnology/2017> Compare with the United States government, who spent \$548 billion on research and development (<https://www.nsf.gov/statistics/2020/nsf20309/nsf20309.pdf>), and China, who spent \$496 billion in the same period (<https://www.forbes.com/sites/niallmccarthy/2020/01/20/china-is-closing-the-gap-with-the-us-in-rd-expenditure-infographic/?sh=4c631a645832>).

⁵⁸ Ibid., 38.

⁵⁹ Ibid., 43.

⁶⁰ Ibid., 44.

of scientific rhetoric'⁶¹—in her words, 'not merely heuristic devices or literary embellishments'— but that 'they are a substantive part of science in that they show scientists how to extend the domains of their theories, what regularities of nature they should expect to find, what questions about nature to ask'.⁶²

Another important consideration Harding discusses in relation to feminist science studies work and the physical sciences is how one possible consequence of the former would be to have no female scientists working in the latter. What would it mean, Harding asks, 'if it is an outcome of the purportedly most radical feminist science criticisms that women should give up trying to understand the natural world. Can we try to create more feminist sciences without any women scientists?'⁶³ As a challenge to the more conventional argument for simply increasing demographic representation of women in the natural sciences, Harding rightly claims that there is little point in campaigning for the 'advancement of women in the existing scientific enterprise if that means leaving science otherwise unchanged'.⁶⁴

In a chapter entitled 'Why "Physics" is a Bad Model for Physics', Harding begins by articulating a position from which feminists might start to advocate for change. Her first concern, she writes, is not to throw the baby out with the bath water: 'my concern is to separate the false beliefs from those that are conducive to empirically, theoretically, and politically more adequate sciences'.⁶⁵ Harding's is an argument which has become increasingly common among some feminist and other cultural theorists of the sciences. With the rise of populist politicians and hard-right nationalism around the world, some left-wing academics who used to take an outright critical position of the sciences have begun to question the extent to which such criticisms may have been used to undermine public trust in the scientific validity of climate change, for example, or vaccine efficacy during the Covid-19 pandemic. Have so-called relativistic criticisms of scientific truths been responsible for providing new tools to be used by 'truth-deniers'? Hence the appearance of statements claiming to not want to throw potentially-useful babies out with the scientific bathwater.

⁶¹ Evelyn Fox Keller, *Reflections on Gender and Science* (New Haven: Yale University, 1985), 12.

⁶² Harding, *Whose Science?*, 44.

⁶³ *Ibid.*, 55.

⁶⁴ *Ibid.*, 67.

⁶⁵ *Ibid.*, 78.

While Harding wants not to throw the baby out with the bathwater, she describes her position as being in contrast to a conventional view, often, she argues, held by practicing scientists and engineers. She ventriloquizes: ‘If bridges stand and the television set works, then the sciences that produced them must be objective and value-free—that’s all there is to the matter.’⁶⁶ The hallmark of this conventional view is an inability to recognise or to admit that the modern sciences have been ‘constructed by and within power relations in society, not apart from them’.⁶⁷ For Harding, it isn’t so much a matter of interrogating how the individual scientist abused power during their tenure, but instead to understand ‘where the sciences and their agendas, concepts, and consequences have been located within particular currents of politics’.⁶⁸ And here is where we’re introduced to Harding’s now well-known ‘standpoint theory’: the idea that not only is the belief that the nonhuman subject matter of the natural sciences can produce ‘impartial, disinterested, value-neutral accounts of a nature completely separate from human history’ false, but that we could ‘begin to understand better how social projects can shape the results of research’ in these sciences once we accept the truth of this falsity.⁶⁹ Harding’s reconceptualisation of objectivity (along with those of Helen Longino or Donna Haraway) is one aspect of feminist epistemology/ies of science which has most troubled mainstream physicists. As Amy Graves has pointed out, it is not so much the idea ‘that a broader community could be generative of more good ideas [that is] troubling to a physicist... [but] that it could be more objective’.⁷⁰

Harding concludes the chapter with an examination of the disconnect between notions of ‘pure’ and ‘applied’ research in the physical sciences. She explores the tension between the idea that ‘pure’ science is a separate process, the only function of which is to produce scientific information. Under this pure-research paradigm, deciding what to do with the information produced (and similarly, being held responsible for the misuses and abuses of that information) becomes the responsibility of policy-makers rather than scientists.⁷¹ Of course, as Harding elaborates, one can hardly make claims to ‘pure science’ in today’s world. Science and technology are so interconnected; for one thing, scientific research in the physical sciences is technology-driven and these technologies

⁶⁶ Ibid., 78.

⁶⁷ Ibid., 81.

⁶⁸ Ibid.

⁶⁹ Ibid.

⁷⁰ Amy Bug Graves, ‘Has Feminism Changed Physics?’, *Signs*, Vol. 23 No. 3 (2003): 881-899, 888.

⁷¹ Harding, *Whose Science?*, 88.

have social implications. Furthermore, crucially, much pure research is ‘often justified on the grounds that it is likely to produce technologically useful information’.⁷²

The feminist project, as defined by Harding, is one of myth-busting. Given the commonly-held view by natural scientists that ‘physics is the best model for the natural sciences’, the assumption is that ‘feminist social science analyses can have nothing to offer the natural sciences’.⁷³ As Harding argues, however, it is not simply the issue that physics provides a poor model for social inquiry. Rather, ‘the paradigm of physics research and explanation, as it is understood by scientists and most other people, is a poor model for physics itself’.⁷⁴ As a final point on the pure/applied dichotomy, Harding also asks why it is—in a world where a more democratic distribution of resources would significantly improve the lives of many—that we should support scientific activity self-defined as ‘pure’ and which delivers no socially-useable results?⁷⁵

That ‘Nature’ is the Most Complex Word in Language

It’s Sunday, the 14th of April, 2019. I’m in Batavia, Illinois, home of Fermi National Accelerator Laboratory and I’m snowed in.

I’d planned to drive the three miles between the farmhouse where I’m staying in The Village and Fermilab’s main building, but as I turn right out of the parking lot, I realise I’m being foolish. There’s a stop sign on the corner to my right, but I can’t see it. I reverse the car and return to the parking lot. I spend most of the rest of the day in my room, taking photographs of the snowstorm from my window.

I arrived at Fermilab six days ago, and there are eleven more days remaining of my trip. Things are not turning out as I anticipated, and I don’t only mean the weather.

⁷² Ibid., 92.

⁷³ Ibid., 97.

⁷⁴ Ibid., 98.

⁷⁵ Ibid., 92. Such views are not as common in the feminist science study literature as I might have hoped. In popular culture, perhaps the most well-known example of such critique is to be found in Gil Scott Heron’s marvellous spoken-word poem, ‘Whitey on the Moon’ from 1970 released during the Apollo Moon landings:

A rat done bit my sister Nell.
(with Whitey on the Moon)
Her face and arms began to swell.
(and Whitey’s on the Moon)
I can’t pay no doctor bill.
(but Whitey’s on the Moon)
Ten years from now I’ll be paying still.
(while Whitey’s on the Moon)

Prior to travelling to Fermilab, I had made a detailed plan of projects to work on, people to speak with, questions to ask. I had intended to make a film of interviews with physicists, asking questions about the nature of neutrinos and indirect observation in particle physics experiments. In my studio in Edinburgh, I had tested out various compositions for filming the interviews and written and rewritten questions to ask:

What does a neutrino look like?

Can you say that you understand how something is in nature (in physics) when you only ever understand how a natural phenomenon interacts with your devices?

Why is it considered unproblematic for physics knowledge that a neutrino signal is captured as indirect information? Is it because theories of beta decay are now so well established and supported?

Is there a useful metaphor that describes your research?

Yet, within thirty minutes of my first morning at Fermilab, I knew that my plans for the film were not going to work. Preparation, for me, means research, reading, thinking, sometimes material experimentation, or making lists of ideas and things to try. But then, on arrival, it so often turns out that the preparation and plans made were conceived around a place that did not exist. Those plans had been made for an imagined, almost certainly idealised world. Methods must be adapted according to the realities of people and place. Plans must be changed. In part this is intuitive; in part, this is what research looks like for an artist.

Although I didn't immediately abandon my initial set of questions on arriving at Fermilab, after a few days I simply made the decision to allow myself the liberty of exploring and questioning without keeping those original research questions too firmly in mind. Instead, I decided to learn and experience as much as possible, not indiscriminately, but according to what interested me at any given time and then see how things settled when I arrived back in my studio.

What immediately struck me about Fermilab was, quite surprisingly, what it looked like. Having been to CERN and to other particle physics research laboratories in Europe and South America, I was expecting the usual parade of oversized aluminium

sheds. At Fermilab, not only is the campus situated in the middle of 6,800 acres of farmland and restored Illinois prairie (including its famous herd of 25 American bison), but its oversized sheds are painted in bright colours—blues, yellows, pinks and oranges—with enormous geometric shapes. Possibly my favourite place on the entire site was a row of ten large gas storage cylinders, horizontally laid out like enormous sausages end-to-end, each one painted in a slightly different shade of coral pink in a left-right gradient from light to dark. Robert Wilson, Fermilab’s founding director, was as concerned with the aesthetics of his laboratory as he was with the research it produced. Remarkably, Wilson’s eleventh hire was Angela Gonzales, a visual artist who was deeply involved in all aspects of Fermilab’s visual culture. She designed its logo, created illustrations for publication covers and conference posters, as well as the colour schemes for brightly-coloured buildings and gas tanks I so admired.

If Wilson was highly attentive to the aesthetic sensibility of his research laboratory—most notably in his designs for Fermilab’s main building, Wilson Hall, a sweeping concrete and glass tower supposedly inspired by Beauvais Cathedral in France—he was equally preoccupied with the aesthetics of Fermilab’s natural surroundings. Wilson’s vision was to ‘surround the scientists studying the smallest particles of nature with a natural laboratory’.⁷⁶ Although Wilson did seem genuinely interested in matters of beauty and aesthetic appeal, his approach was perhaps more utilitarian than might first appear. Given the fact that Fermilab was at the time largely unknown—building not on an existing laboratory in an established location, but constructing an entirely new accelerator amidst rural Illinois farmland—Wilson needed an edge to attract high-quality physicists, and more importantly, to retain them for the long term. For Wilson, that edge was ‘nature’. It was Wilson who, along with Northeastern Illinois University professor Robert Betz, re-established prairie grasslands and woodlands across the site, and re-introduced a herd of American bison; Wilson who encouraged his employees to be concerned with the ‘physical beauty of the place’⁷⁷; and Wilson who argued, uncharacteristically for the director of a large scientific institution, that the laboratory should be more than a tool for doing science, but a ‘creation of great beauty’ which would ‘add to the satisfaction of our lives’.⁷⁸

⁷⁶ ‘Why We Restore and Manage Habitat.’ *Fermilab* website. Accessed 17 April, 2019. <https://ecology.fnal.gov/why-we-restore-and-manage-habitat/>

⁷⁷ Lillian W Hoddeson, Adrienne W Kolb, and Catherine W Westfall, *Fermilab: Physics, the Frontier, and Megascience* (Chicago: University of Chicago Press, 2009), 111.

⁷⁸ *Ibid.*, 109.

The conception and representation of ‘nature’ in the sciences has long been a subject of interest to philosophers and, more recently, scholars of science and technology studies.⁷⁹ The concept takes on particular significance in the field of physics where nature as in our everyday experience seems distant to the work of the physicist who nevertheless claims a vested interest in uncovering ‘nature’s secrets’. By which he—and it usually is a he—means discovering the mass of the neutrino or the existence or super-symmetric particles.

Physics rests on a bedrock of accumulated scientific knowledge commonly referred to as laws of nature. Drawing on a long tradition dating back to Heraclitus’s aphorism ‘nature loves to hide’, physicists often casually speak about ‘nature’—by which they mean the smallest constituent parts of physical matter, typically expressed in complex mathematical forms—as hiding knowledge or secrets. Even before my visit to Fermilab and the surprisingly frequent appeals to nature made by Fermilab’s physicists in conversation, I had become interested in the motif of ‘nature’ hiding and ‘science’ unveiling nature’s secrets. Although there is a long visual tradition of personifications of Science unveiling personifications of Nature (the unveiling a symbol of secrets being revealed) dating back to at least the 1600s, one of the more astonishing representations is Louis-Ernest Barrias’s 1899 marble sculpture, *La Nature se dévoilant à la Science* (*Nature Unveiling herself before Science*). Commissioned in 1889 by the new medical faculty of the University of Bordeaux, nature is depicted by Barrias in white marble as a nubile young woman with bended head and exposed breasts. She lifts her veil, ‘revealing herself’ to science and to the spectator. Many marble and bronze copies of the statue were made in Barrias’s lifetime—a version in marble and a beautiful polychromatic onyx is now one of the most photographed sculptures in the Musée d’Orsay. While today such representations seem profoundly sexist and outdated, the reverse of the Nobel Prize medal for physics features an image from the same tradition, that of science ‘unveiling’ nature. Every year, a (usually) male physicist, collects his prize medal in Stockholm. Nestled in its presentation case, a relief image on the reverse of the medal, of Nature baring her breasts before Science, presses against the velvet lining.

In his 1976 collection of essays about key words in culture, the Marxist academic and historian of meanings, Raymond Williams, claimed that ‘nature is perhaps the most

⁷⁹ For example, *The Physicist’s Conception of Nature*, Werner Heisenberg (1958); *Reading the Book of Nature: An Introduction to the Philosophy of Science*, Peter Kosso (1992); *Science and Narratives of Nature: East and West*, Sundar Sarukkai (2017).

complex word in the language'.⁸⁰ Williams draws a distinction between the two most prominent historical uses of the term nature: the simple quality or character of something, as in the original Latin phrase *rerum natura* or 'the nature of things'; and nature as a singular absolute, for example the material world itself which can be taken as including or not including human beings.⁸¹ More recently, David Harvey has lamented the 'tendency in discursive debates to homogenise the category "nature" [...] when it should be regarded as intensely internally variegated—an unparalleled field of difference'.⁸²

As an artist that frequently makes work about scientists and the sciences, I am sympathetic with regards claims as to the extreme semantic complexity of 'natural' and 'nature'. Many physicists (many scientists, even) are staunch believers in the idea of nature as a singular absolute, a material universe whose laws should remain free from any significance or dependence on human observation or interference.⁸³ Charles Darwin, for example, writing less than ten years after publication of *On the Origin of Species*, stated 'Man has no power of altering the absolute conditions of life; he cannot change the climate of any country...It is an error to speak of man "tampering with nature" and causing variability.'⁸⁴ These views, and others like them, continue to play an important part in scientific mindsets.⁸⁵

One afternoon, wandering through the dappled shade of a small tract of forest in a tucked away corner of Fermilab's vast site, I think about definitions of 'nature'. Is 'nature' to be found here in the forest? Is it in the community of researchers who have come together from all across the world to work at this laboratory? Is it to be found in one of the experimental detectors housed thirty metres below my feet? Can 'nature' truly be the answer to these three completely different questions? Later, back in my room, I open a new text document and type:

Amended PhD Research Question:

⁸⁰ Raymond Williams, *Keywords: A Vocabulary of Culture and Society*, revised ed. (Oxford: Oxford University Press, 1985), 219.

⁸¹ *Ibid.*, 219ff.

⁸² David Harvey, *Justice, Nature and the Geography of Difference* (London: Blackwell, 1996). Cited in Nicole Shukin, *Animal Capital*, 15.

⁸³ This is why, although a majority of physicists prefer the Copenhagen interpretation of quantum physics, their chief complaint is the fact that the role the observer plays in determining the physical state is given too much importance. See Kristian Hvidtfelt Nielsen and Sujeevan Sivasundaram's 2016 article 'Surveying the Attitudes of Physicists Concerning Foundational Issues of Quantum Mechanics' <https://arxiv.org/pdf/1612.00676.pdf>

⁸⁴ Charles Darwin, *The Works of Charles Darwin*, vol. 19: *The Variation of Animals and Plants under Domestication*, 1875 (London: Routledge, 2016), 2.

⁸⁵ Anecdotally, during a dinner in 2019 with three particle physicists (of different ages, nationalities, levels of professional experience and gender) at a research facility in Japan, it transpired that none of the three were aware of climate change and equally unaware that, for example, travelling by train instead of by plane was significantly lower in CO2 emissions.

What do particle physicists mean when they state that nature hides or that nature has secrets? How can interrogating this and related narratives, for example, involving the laws of nature and their origin, or naturalness in physics, be used to question or reimagine objective, materialist discourses in scientific research?

A Consideration Upon the Photo Essay

In *Picture Theory*, W.J.T. Mitchell defines the photographic essay as a ‘literal conjunction of photographs and text—usually united by a documentary purpose, often political, journalistic, sometimes scientific’.⁸⁶ Mitchell cites James Agee and Walker Evans’s *Let Us Now Praise Famous Men*, a 1939 book meditating on the lives of impoverished tenant farmers during the worst of the Great Depression, as a classic example of the form. For Mitchell, it is both the tension between the claims of the ethical, political, aesthetic, and rhetorical, as well as the artist’s intention to stimulate political reform for leftist causes that are the defining features of the photo-essay.⁸⁷

While Mitchell does acknowledge the ‘root sense of the essay as a partial, incomplete “attempt”, an effort to get as much of the truth about something into its brief compass as the limits of space and writerly ingenuity will allow’, his definition of the photographic essay nevertheless leans heavily on the importance of the relationship between text and image and the ultimate goal of political or social change.⁸⁸

If Mitchell’s conception of the photo-essay expresses that which is commonly understood by the term, I would like to propose another understanding, one shaped by the form of the essay/*essai*. That is, a photographic essay as a practice to try to make sense of things. A photographic essay as a form that, rather than Mitchell’s simplistic conjunction of image and text, defies easy categorisation and embraces uncertainty as part of its process of creation. Thus conceived, the photo-essay becomes a way to make sense through image making. But if the photo-essay provides a form in which one can make sense of things through image making, it also enables one to experiment with making visible the attempt to make sense of things. By which I mean, in bringing together

⁸⁶ W.J.T. Mitchell, *Picture Theory: Essays on Verbal and Visual Representation* (Chicago: University of Chicago Press, 1995), 285.

⁸⁷ *Ibid.*, 287.

⁸⁸ *Ibid.*, 289.

the different forms of research which underpin my practice—material, textual, site-based—the photo-essay offers a scaffold with which one can test various strategies for integrating different types of research into the work without necessarily or exclusively ‘visualising research’.

This revised understanding of the photo-essay particularly informed the making of an artwork largely carried out during the first year of my PhD, which included fieldwork trips to my three main sites of interest: CERN, Fermilab and Kamioka Observatory. This work—*The Point of the Veil is to Promise that Something is Behind it*—explores gendered representations of Nature, and pervasive problems with sexism in scientific research cultures, particularly physics. The work’s title is taken from a line in a Donna Haraway essay commenting on the long tradition of sexist gender associations in the visual and rhetorical language of science. Of the final series of twenty-one photographs, some are documentary, some constructed, while others are staged—a combination of found environments with placed images or texts. For example, to construct one image, I created an oversized copy of the reverse of the Nobel Prize medal for physics and inserted it into the experimental cavern of the Super-Kamiokande neutrino detector, one-hundred metres below ground. Through subtle visual cues, this photo-essay also emphasises the importance of text to my research and practice. Rather than simply show a stack of books, however, I wanted to show extracts from particular passages on pages in particular books. In a material nod to the essay’s theme, redactions were made using organic materials such as sugar and blades of grass to hide and reveal portions of the text on the page.

A companion work to the *Veil* photo-essay was made using digital images—many of these taken on my smartphone as additional documentation during fieldwork trips. With these images, printed as digital inkjet prints, I experimented with toning; partly as a means to materially differentiate them from the black-and-white silver gelatine prints, partly to play with other ideas around the word ‘nature’ and naming conventions. Overlaying a single colour on the black and white images, I sampled tones from the names of domestic interior paints which include the word ‘nature’, for example, ‘Nature’s Gift’ or ‘Back to Nature’.

Behind Nature's Veil

Physicist Josh Klein is being filmed in the main atrium of Fermilab's Wilson Hall. Asked to explain why he loves neutrinos, Klein responds: 'The fact that somehow nature seems to be trying to hide something. It makes them [neutrinos] so hard to study.'⁸⁹

In 2004, French philosopher Pierre Hadot published *La Voile d'Isis*. Four years later an English translation by Michael Chase was published as *The Veil of Isis: Essay on the History of the Idea of Nature*. In this extended essay, Hadot painstakingly traces the origin and etymology of Heraclitus' famous aphorism 'Φύσις κρύπτεσθαι φιλεῖ', usually translated as 'nature loves to hide'. Hadot convincingly demonstrates that the phrase's original meaning almost certainly did not refer to a nature which hides secrets, but something more akin to a notion that 'what is born tends to disappear'.⁹⁰

Whether rendered accurately or not, pithy aphorisms such as Heraclitus's tend to take on a cultural life of their own, and Hadot charts the use and reuse of the phrase through Western cultural history, most notably from the seventeenth to the twentieth centuries when the concept was particularly generative. Assuming one accepts that 'nature' does indeed have secrets, Hadot suggests another binary under which such attempts have historically been made. On the one hand, Hadot outlines a position which accepts that nature's secrets are impossible to reveal, and therefore any attempts to 'lift the veil of Isis'⁹¹ are futile. On the other hand, if one believes in the possibility of uncovering nature's secrets, Hadot suggests another binary category for historical attempts: Promethean or Orphic. 'Whereas the Promethean attitude is inspired by audacity, boundless curiosity, the will to power, and the search for utility,' Hadot writes, 'the Orphic attitude, by contrast, is inspired by respect in the face of mystery and disinterestedness.'⁹²

Historically, the Promethean attitude, according to Hadot, is best exemplified by figures such as Francis Bacon⁹³, the so-called 'father of empiricism', and eighteenth-century French naturalist Georges Cuvier.⁹⁴ Among more contemporary scientists, one

⁸⁹ 'Josh Klein - Why I Love Neutrinos' YouTube vide, 1:05, Fermilab, 17 September, 2015. <https://www.youtube.com/watch?v=6h8CSLjt-BUg>

⁹⁰ Pierre Hadot, *The Veil of Isis: An Essay on the History of the Idea of Nature* (Cambridge: Harvard University Press, 2006), 10.

⁹¹ The veil of Isis refers to the allegorical figure of the veiled goddess of Isis.

⁹² Hadot, *Veil*, 96.

⁹³ *Ibid.*, 120: 'For as in public life the nature of an individual and the hidden deposition of his mind and his passions are better uncovered when he is disturbed than at any other moment, so the secrets [*occulta*] of nature are better discovered under the torture of the [mechanical] arts than when it proceeds in its natural course. ...once again the image of unveiling the secrets of nature obtained in a manner analogous to that of a judicial procedure. Nature is a defendant (or a witch?) from whom one extorts confessions.'

⁹⁴ *Ibid.*, 94. Cuvier's celebrated formula takes up the same metaphor: 'The observer listens to Nature, the experimenter submits it to interrogation and forces it to unveil itself.'

might point to the physicist Robert Oppenheimer who justified his research on atomic weapons as simply inevitable, claiming that scientists must expand man's understanding and control of nature. In his November 1945 farewell to the Association of Los Alamos Scientists, Oppenheimer drew his speech to a close with the following words: 'I think that we have no hope at all if we yield in our belief in the value of science, in the good that it can be to the world to know about reality, about nature, to attain a gradually greater and greater control of nature, to learn, to teach, to understand.'⁹⁵

Of all Hadot's representatives who feature under the rubric of the Orphic approach to nature's mysteries, that of Nietzsche and his opposition to the will to truth at all costs is, personally speaking, one of the more attractive. Nietzsche contrasts the will to truth at all costs, this obsession with digging ever deeper, to the courage required to remain at the surface or the world of appearances. Not only does 'Nature' have good reasons to conceal her ultimate truths, Nietzsche suggests, since knowing them is dangerous for humankind, but for Nietzsche truth *is* surface. In the forward to the second edition of *The Joyous Science*, published in 1886, Nietzsche lauds the ancient Greeks for their ability to know when to stop in their investigations of 'nature':

Oh, those Greeks! They knew how to live. What is required for that is to stop courageously at the surface, the fold, the skin, to adore appearances, to believe in forms, tones, words, in the whole Olympus of appearance. Those Greeks were superficial – out of profundity.⁹⁶

Was it not, after all, Oppenheimer and other physicists' desires to penetrate the secrets of 'nature' that resulted in the most deadly and unnecessary weapon in human history? Was it not we humans, as the Roman philosopher Seneca already comprehended in the first century BC, who refused to remain content with the bounty of the Earth's surface and instead dug up the land to extract that hidden below to our own detriment? 'We can complain only about ourselves,' he wrote. 'We have uncovered what will cause our downfall against the will of Nature, who had hidden it from us.'⁹⁷ At a time when newspaper headlines carry stories of human-induced climate change caused by years of in-

⁹⁵ Robert Oppenheimer, 'Oppenheimer's Farewell Speech', *Atomic Heritage Foundation*, accessed 19 July, 2019, <https://www.atomicheritage.org/key-documents/oppenheimers-farewell-speech>.

⁹⁶ Friedrich Nietzsche, *The Joyous Science* (London: Penguin Classics, 2018), 13.

⁹⁷ Lucius Annaeus Seneca, *Epistles, Volume III: Epistles 93-124*, trans. Richard M. Gummere. Loeb Classical Library (Cambridge: Harvard University Press, 1925), 264.

tensive fossil fuel use, Seneca's comments read even now as a warning to our boastful claims of progress and mastery over our natural environments.

Although perhaps less semantically complex than the word 'nature', in English, the multiple definitions of the word 'surface' also embody a number of complex, interrelated ideas, from the outer boundary of an object to a superficial or external aspect of a person or thing. In this latter meaning, surface then has largely come to be associated with shallowness or a lack of depth. But as the artist and photographer Darren Harvey Reagan points out in an interview for the website *American Suburb X*, one of the most influential understandings of the idea of surface in the twenty-first century connects to the photograph:

Photography is a medium that typically hides its own materiality – we commonly look at an image rather than the material surface it appears to us on. Photography translates everything to surface, its depicted world flattened, the space is squeezed out of it. And yet it still usually looks like the world we know. This sets up tensions between the world and the image, the two and the three-dimensional, surface and mass, appearance and experience, etc.⁹⁸

For film theorist, Kim Knowles, rather than the commonplace reading of the photograph as a dematerialised image, the photographic surface is of interest as a site of what she calls 'representational re-negotiation'.⁹⁹ There is, in fact, no separation possible between the photographic image and its material surface.¹⁰⁰

On Cultural Translation

One of my original three research questions was: 'How can the theory and practice of translation—as metaphor, political mode, or linguistic practice—offer interpretive frameworks for engagement between art and science?' I wasn't then keeping a detailed

⁹⁸ Daniel Harvey Regan, 'Interview Darren Harvey Regan - "The Erratics" @Unseen'. Interview by Brad Feuerhelm. *American Suburb X*, 16 September, 2015, <https://www.americansuburbx.com/2015/09/an-interview-with-darren-harvey-regan-the-erratics-unseen.html>.

⁹⁹ Kim Knowles, 'Politics of Process: Gestures of Material Understanding in Contemporary Film Practice,' presented at Light | Sensitive | Material conference, University of West London, 1 November, 2019.

¹⁰⁰ Just because, for example, I might view an image on a digital screen, say my smartphone, does not mean that this image is dematerialised or flattened to a dematerial surface. My phone is a material object, it is not possible for the screen to function without the LEDs, wires, rare earth minerals and aluminosilicate glass that comprise its component parts. The image is not floating in a dematerial space, but is anchored to the material histories of each of these component parts.

research diary, so I can't correctly recall the exact sequence of events, but in the summer before beginning my PhD at Northumbria, on a visit to my favourite Parisian bookstore, I encountered Michel Serres's five volumes dedicated to Hermes, translator and messenger of the gods.¹⁰¹ For Serres, the figure of Hermes functions as a touchstone for a philosophy of science that hinges on the concept of translation. Not only does Serres consider translation between different accounts within the sciences, but also translations of accounts which traverse the disciplinary boundaries between the humanities and the natural sciences. According to Rainer Guldin, Serres's 'interdisciplinary exchange is not about generating direct links and creating transparent noise-free forms of communication... [but rather] a specific view of translation focusing on differences rather than similarities, on difficult passages and not on easy successful crossings.'¹⁰²

With his *Hermès* series, Serres was an avant-garde for the field of cultural translation which emerged as an expression of the cultural turn in translation studies in the 1990s.¹⁰³ As opposed to reading translation as a purely literary endeavour that attempts to recreate a source text in its original language as faithfully and accurately as possible in the target language, cultural translation is attentive to the many complexities and contradictions that underpin ideas of originality, authenticity, and faithfulness, as well as the cultural contexts of both the source and target languages. Cultural translation's interest in translation as a metaphor, as a political mode as well as a linguistic practice offers a rich theoretical framework for an artistic practice concerned with interpreting, critiquing or otherwise appropriating scientific research and research cultures.

For example, Rainer Guldin again, this time drawing on British social anthropologist Godfrey Lienhardt, states that the translational turn in culture studies¹⁰⁴ has seen culture itself re-conceptualised in translational terms. 'Cultures are not just translatable,' Guldin writes, 'but are themselves constituted in and as translations. They are the result of translation processes and at the same time continuously feed into cross-cultural translation processes.'¹⁰⁵ Given many of the difficulties and problems often faced by artists who engage with science,¹⁰⁶ might not the theory and practice of cultural translation

¹⁰¹ Michel Serres, *Hermès*. 5 vols (Paris: Éditions de Minuit, 1968-1980).

¹⁰² Rainer Guldin, *Translation as Metaphor* (Abingdon: Routledge, 2016), 111.

¹⁰³ See especially Susan Bassnett and André Lefevre, *Translation, History and Culture* (London: Cassell, 1995).

¹⁰⁴ See Susan Bassnett, 'The Translation Turn in Cultural Studies,' in *Constructing Cultures: Essays on Literary Translation*, ed. Susan Bassnett and André Lefevre (Bristol: Multilingual Matters, 1998), 123-141.

¹⁰⁵ Guldin, *Translation*, 85.

¹⁰⁶ Many of which are discussed in more detail in a series of conversations between myself and my husband, writer Tom Jeffreys, for a series of four online articles in the *Roman Road Journal*. <https://romanroadjournal.com/author/crystal-bennes-and-tom-jeffreys/>

open up an interesting site of exploration for a practice-based research project that makes use of scientific research and research cultures?

While I was initially attracted to this set of ideas as a basis for practice, none of the reading I had done on cultural translation suggested a way forward in terms of methods. Eventually, however, I obtained a copy of Sarah Maitland's *What is Cultural Translation?*, a book which had been cited many times in my reading on translation. In Maitland I finally encountered a framework which felt adaptable and generative. Maitland's definition of cultural translation has been heavily influenced by her readings of Paul Ricœur and Walter Benjamin. Her formation of cultural translation 'looks to its foundations in Ricœur's hermeneutic philosophy and to Benjamin's complementary notions of survival, afterlife and "fame", to raise translation both as a form of representation that appropriates rather than reflects the realities it represents and as a doubly historicising process by which both the source text and the translator are shown to be located in their historically contingent spaces'.¹⁰⁷

Maitland structures her book in accordance with the three key tools for thinking through cultural translation referred to—directly and indirectly—in the previous passage: interpretation, distanciation and appropriation. Borrowing directly from Ricœur, Maitland's interpretation "brings together", "equalizes", renders "contemporary and similar," thus genuinely making one's own what was initially alien."¹⁰⁸ Interpretation is the first active task in Maitland's process of translation. The source text is considered and processed by the translator with an appreciation for its original context, before shifting through interpretation into a form of understanding unique to the particular interests or prerogatives of the translator.

Distanciation, in part, is a process that assists the translator in re-situating the source text into its new context through estrangement. Distanciation, as Maitland writes, reminds us 'that our access to the world is not immediate; that human understanding is fallible and cannot be assumed.'¹⁰⁹ Like Serres's emphasis on difficult passages rather than easy crossings, Maitland, too, considers distanciation as a site of struggle, both social as well as textual. For me, this foregrounding of difference and difficulty is one of the key appeals of cultural translation as a method for art-science engagement. I sympathise with Paul Feyerabend's sarcastic quip that 'today, many scientists want to make

¹⁰⁷ Sarah Maitland, *What is Cultural Translation? (Bloomsbury Advances in Translation)* (London: Bloomsbury Academic, 2017), 29.

¹⁰⁸ *Ibid.*, 87.

¹⁰⁹ *Ibid.*, 88.

us believe that scientific research is not...tight-assed... There is an artistic spirit, they say, there is “creativity”, “imagination”, there are metaphors, analogies, “aesthetic dimensions” - and so on’.¹¹⁰ Such claims sound well and good, Feyerabend continues, but he wonders, ‘where is the research team that gets a prize for its aesthetic achievements? Where is the journal that accepts articles because of the creative insights they contain?’¹¹¹ As with overly-simplistic understandings of translation, where success is often judged on ‘faithfulness’ and ‘authenticity’, so too with artists engaging with science; the assumption is often that the artists must remain faithful to the science and communicate it to a non-scientific public as accurately and directly as possible.

Finally, appropriation signifies the point where the translator effectively departs from the source text to create something new. Maitland’s concept of appropriation recognises and appreciates the fact that the source text maintains a cultural life of its own irrespective of the work of the translator or the changes which may be enacted in the culture of the translator rather than in the culture of the original source. As an artist who seeks primarily to make an impact in my own field, and not necessarily in the field of physics, Maitland’s emphasis on appropriation holds particular appeal. ‘The task of translation,’ she writes, ‘is not concerned, as previously believed, with finding, locating and uncovering – the so called maxim ‘understanding the author better than he understands himself’ – but with creating, constructing and innovating’.¹¹²

Maitland’s approach also incorporates an understanding of the process of translation as a journey or map, perhaps a useful definition for practice-based research. ‘Translations can therefore be read as cartographic representations: as highly individualised accounts of a journey of interpretation that mediates – and contains – the different worlds it encounters.’¹¹³ However, one aspect of considerable interest to me, that of translation and/as criticism, is not covered in any serious depth by Maitland. While she does consider translation as appropriation as criticism, my interest lies more in thinking through how one deals with a source ‘text’ which one feels is morally objectionable, or at least does not describe a straightforwardly positive relationship¹¹⁴. Among translators of contemporary poetry or fiction, one frequently encounters arguments for the import-

¹¹⁰ Paul Feyerabend, *The Tyranny of Science* (Cambridge: Polity Press, 2011), 7.

¹¹¹ Ibid.

¹¹² Maitland, *Cultural Translation*, 124.

¹¹³ Ibid., 29.

¹¹⁴ The text that came immediately to mind was Joseph Arthur’s 1853 *Essai sur l’inégalité des races humaines*.

ance of translation as a political act that gives voice to voices often absent from particular cultures or particular languages (especially in the case of translation into English).¹¹⁵ But because I am an artist engaging with science, the power dynamic is frequently (although not always) inverted, and while I always want to be cautious about how I appropriate and interpret their words, actions and research, occasionally I want to be very critical. One area of cultural translation that I have been particularly interested in exploring and expanding upon is how Maitland's methods of interpretation, distancing and appropriation might also allow for cultural translation as a form of critique.

Indirect Observation

While working at Fermilab, I have an idea. How might I attempt to indirectly observe the instruments used by physicists to make their indirect observations? Or, how could I image the experimental apparatus, indirectly, without resorting to purely representational photographs of the detectors themselves? I begin to build a materials collection: bits and pieces of different detectors given to me by scientists and engineers, or scavenged from Fermilab's rubbish dump. Among other things, I've collected a milky white piece of extruded scintillating plastic from one of the neutrino detectors, a small length of fluorescent green glowing fibre optic cable, a shard of a remarkably thin double-sided mirror from a scrapped muon detector, and a flexible copper circuit board removed years ago from an unknown experiment. The research and development of these and similar materials underpin physicists's search for the 'secrets of nature'. Not one of their experiments would be possible without these indispensable tools and materials.

After collecting all the fragments, I start to think about the physicists themselves. Is there some way I can indirectly visualise the bodies of the people who dream up, construct and make observations with some of the world's most powerful particle physics experimental detectors? I pay a visit to the neutrino experiment control room on the ground floor of Wilson Hall. Although it's staffed twenty-four hours a day, access is by key card only. Mine doesn't work. I knock on the door and explain what I'd like to do. I get strange looks, but am waved through by the on-duty physicist. The control room is

¹¹⁵ A typical example is provided by the first editorial written by newly-appointed editor of *Modern Poetry in Translation* Clare Pollard in 2018: 'I am honoured to be taking over the editorship of *Modern Poetry in Translation* this issue from Sasha Dugdale who, like David and Helen Constantine, Daniel Weissbort and Ted Hughes before her, recognises the importance of translated poetry as a way of bearing witness and giving voice to the silenced.'

full of computer monitors and, armed with a small plastic ziplock bag, I walk from one computer to another, collecting dust from the top of each monitor with a swipe of my index finger. It's not long before I've gathered a sizeable amount of dust in the bag.

Rather than photograph my various material samples, I decide to make images of their surfaces using a scanning electron microscope (SEM) once back in Edinburgh. Remarkably, during the scanning process, one of the samples—that of the flexible circuit board—reveals an interesting secret of its own, a secret not visible to the eye alone. Spread across the surface of the circuit board is a vast network of gauzy, web-like structures. Conferring with the SEM technician, we conclude that the webs are possibly some kind of mould; certainly organic matter of some description. I had found the circuit board in a dumpster, outside, where it had been disposed of who knows how many years ago. Having lived out its professional life as a minuscule component of a Fermilab physics experiment attempting to uncover 'nature's secrets', on retirement, the circuit board transformed into a host for another kind of natural life. The dust gathered from the computer monitors reveals interesting secrets about the physicists on duty in the control room. The sample shows fibre particles from clothing, most likely synthetic, or possibly paper. Is that an insect? *What is that?* Perhaps it's only a flake of dead skin. The microscope can only tell you so much.

From the outset, the SEM images were always intended as one step in a larger process of translation and interpretation. I first encountered the nineteenth-century photographic technique of carbon transfer printing in late 2018 via the work of French artist Caroline Corbasson. Creating carbon prints from the SEM photographs was always part of my plan for the transformation of these materials into images. Invented by French chemist Alphonse Poitevin in the mid-nineteenth century, carbon transfer printing is a pigmented colloid photographic process created in response to concerns about the fading of early types of silver-based black-and-white prints. Indeed, the archival quality of carbon prints are such that, compared to the discolouration and fading which has affected silver-based prints from a similar date, carbon prints show little to no degradation of the image. For many historical and contemporary proponents of the carbon process, this stable image and its associated archival qualities are a primary draw.¹¹⁶ Two of its other characteristics, however, are of interest to my research. One is connected to the

¹¹⁶ 'It is the indisputable permanency of carbon pictures, that appeals with irresistible force to every professional or amateur photographer who has the good and reputation of the profession at heart'. From *A New Treatise on the Modern Methods of Carbon Printing*, Marton, A.M. (Bloomington, 1905), 1.

unique surface qualities offered by carbon printing and the other is linked to the ‘carbon’ in carbon transfer process. To start with the latter, although many mineral-based pigments could be successfully used in the carbon printing process, historically, the most commonly employed were blacks derived from various sources of carbon. Lampblack was obtained by burning resin or pine pitch, turpentine and camphor; ivory black by the calcification of ivory; and Frankfurt black from charcoal mixed with a small amount of calcined Prussian blue. Unlike many other photographic processes, with carbon printing, the image maker is able to exert full control over the tone and intensity of colour displayed in the final print. Given the subject of my research, there is a pleasing relationship between the use of carbon-based pigments—carbon being the common element of all known life and the fourth most abundant element in the universe by known mass—to image the physicist’s tools for observing ‘nature’ in the laboratory.

While all photography is concerned to some extent with surfaces, the unique surface qualities that result from carbon printing expand the photographic surface to something approaching the sculptural, albeit a limited expression. Carbon transfer printing is labour-intensive and technically demanding, particularly as I have adopted the lesser-known modern technique of substituting 4,4 ‘ – diazidostilbene -2,2’ – disulfonic Acid Disodium Salt Tetrahydrate (commonly referred to as DAS) for the more traditional, and highly toxic, potassium dichromate as chemical sensitiser. Because of the nature of the process, in which the negative is exposed through ultraviolet light onto a printing matrix comprising gelatine, the carbon-based pigment and the sensitising chemical before being transferred onto a final paper support (either fixed out resin-coated photographic paper or acrylic-sized watercolour paper), the exposed gelatine effectively sits on top of the paper. This creates a relief quality to the photographic image which almost resembles letterpress printing. So, although carbon printed photographs, like most other forms of photography, exist as two-dimensional representations of the world flattened to the level of the surface, they do not hide their own materiality. Rather, they celebrate the materiality both of the image and of the surface.

Nature's Laws

Scientists construct systems in order to escape the messiness of nature, to study controlled, cleaned, and purified phenomena, about which models can be more easily made. Experimentalists can know much more about artificial phenomena than messy nature. In a strict sense they rarely study nature.¹¹⁷

The subject of 'laws of nature' is too vast to be meaningfully addressed here in detail, but there are a number of aspects which are important to raise in connection with my research. I find it fascinating, for example, that Western scientists drew on the concepts and rhetoric of civil law to bolster their fledgling enterprise in the seventeenth century; rhetoric and concepts which persist today in the language of 'laws of nature'. My interest also centres on the realities of doing science, in the manner in which Helen Longino draws our attention to in the quotation cited above, essentially that physicists must do many things in order to get nature to conform to their laws.¹¹⁸

'Nature is the most complex word in language'.¹¹⁹ How is it that 'nature' can be both the sexualised image of a woman coyly resisting—'science made was nature undone', as Haraway wrote, paraphrasing Latour¹²⁰—and a universe understood through a set of seemingly-fixed rules defined in relation to civil law? As Evelyn Fox Keller astutely observed, 'The very concept of "laws of nature" is, in contemporary usage, both a product and an expression of the absence of reflectivity. It introduces into the study of

¹¹⁷ During my fieldwork trip to Fermilab, I was given a small office—largely used by physicists on the floor as an informal meeting room—for my own use. Every few days, I would tape a postcard up on the outside door. I would write a yes/no question with erasable marker above the card and leave the marker pen on a string for people to draw a mark under whichever side they supported. On the first day, I pinned a card with this quote to the door and asked, 'Do you agree?' For the first twenty-four hours, the vote was split down the middle, but it eventually tipped in favour of 'yes' by a single vote. The quote is a paraphrase of Sergio Sismondo, *An Introduction to Science and Technology Studies* (London: Blackwell Publishing, 2010) 160:

Scientists construct systems in order to escape the messiness of nature, to study controlled, cleaned, and purified phenomena, about which models can be more easily made. Experimentalists can know much more about artificial phenomena than messy nature, so they rarely study nature as it is. Nature is systematically excluded from the lab (Knorr Cetina 1981; Hacking 1983; Latour and Woolgar 1986; Radner 1993 challenges the importance of this).

¹¹⁸ A more recent example of a similar sentiment is offered by the biologist Merlin Sheldrake, quoted in Robert Macfarlane's *Underland*:

'I have this plan that for each formal scientific paper I ever publish I will also write its dark twin, its underground mirror-piece—the true story of how the data for that cool, tidy hypothesis-evidence-proof paper actually got acquired. I want to write about the happenstance and the shaved bumblebees and the pissing monkeys and the drunken conversations and the fuck-ups that actually bring science into being. This is the frothy, mad network that underlies and interconnects all scientific knowledge—but about which we so rarely say anything.'

I haven't read Robert Macfarlane's book. Instead, I encountered this quote in an essay written by Sean Lynch to mark the occasion of Stuart Whipp's exhibition in 2020 at Dundee Contemporary Arts, *If Wishes Were Thrushes, Beggars Would Eat Birds*.

¹¹⁹ Williams, *Keywords*.

¹²⁰ Donna Haraway, 'Modest Witness: Feminist Diffractions in Science Studies' in *The Disunity of Science*, eds. Peter Galison and David Stump (Stanford: Stanford University Press, 1996), 435.

nature a metaphor indelibly marked by its political origins'.¹²¹ Drawing connections between the pervasive language of objectivity which props up much physics research, Fox Keller, attests to the ways in which 'the philosophical distinction between descriptive and prescriptive laws is invoked to underline the neutrality of scientific description'.¹²² While certain practitioners may have been more circumspect about the relationship between scientific and civil laws—notably, English mathematician Karl Pearson, who wrote in his 1892 book, *The Grammar of Science* that, 'Scientific law is of a totally different nature from civil law; it does not involve an intelligent lawgiver, a command, and a corresponding duty. It is a brief description in mental shorthand of as wide a range as possible of the sequences of our sense-impressions'—Fox Keller notes that, like laws of state, laws of nature are 'historically imposed from above and obeyed from below'.¹²³ For further evidence, Fox Keller cites the Oxford English Dictionary's definition of law, under the categories of scientific and philosophical uses: 'By those who first used the term, [laws of nature] were viewed as commands imposed by the deity upon matter, and even writers who do not accept this view often speak of them as 'obeyed' by the phenomena, or as agents by which the phenomena are produced'.¹²⁴

Perhaps more troublingly are the ways in which the idea of 'laws of nature' have been used by scientists in relation to gender, specifically to preserve certain societal status quos. Eugenicists deployed such techniques to justify their conviction of the 'natural supremacy' of the white race over other races, and patriarchy deployed such techniques to justify the ongoing subordination of women to men. As Margaret Wertheim notes, the public-private, male-female dualisms of eighteenth-century Enlightenment philosophies made it easier for early scientists to justify the exclusion of women on the grounds of nature's laws. 'If women were "naturally" situated in the private sphere,' Wertheim writes, 'and men "naturally" dominated the public sphere, then the "laws of nature" naturally fell into men's territory—for they are the most public laws of all'.¹²⁵ Such ideas persisted well into the late-nineteenth century when they were uttered from the mouths of eminent scientists such as theoretical physicist Max Planck and chemist Wilhelm Ostwald. In 1897, Planck wrote: 'Generally, it cannot be emphasised enough

¹²¹ Fox Keller, *Reflections*, 131.

¹²² *Ibid.*

¹²³ *Ibid.*; Karl Pearson, *The Grammar of Science*, Everyman (1892), 98.

¹²⁴ *Ibid.*; OED, s.v. "law" scientific and philosophical uses.

¹²⁵ Wertheim, *Pythagoras*, 149.

that nature herself prescribed to the woman her function as mother and housewife, and that the laws of nature cannot be ignored'.¹²⁶ According to the physicist and educator Dorit Heinsohn, in the late-nineteenth century, Wilhelm Ostwald used the principle of energy conservation to argue that women could not both pursue a rigorous intellectual career and have strong, healthy babies.¹²⁷

While some male scientists of the period justified the exclusion of women from the pursuit of scientific knowledge by deploying natural law rhetoric, others justified such exclusion not only on sexist, but often also on racist grounds. Mary Midgley cites the example of Dr. J.H. Bennet, writing in 1870:

The principal feature which appears to me to characterise the Caucasian race, to raise it immeasurably above all other races, is the power that many of its male members have of advancing the horizons of science, of penetrating beyond the existing limits of knowledge – in a word, the power of scientific discovery. I am not aware that the female members of our race participate in this mental power, in this supreme development of the human mind.¹²⁸

Midgley, a staunch opponent of scientism, takes Bennet's view—particularly the messy interplay of concepts of race, gender and nature—to be one of the fundamental problems of the 'scientific attitude'. In their seemingly ceaseless efforts to 'penetrate' and 'objectify' nature, these men have sought to 'get rid of all reverence, all belief in something greater than ourselves', and have instead promoted feelings of 'contempt, horror, resentment, fear, hostility, estrangement and the ambition to dominate' [the physical world].¹²⁹ And while this approach may have produced useful scientific knowledge, Midgley argues that a terrible side effect of this kind of rhetoric has been an invitation to 'see the universe as something to be conquered, something beneath us, "objective" in the sense of lifeless, drained of creativity and purpose, and it takes this to be the truly scientific attitude'.¹³⁰

¹²⁶ Cited in Wertheim, *Pythagoras*, 194.

¹²⁷ Maralee Harrell, 'On the Possibility of Feminist Philosophy of Physics', 15-34, in M.C. Amoretti and N. Vassallo (eds.), *Meta-Philosophical Reflection on Feminist Philosophies of Science*, Boston Studies in the Philosophy and History of Science, Springer International Publishing (2016), 24. Dorit Heinsohn, 'Thermodynamik und Geschlechterdynamik um 1900', *Feministische Studien*, Vol. 18 No. 1 (2000), 52-68.

¹²⁸ Mary Midgley, *Science as Salvation: A Modern Myth and its Meaning* (London: Routledge, 1992), 68. My husband, the writer Tom Jeffreys, first introduced me to Mary Midgley through this book.

¹²⁹ *Ibid.*, 73.

¹³⁰ *Ibid.*

Both Midgley and Carolyn Merchant have written extensively about the literature of early modern science as being riddled with language that describes nature, not as the objective physical world of today's scientific language, but as a:

seductive but troublesome female, to be unrelentingly pursued, sought out, fought against, chased into her inmost sanctuaries, prevented from escaping, persistently courted, wooed, harried, vexed, tormented, unveiled, unrobed, and 'put to the question' (ie interrogated under torture), forced to confess 'all that lay in her most intimate recesses', her 'beautiful bosom' must be laid bare, she must be held down and finally penetrated', 'pierced' and 'vanquished' (words which constantly recur).¹³¹

As Midgley rightly notes, such language is not the rhetoric of a few writers. Rather, it is the widespread idiom of the age. Carolyn Merchant is interested in the transition that took place between the sixteenth and seventeenth centuries, in which 'the image of an organic cosmos with a living female earth at its centre gave way to a mechanistic world view in which nature was reconstructed as dead and passive, to be dominated and controlled by humans'.¹³² Merchant makes a particularly fascinating connection between the notion of chaotic nature as something which needed to be controlled by man's firm hand and the fear of disorderly women who were condemned as witches. As witches were known to cause illness, destroy crops and raise storms, they were perceived as symbols of the violence of nature.¹³³ Of all writers in this period, Merchant singles out Francis Bacon as someone who developed and transformed the language and imagery of female-gendered nature from powerful goddess or nurturing mother to 'a resource for economic production,' and then used this new image to articulate man's power over nature.¹³⁴ Drawing out the connections between 'problematic women' and the inquisition of witches, Merchant comments that the language of the inquisitions 'permeated [Bacon's] description of nature and his metaphorical style and were instrumental in his transformation of the earth as a nurturing mother and womb of life into a source of secrets to be extracted for economic advance'.¹³⁵

For Bacon, it was only by 'digging further and further into the mine of natural knowledge' that mankind could return to the state of grace as in the Garden of Eden.

¹³¹ Ibid., 77.

¹³² Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (New York: Harper One, 1980), xvi.

¹³³ Ibid., 127.

¹³⁴ Ibid., 165.

¹³⁵ Ibid.

Through such digging, ‘the narrow limits of man’s dominion over the universe’ could be stretched ‘to their promised bounds’.¹³⁶ Bacon’s view of nature as a resource to be exploited was expressed in his language as a series of sexualised verbs: scientists should ‘hound’, ‘vex’, ‘squeeze’, ‘mould’, and ‘penetrate’ nature. Merchant reads Bacon’s rhetoric as symbolically mapping the ‘interrogation of witches [onto] the interrogation of nature’.¹³⁷ Hence, Bacon’s use of the courtroom as a model for inquisition and torture through mechanical arts as a tool for the subjugation of disorder—these, Merchant, argues, ‘were fundamental to the scientific method as power’.¹³⁸ Although, as Merchant points out, the image of nature as a nurturing mother did not completely disappear, it was utterly overtaken by the newer imagery of control.¹³⁹ One of the consequences of this was that ‘the constraints against penetration associated with the earth-mother image were transformed into sanctions for denudation’, and nature became viewed increasingly as a site for legitimate exploitation for natural resources.¹⁴⁰ ‘From an active teacher and parent, she has become a mindless, submissive body... The new mechanical order and its associated values of power and control would mandate the death of nature’.¹⁴¹

¹³⁶ Cited in Merchant, *Death*, 170.

¹³⁷ *Ibid.*, 172.

¹³⁸ *Ibid.*

¹³⁹ *Ibid.*, 189.

¹⁴⁰ *Ibid.*

¹⁴¹ *Ibid.*

BOOK TWO

A Portrait of the Artist as Hermes

Hermes is my favourite Olympian deity. Not Zeus or Aphrodite. Not even Athena, goddess of wisdom and of weaving. But Hermes. I love his talaria, the winged sandals of imperishable gold created by Hephaestus. But I am also attracted to the idea of a god of boundaries; a god who occupies the spaces between life and death, between the earth and the underworld, and more prosaically, between different villages. Indeed, the name Hermes in its greek form, Ἑρμῆς or herma, is associated with the piles of stones that stood as boundary markers placed throughout Greece to protect travellers on their journey. It was only when I became increasingly interested in theories of translation that I began to more fully appreciate Hermes as the messenger who relays divine tidings between gods and mortals. Hermes represents border-limits and border crossings—all that separates the world of gods from the world of mortals. He also serves as a symbol for the co-existence of mysterious and incomprehensible realms of understanding that make mutual understanding impossible.¹⁴²

Although there is little substantial evidence that the word hermeneutics derives from Hermes, the messenger-god nevertheless serves as a useful emblem for the art of understanding. What is interpretation if not the deciphering of messages, clear or unclear; acts of mediation, or translation? Hermes represents the need for translation in the two-way act of communication from sender to receiver. But as a divine messenger with agency of his own, Hermes can choose to dissemble or obfuscate as well as to reveal. His nature as a trickster alludes to the importance of recognising the translator as an active agent of interpretation: there is no such thing as a perfect transmission of messages, decisions must be made about what to include, what to omit, and how to convey information.

I once believed, and in many ways do still believe, that academic disciplines are limiting, intentionally isolating, enervating, patriarchal constructs, and that the preservation of their strict borders does research (and researchers) more harm than good. Increasingly, I have come to recognise that, despite my distrust of and disdain for ever-increasing specialisation, certain professional realities, particularly with respect to the power structures of academia, demand consideration of and attentiveness to disciplinary differences. In this, Michel Serres's idea of border crossings has provided a useful framework

¹⁴² Sarah Maitland, *What is Cultural Translation?*, 34.

for thinking through some of these questions.¹⁴³ Serres's starting point is that 'disciplinary and conceptual divisions, although complex and provisional, may be analysed by exploring potential channels or 'passages' that run between them'.¹⁴⁴ While it is possible for communication to travel, like Hermes, between these passages, it does so at the risk (the benefit, perhaps?) of being transformed. Hence, Serres refers to the particular passage between the sciences and the humanities as the 'Northwest Passage', referring to the treacherous sea route that traverses the Atlantic and Pacific Oceans through the Arctic Ocean. Serres reaches for this metaphor because it 'tells of the difficult journey between disciplines whose itinerary is not predicted from the outset and whose map is the process of the passage'.¹⁴⁵ Whose map is the process of the passage.

Drawing on the image of Hermes, Serres emphasises that while such journeys should and ought to be made, they will involve complex forms of navigation based on translation, and on making connections. Like Steven Brown, I take Serres's point to be that I (as an individual, as an artist) should not seek instruction from the sciences alone, nor any singular form of understanding, but should instead seek to occupy the difficult spaces of transformation, translation and connection which lie in between.¹⁴⁶

Anthropologist Vincent Crapanzano has written of the ethnographer as someone who not only studies other societies, but 'presents languages, cultures, and societies in all their opacity, their foreignness, their meaninglessness; then like the magician, the hermeneutic, Hermes himself [herself?], he clarifies the opaque, renders the foreign familiar, and gives meaning to the meaningless. He decodes the message. He interprets'.¹⁴⁷

A portrait of the artist as ~~essayist as ethnographer as translator~~ as Hermes.

When Computers Were Women

It's the 17th of February, 2020. I'm back at CERN for the first day of my second week-long fieldwork trip. In the basement of a large computing building, I'm working in a small, cluttered workshop that has been made available for my use as a studio for the

¹⁴³ Michel Serres, *Hermès V. Le passage du Nord-Ouest* (Paris: Les Editions de Minuit, 1980).

¹⁴⁴ Steven D. Brown, 'Michel Serres: Science, Translation and the Logic of the Parasite,' *Theory, Culture & Society* Vol. 19 No. 3 (2002): 1-27, 1-2.

¹⁴⁵ Laura Salisbury, 'Michel Serres: Science, Fiction and the Shape of Relation,' *Science Fiction Studies* Vol. 33 No. 1 (2006): 30-52, 37.

¹⁴⁶ Brown, 'Michel Serres,' 12.

¹⁴⁷ Vincent Crapanzano, 'Hermès' Dilemma: The Masking of Subversion in Ethnographic Description,' in *Writing Culture*, eds. James Clifford and George E. Marcus (Oakland: University of California Press, 1986), 51. Cited in Maitland, *Cultural Translation*.

week. Although I have other plans—meetings, visits to experiments, and another trip to the archives—my principal reason for being here is to photograph 2,000 computer punch cards. In a few days, I will track down the scientist who wrote the computer programme and find out more about its history; but today, I know only that it is a computer programme written for a physics experiment that ran at CERN in the 1970s. When my contact at CERN completes the registration form to authorise my stay, she writes ‘data textile project’ as the reason for my visit. Not evocative, but accurate.

During my first CERN visit in 2018,¹⁴⁸ I spotted a small stack of computer programming punch cards in an out-of-the-way cabinet in the main data centre. As soon as I saw them, I was struck by their resemblance to a much older form of data-processing technology: the long, thin punch cards used to control the rods and hooks that raise the warp threads of looms fitted with Jacquard devices. There is a truism in the history of computing holding that the English mathematician Charles Babbage drew on Jacquard loom punch cards as inspiration for his general-purpose computer, the Analytical Engine.¹⁴⁹ As with many popular histories of technology, those told about Jacquard and Babbage are replete with numerous omissions and oversimplifications. Although Jacquard’s name is now associated with the device he invented in 1803, his chief contribution was really the amalgamation of previous devices already created by Lyonnaise weaver Jean Baptise Falcon and silk factory inspector, Jacques Vaucanson.¹⁵⁰

Moreover, Jacquard’s involvement in the weaving trade, and thus his familiarity with weaving technology, was deeply rooted in his family history. His mother, Antoinette Rive, was a pattern reader and his father, Jean Charles, was a master weaver. Jacquard spent his childhood as a ‘draw boy’, collaborating with weavers and pattern readers by controlling the warp threads as they are fed to the other workers.¹⁵¹ Similarly, for a long time Babbage’s was the only name in a history of computational machines that leapt from Jacquard to Babbage to Bill Gates. In recent years, however, the contribution of at least one woman—Ada Lovelace—has been increasingly recognised. Where Babbage conceived of his Analytical Engine as a tool for pure calculation, it was Ada

¹⁴⁸ Book 1, 4.

¹⁴⁹ This entry, for example, on the Computer History Museum’s online catalogue states that Babbage’s Analytical Engine was programmable thanks to punched cards, ‘an idea borrowed from the Jacquard loom’. <https://www.computerhistory.org/babbage/engines/>

¹⁵⁰ James Essinger, *Jacquard’s Web: How a Hand-loom Led to the Birth of the Information Age* (Oxford: Oxford University Press, 2004), 36-37.

¹⁵¹ *Ibid.*, 29. As Essinger points out, although some of Jacquard’s contemporary biographers claimed that he worked as a drawboy—a weaver’s assistant who sat atop the loom and manually raised or lowered each of the warp threads to form a ‘shed’ through which the shuttle holding the weft thread could pass; this allowed for the weaving of intricate and complex patterns and pictures, but was very slow and required meticulous attention—for his father as a child, there is no conclusive proof.

Lovelace who recognised its potential as a ‘computing machine’ and developed the first algorithm intended to be carried out by such a machine.¹⁵² It was also Ada Lovelace who fully appreciated that ‘the introduction of the principle which Jacquard devised for regulating, by means of punched cards, the most complicated patterns in the fabrications of brocaded stuffs’ gave the Analytical Engine its ‘distinctive characteristic’ and ‘rendered it possible to endow [the] mechanism with such extensive faculties as bid fair to make this engine the executive right-hand of abstract algebra’.¹⁵³

When I first noticed the computer punch cards at CERN, the connections between histories of computational and weaving technology were too generative to ignore. Not only were there parallels between sexism in physics and technology, namely, the erasure of women and minority figures from conventional histories that tend to glorify white male figures. But there were also correspondences between the use of gendered, sometimes ‘low skill’ labour—women in weaving as pattern readers; women in physics as ‘computers’¹⁵⁴ or ‘scanner girls’¹⁵⁵—and the later evolution of such gendered work into labour-saving computerised algorithms and voice assistants. Such shifts were also embedded in language. In the early 1950s, Webster’s dictionary changed its definition of a computer from ‘one who performs a computation’ to ‘one or that which performs a computation’. The punch cards resonated as a symbolic reminder of these connections and I wondered how I could best make use of them, translate them, into a different form that would make such connections materially evident.

¹⁵² Robin Hammerman and Andrew Russel, *Ada’s Legacy: Cultures of Computing from the Victorian to the Digital Age* (San Rafael: Association for Computing Machinery and Morgan & Claypool Publishers, 2016).

¹⁵³ Ada Lovelace, ‘Notes’ to ‘Sketch of the Analytical Engine Invented by Charles Babbage, by L.F. Menabrea’, *Scientific Memoirs* Vol 3 (1843): 666-731. Quoted in Sadie Plant, *Zeros and Ones: Digital Women and the New Technoculture* (London: Fourth Estate, 1997). After posting something about my textile project on Twitter in September 2020, fellow architecture and design journalist, Anna Winston, recommended Sadie’s book to me. I ordered a second-hand copy and its arrival prompted an interesting comment by my husband to be wary. Unbeknownst to me, Sadie Plant was a founder member of an ‘unofficial’ research group called the Cybernetic Culture Research Unit at University of Warwick which existed between 1993 and 2003. The group was an experimental cultural theory collective largely interested in cyberpunk, cyberfeminism, Gothic horror, and surreal theory-fiction. Both Plant and another group member, Nick Land, developed philosophies of accelerationism—the idea that an intensification of capitalist and technological practices can be ‘accelerated’ to create radical social change. While accelerationism been applied in both left-wing and right-wing contexts, Nick Land has subsequently become an outspoken eugenicist and popular intellectual of the alt-right. I think was husband was worried that Plant might also have hidden, or not so hidden, eugenicist tendencies. I found much to admire in this particular book—the subject, the tone, the format, the interesting (maybe a little bit problematic, I haven’t decided) citation method.

¹⁵⁴ At NASA’s Langley Memorial Aeronautical Laboratory, between 1935 to 1970, female ‘computers’ were hired in large numbers to ‘relieve’ engineers of time consuming, but essential calculating work. Although the hiring process included a Civil Service examination and most of the women had at least a bachelor’s degree in a related subject, ‘computers’ were classed as ‘subprofessionals’ and topped out at \$3,200 per year salary. Men with similar qualifications were frequently hired as ‘Junior Engineers’ a ‘professional’ classification with a starting salary of \$2,600. More information on the NASA webpage: https://crgis.ndc.nasa.gov/historic/Human_Computers

¹⁵⁵ Between the 1960s and the mid-1980s, dozens of women worked at CERN as ‘scanners’. Their job consisted in looking through vast numbers of bubble chamber photographs to flag and identify ‘events’ to pass on to physicists. This work was considered to be clerical rather than scientific, despite the fact that the women had to be able to recognise interesting or unusual particle events. This 2015 article in *Viewpoint* goes into more detail of some of the stories of individual ‘scanner girls’: <http://www.bshs.org.uk/wp-content/uploads/Viewpoint-108-Web.pdf>.

Individually photographing 2,131 punch cards is a mindless business; it is surprising how little time it takes to slide into automation, to allow, encourage even, the body to become more mechanical. Having rigged up a support structure in which my phone rests on top of a projected arm on a small cardboard box over another piece of cardboard serving as makeshift backdrop, I place a single punch card on the cardboard with my right hand, press the phone shutter button with my left, remove and repeat over and over. Hours pass. Even the process of taking breaks becomes mechanised. After photographing fifty more cards, I tell myself, I will pause to eat a few pieces of candy and take a sip of water.

Occasionally, when scrolling digitised texts on Google Books, I encounter an image of the hand of the scanner operator; a hand which hasn't moved quickly enough, a hand likely belonging to a person of colour¹⁵⁶ being paid minimum wage for data-entry work, caught by the camera like the movement of a bird that's just taken flight, haunting the pages of the book. When I look back at the thousands of photographs I had taken that week, only once had I accidentally caught an image of my ghostly hand floating over the punch card.

On the Artist in Residence

The textile piece for which I am photographing punch cards, the one that will intertwine the layered histories of computational Jacquard loom mechanisms with particle physics data analysis processes, was not actually the artwork I wanted to make about CERN. In 2018, I was contacted by a physicist from the ATLAS experiment who was at that time involved in setting up a new art programme.¹⁵⁷ They had seen a previous work of mine—a large stained-glass window which I had designed and fabricated based on a data visualisation from the ATLAS experiment at CERN¹⁵⁸—and invited me to make an extended visit with the intention of making a new piece of work.

¹⁵⁶ In a number of interviews connected with his 2007 artwork, *ScanOps*, ex-Google employee Andrew Norman Wilson spoke about his experiences working on the Google campus for a year. Wilson drew particular attention to the existence of 'yellow badge' workers which differed from those of the red for contract employees, white for fulltime staff, and green for interns. Wilson described how the 'yellow badge workers' stood out, not only because of their badges, but because many were Black and Brown and because they only ever entered and exited from one building, leaving at 2:15pm every day. Wilson eventually began speaking with the yellow badge employees and discovered that they were working on Google's *ScanOps* project to digitise books in public collections. <http://www.andrewnorman-wilson.com/ScanOps.html> <https://aperture.org/magazine-2013/andrew-norman-wilson-with-laurel-ptak-scanops/>

¹⁵⁷ Book 1, 4.

¹⁵⁸ 'Atlas Experiment event of 14 September, 2014, in stained glass', mouth-blown glass, lead, tin, linseed oil, chalk dust, white spirits, carbon powder, bronze wire, steel, 2m diameter, 2014-15. In the permanent collection of Aalto University, Helsinki.

Prior to that first visit, I thought that perhaps I would make a new work about data visualisation or data simulation, either of which would seem a natural follow-on from the stained-glass piece, and would also connect to the proposed research subject of my soon-to-commence PhD. Yet, for reasons I had yet to fully comprehend, I was ambivalent about continuing with this subject. I did know that part of this ambivalence stemmed from the reception of my stained-glass artwork. Where I had conceived of the work as a criticism of certain narratives around ‘raw data’ perpetuated by CERN, and as a way of drawing attention to the fact that visual materials produced by CERN to promote its research didn’t automatically emerge fully realised from its experiments, but were subject to huge amounts of human editing, processing, analysing, and interpretation, the artwork was largely received and disseminated—by certain members of the public, but particularly by particle physicists—as an ‘artistic’ expression of the beauty of particle physics.

Perhaps some of my ambivalence also stemmed from the fact that, although during that first CERN visit I met many people (most of whom were polite and interesting), on the whole the experience was surprisingly unpleasant. In particular, some of the male physicists I encountered were rude and hugely condescending. Despite the warm welcome I received from the physicist who invited me, who went out of her way to facilitate meetings and visits and was one of the few people I felt a genuine attachment to, overall, the atmosphere was insular and unfriendly. While a handful of physicists seemed flattered by the interest of a well-informed outsider, that interest was almost never reciprocated. No one asked, for example, about me or my work. Conversations were one-way, transactional, almost always gendered; the male physicist imparting information to the woman artist.

Thankfully, a mistake with my on-site hotel booking for a private room meant that for much of the first visit I shared a room with a series of young, international women graduate students who were far more forthcoming in conversation than the senior physicists I encountered elsewhere. Invariably, these late-night, uncensored conversations were among the most interesting I had while at CERN. The women spoke of their stresses at feeling overworked and the financial worries of how to secure research funding for trips to CERN when travelling from less-wealthy countries like India. They spoke of their frustration with a system that requires huge numbers of graduate and post-doc students to keep CERN’s experiments fully-staffed with number-crunching analysts and technicians, but provides a minuscule number of permanent positions, meaning too

many people dropped or were forced out after their third or fourth, even fifth postdoc. They spoke so matter-of-factly about sexism and racism that I felt angry on their behalf, not to mention depressed that they seemed merely resigned to doing their best within an environment utterly uninterested in their long-term professional success.

I also spoke informally to the women who cleaned the hotel rooms and to the women who sat behind the cash tills in the main CERN restaurant. I would often sit at one of the tables near the restaurant and watch interactions between the mostly black women who operated the tills and the procession of scientists—mostly white European and American males—who paid for meals and snacks throughout the day. If many of the Europeans seemed perfectly at ease conversing with the restaurant's employees in a variety of languages, most frequently French, their American counterparts appeared utterly disconcerted, unsettled even, when greeted at the tills in a language other than English.

Back home, after a great deal of thought, I realised that the artwork I most wanted to make about CERN had nothing to do with its scientific research. Instead, I thought about how to draw more attention to the people whose labour, almost entirely absent from public discourse about CERN, enables the scientific research of the site to function with as little friction as possible. Rather than celebrate, yet again, the physicists and their experiments, I wanted to foreground the cleaners, cashiers, administrators, landscape maintenance crews and others, often women and/also people of colour, who comprise the bulk of the non-scientific workforce. I put together a proposal for the ATLAS arts team outlining my plan to make a video art piece featuring the women who work 'behind the scenes' at CERN.¹⁵⁹

My proposal was rejected. I was told that if I expanded or changed my artwork to predominately feature scientific or technical staff who worked on ATLAS or other experiments, then it might be possible to grant permission for my film. I refused as the crux of the proposed piece was not to further glorify the scientific or technical work of CERN, but instead to highlight the fact that CERN would not exist in its current form were it not for the unsung work carried out by the women I hoped to portray. Although the physicist who originally invited me to visit with a view toward making new work attempted valiantly to secure permission for the work through another avenue—a central CERN committee—that committee returned another rejection. It was suggested that per-

¹⁵⁹ Book 1, 6.

haps Monica Bello, current director of the Arts@CERN programme, might be able to facilitate. Bello, however, refused to discuss the proposal with me or even respond to any of my emails. Despite having been unambiguously invited to CERN to make a new artwork, ultimately my proposal was rejected and I was told that perhaps I should consider applying to the next Collide@CERN¹⁶⁰ open call.

Although I appreciate the perils of making broader claims based on personal experience, I would nevertheless argue that my experience is typical of the way CERN controls who can speak and what can be said with the support of the institution's 'legitimate' platform. Indeed, in her doctoral thesis, *At the Edge of their Universe: Artists, Scientists and Outsiders at CERN*, art historian Camilla Røstvik investigates CERN's artist-in-residence programmes as forms of institutional gatekeeping.¹⁶¹ Røstvik's research centres around the following questions: 'Why are there artists at CERN right now? Why does so much CERN-inspired art look the same? What are the funding structures behind SciArt?'.¹⁶² Her answers to these questions largely posit that CERN's art programme is an extension of its PR strategy. In other words, the sanctioned artist residence programmes represent 'the institutional use of art and artists as public relations'.¹⁶³ Røstvik also speculates that, given both CERN and the art world require large sums of money to function, and often struggle to justify the necessity of public funds for their endeavours, it is as much the 'financial buoyancy of the art market' as 'the cultural capital it brings which makes art an attractive partner for the image-conscious CERN'.¹⁶⁴

In my professional capacity as a culture journalist,¹⁶⁵ I am frequently invited on international press trips to review buildings or art biennales. The differences between, for example, attending the Venice Biennale independently or on a press trip offer a useful analogy for the differences between an artist's experience as invited to participate in the Collide@CERN programme versus making an 'independent' visit.¹⁶⁶ Travelling in-

¹⁶⁰ Arts@CERN is the overall umbrella for the art programme, while Collide@CERN is the current international artist-in-residence competition. Given that CERN, as far as I am informed, does not contribute funding for the programme, since its 2011 founding, Collide is always run in conjunction with a collaborating partner. From 2012 to 2015, the collaborating partner was Ars Electronica; from 2016 to 2018, it was Liverpool's Foundation for Art and Creative Technology; and since 2019, the partner has been Barcelona City Council and the Institute of Culture of Barcelona. Collide residents tend to spend up to two months at CERN and up to one month with the collaborating partner.

¹⁶¹ Camilla Røstvik, 'At the Edge of their Universe: Artists, Scientists and Outsiders at CERN,' (PhD thesis, University of Manchester, 2016).

¹⁶² Ibid., 21.

¹⁶³ Ibid., 12.

¹⁶⁴ Ibid., 99.

¹⁶⁵ Since 2009, I have worked as a staff writer and freelance writer for a number of international design and architecture magazines.

¹⁶⁶ 'Independent' in acknowledgement of the fact that no visit to an institution like CERN is ever truly independent. Regardless of through which channel one gains access, there are always gatekeeping measures in place, in addition to questions of access to financial or other resources to enable such visits to take place.

dependently, limitations are mainly down to taste and budget. One decides where to go (assuming where one wants to go is allowed), how to get there, with whom and when. Of course, the bill must also be paid out of pocket. Travelling on a press trip, one must first be vetted. Although the trip and all related expenses are provided free of charge, a published article is expected in return. Not every publication is deemed worthy. One's time is fully scheduled on a press trip; who you meet and what you see are carefully determined by the public relations team charged with organising the trip. Based on such comparisons, the Collide@CERN residency is far more like a press trip than an independent visit. Artists must first be vetted through an 'excellence-seeking' competition. Once through the selection process, the artist's visit is carefully shaped; access is provided only to certain people, places and narratives. Artists who visit CERN on the Collide programme do not, for instance, often meet overworked graduate students with grievances. Setting the analogy aside, official institutional gatekeeping is also accompanied by additional problems. Perhaps unsurprisingly, given that the percentage of women staff at CERN have remained less than 20% in the last twenty years¹⁶⁷, Røstvik observes that women artists at CERN 'often remain outsiders, cut off from networks funding and influence...CERN artists are overwhelmingly male'.¹⁶⁸

Thus, the chosen few (there are only around twenty officially-sanctioned artist visits at CERN each year) meet the same handful of senior physicists who share the same well-rehearsed anecdotes and stories. Although in theory, selected artists can produce work on whatever subject or theme they want, it is noteworthy that much of the work produced by previous artists shares similar characteristics. As Røstvik highlights, 'while [the artist plays] the role of the independent layperson, the insider status they achieve after winning a Collide@CERN competition affects their autonomy, their choices, and their artwork'.¹⁶⁹ Hence, in group exhibitions of work created by former CERN residents, such as that hosted by FACT in 2019, a degree of homogeneity is apparent with

¹⁶⁷ According to CERN Personnel Statistics from 2019, 19.20% of staff were women (compared to 17.22% in 2013). These statistics are broken down into professional categories. Of research physicists, 20.37% are women. In professional administrative work, 69.86% are women. So, although CERN uses the statistic of '20% female staff', the breakdown shows that this is a proportionally large number, artificially inflated by the domination of women in the administrative sector. CERN Human Resources, 'CERN Annual Personnel Statistics 2019', Human Resources Department website (May 2020): <https://cds.cern.ch/record/2719035/files/CERN-HR-STAFF-STAT-2019-RESTR.pdf> (accessed 23.07.2020).

¹⁶⁸ Røstvik, *At the Edge*, 53. The situation has improved somewhat since Røstvik's research and the change of Arts@CERN's directorship.

¹⁶⁹ *Ibid.*, 21.

similar tropes appearing throughout.¹⁷⁰ Although CERN's residency ostensibly provides artists with no prior physics knowledge access to cutting-edge particle physics research, one could argue that, by choosing artists with little physics knowledge the artists can more easily be steered into selecting, interpreting, or otherwise highlighting certain narratives which CERN wishes to promote. Hence, it is noteworthy how few artworks are made which, for example, offer up a social-political critique of CERN itself; there's very little that isn't directly connected to the content of the scientific research as opposed to the context in which such research is produced. In Røstvik's analysis, she argues that the specific genre of SciArt¹⁷¹:

is a convenient investment strategy where local and global, state-owned or private funders can get two intriguing and intellectually rich subjects covered by investing in one. In this context the artist's access to science can result in 'contract art', meaning art that is created with the chief aim of satisfying a client's wishes. There are not many examples of artists who try to critique or shake up the organisation they work with as part of a SciArt project.¹⁷²

Parsing Røstvik's notion of an investment strategy, what is fascinating is that historically CERN has refused to spend any of its budget to pay and commission artists. When British curator Ariane Koek first spent four months investigating the feasibility of an arts programme at CERN in 2009, she did so entirely of her own volition, funded by a fellowship provided by the British Clore Foundation.¹⁷³ CERN's Council approved the Collide@CERN programme on the condition that they would not be held responsible for paying for it. Instead, early funding for the Collide programme was initially provided by the city of Geneva, Ars Electronica, private corporate donors, and by the Exclusive

¹⁷⁰ Mónica Bello and José-Carlos Mariátegui, curators of 'Broken Symmetries' at FACT Liverpool, 2018. <https://www.fact.co.uk/projects/broken-symmetries.aspx> (accessed 6.08.2020). Although the gender ratio of artists has improved in recent years, the exhibited works share a number of material and conceptual features, from the repeated use of LED lights and pre-existing physics imagery (such as cloud chamber images) to the imitation of experimental apparatuses and uncritical adoption of scientific points of view (for example, questions such as 'how does abstraction help us to understand the universe?', as evidenced both by certain displayed artworks and comments made by participating artists in public talks on the exhibition).

¹⁷¹ It is worth noting that Røstvik writes from an art history context and her use of 'SciArt' in reference to contemporary art practice is not without problems. For one thing, many of the artists discussed would no doubt object to being categorised as SciArtists. For the sake of clarification, my interpretation of Røstvik's use of the term SciArt is that it applies to institutional frameworks and structures rather than individual art practices. So, artwork produced as part of a CERN residency or Wellcome bursary is considered SciArt, rather than the entire work of an individual artist.

¹⁷² Røstvik, *At the Edge*, 120. For clarity, I do not consider my practice to be a SciArt practice, but a contemporary visual art practice which regularly engages with science. Despite her focus on SciArt, Røstvik's analyses is of pertinence and value for my own research project.

¹⁷³ A grant-making charity that supports 'cultural learning, the creation of learning spaces within arts and heritage organisations, leadership training, and enhancing Jewish life'.

Friends of Collide@CERN, private anonymous patrons.¹⁷⁴ Today, although I have been unable to determine whether the current arts director receives a CERN salary, funding for artist residencies is largely provided through external partnerships with other cultural institutions or cities, such as FACT in the UK or the city of Barcelona and the ICUB (Institute of Culture of Barcelona) in Spain—successful artists obtain a residency at CERN, followed by a residency of equal or lesser duration at the partner institution. Should Collide artists wish to produce work following their residency, production funds must also be obtained from external parties. Even exhibition opportunities must be found elsewhere, as CERN currently has no exhibition space or provision for exhibitions. Regardless of the fact that CERN does not financially support residencies or pay for produced artworks, it nevertheless constitutes the ‘client’: physicists often sit on residency selection juries and, more crucially, CERN controls artists access to its sites and staff.

Despite being invited by the ATLAS arts organisation to visit and make an artwork about CERN, it was only after I arrived that I was informed that ATLAS had no budget to actually commission artwork. I was expected to fund the work myself through external sources. And it was only after I submitted my project proposal that I was informed, reading between the lines, that my proposed artwork did not satisfy the ‘client’s wishes’. Although frustrating and depressing in equal measure, the experience was nevertheless valuable in terms of shaping my thinking around future visits to sites of scientific research. For one thing, I would no longer seek invitations through official artist-in-residence channels—those ‘clear entry points for artists to visit’, as CERN’s cultural policy document states. I would also organise my own financial support.¹⁷⁵ The client could not have desires or expectations if there was no client. As Røstvik notes, ‘SciArt, created by institutions [such as CERN] rather than individuals, continues to first and foremost serve those institutions’.¹⁷⁶ Instead, I would draw on Traweek, and on the work of John Latham and Barbara Steveni, adapting and appropriating various strategies developed through their Artist Placement Group (APG).¹⁷⁷ To make the kind of work I wanted to

¹⁷⁴ ‘We are entirely supported by external funds – from donations from our private donors known as Exclusive Friends of Collide @CERN, the City and Canton of Geneva, Prix Ars Electronica, and UNIQA who sponsor all the artists’ insurances’. From Collide@CERN press pack available exclusively online (undated): <http://arts.web.cern.ch/sites/arts.web.cern.ch/files/Collide%40CERN%20Press%20Pack.pdf> (accessed 20.7.20).

¹⁷⁵ Given that my PhD was fully funded by the AHRC, with generous additional financial support to carry out fieldwork and to travel, I wholly acknowledge the privileged position of being able to negotiate access to physics sites outside of ‘official’ artist-in-residence channels.

¹⁷⁶ Røstvik, *At the Edge*, 120.

¹⁷⁷ A radical artist-run organisation established by Barbara Steveni in 1965 in London as a means to move outside gallery spaces by placing salaried artists in businesses or governmental institutions for fixed periods of time.

make and to ask the kinds of questions I wanted to ask, I would need to rely on my own funding and maintain distance from official institutional pathways. Thus, I sought permission to make fieldwork visits to CERN and other research sites through my own contacts and connections, developed over the last five years of working on physics-related projects. And while APG's programme of installing salaried artists in governmental, corporate or other institutional spaces for fixed durations is an ideal scenario, inspiration for my own work is drawn from their insistence that artists be able to spend time in organisations with no expectation of producing anything. Although many of APG's resident artists did go on to produce work, it was nevertheless acknowledged from the outset that non-materially-productive acts such as visiting, conversing, exploring, analysing, synthesising, and criticising were of equally important value.

Listen to the Scientists

Throughout 2019, in speeches given to the French National Assembly, the United States Congress, and the European Economic and Social Committee, Greta Thunberg, the Swedish teenage climate-change activist, frequently repeated an appeal for the world's political leaders to defer to scientific research and act accordingly. 'Listen to the scientists,' Thunberg entreated.¹⁷⁸ At a November 2019 photography conference in London, I was surprised when philosopher of photography Daniel Rubenstein echoed my own sentiments during his talk on philosophy and photography. In it, he countered Thunberg's statement by suggesting that 'science is what got modern society into our current predicament in the first place.'¹⁷⁹ Similarly, the Belgian philosopher of science, Isabelle Stengers, has spent much of her career attempting to think through precisely this tension. How can we, for example, criticise certain conceptions of the sciences without necessarily undermining trust in contemporary scientific research, particularly that related to climate change or environmental and public health?¹⁸⁰ Do we even want or need to pre-

¹⁷⁸ 'We know that most politicians don't want to talk to us. Good, we don't want to talk to them either. We want them to talk to the scientists instead. Listen to them, because we are just repeating what they are saying and have been saying for decades.' Greta Thunberg, speech to the European Economic and Social Committee made in Brussels on 21 February, 2019. Transcript archived at <https://www.eesc.europa.eu/en/news-media/videos/youre-acting-spoiled-irresponsible-children-speech-greta-thunberg-climate-activist>.

¹⁷⁹ Daniel Rubenstein, 'Philosophy and Photography', Light | Sensitive | Material conference, University of West London, November 1-2, 2019.

¹⁸⁰ See, for example, Isabelle Stengers, *Another Science is Possible: A Manifesto for Slow Science* (Cambridge: Polity Press, 2018).

serve trust in the sciences? These tensions, and the questions they raise, are important underlying aspects of my own research.

In February 2017, I was invited to give an artist's talk to a group of MA architecture students at the University of Canterbury. During the Q&A afterwards, a student asked me a question. I can no longer remember the exact phrasing of her question, but it was along the lines of whether or not I considered my practice to be political. Again, I cannot remember precisely what I said but I do remember that I dissembled and avoided answering the question directly. In essence, I replied that I had studied and worked in politics 'in a previous life' and that the experience was so traumatising that I fled the field and never looked back. Why I offered that response instead of an emphatic 'yes' is perhaps tied up in the fact that I am deeply uncomfortable with the argument that art *must* be political or useful.¹⁸¹ Art can be either of those things, of course, but not prescriptively so¹⁸². And yet, I do consider my work to be political. While it isn't always obvious in completed, exhibited artworks, I am nearly always preoccupied with complex, difficult questions of ethics, labour, value judgements, sexism, and subjectivities. There are other qualities, too—experiments with narrative, process and attentiveness to materials—but, yes, I should have said to the enquiring student, my work is political.

This Q&A resurfaces in my mind in September 2019 while on a fieldwork trip to Kamioka Observatory in rural Japan. Located in Gifu prefecture in a tiny hamlet around three hours by train and bus from Tokyo, the observatory consists of a single research building and a dormitory for visiting researchers across the street. There's a small Buddhist temple, a Shinto shrine, and a private family home which doubles up as an oc-

¹⁸¹ For example, comments made by curator Alistair Hudson in relation to his plans as new director of Manchester's Whitworth Art Gallery: 'Art should address what matters in people's lives, respond to current urgencies and propose solutions to issues around us'. Quoted in Ian Youngs, 'The Manchester galleries using art to try to change the world', *BBC News*, 9 April, 2019 (accessed 20.7.20) <https://www.bbc.co.uk/news/entertainment-arts-47807780> Although I have no objection to artists doing any of these things, I do object to the use of 'should' in this and other similar contexts.

An addendum. In August 2021, the Whitworth Art Gallery temporarily closed an exhibition by Forensic Architecture—a research group led by architect Eyal Weizman that investigates at human rights violations and state violence around the world—after a right-wing Zionist Israeli pressure group accused the exhibition of 'provoking racial discord'. The main point of contention was a solidarity statement with Palestine included in the show by Forensic Architecture. Without consulting the artists, the Whitworth agreed to remove this text. The artists found out about this plan and demanded the exhibition be closed as the statement had been removed without their consent. Alistair Hudson later announced, in a U-turn, that the statement would not be taken down, but that a 'space which gives voice to different perspectives on the issues raised by the exhibition and help contextualise them' will be displayed in the gallery. Alistair Hudson quoted in Kabir Jhala, 'Whitworth Gallery in Manchester U-turns on decision to remove pro-Palestine statement after Forensic Architecture threaten to pull work', *Art Newspaper*, 18 August, 2021 (accessed 30.11.21). <https://www.theartnewspaper.com/2021/08/18/whitworth-gallery-in-manchester-u-turns-on-decision-to-remove-pro-palestine-statement-after-forensic-architecture-threaten-to-pull-work>

¹⁸² One thing that I share with a number of physicists who work at the sites I investigate is an interest in 'pure research'. Of course, I fully acknowledge that there really is no such thing as 'pure research'. This relationship between pure and applied research in physics is an interesting tension that manifests itself differently depending on the context and situation. For example, while many physicists I speak to are proud to consider themselves as participants in a research field that is 'pure' with no obvious applications, the outreach centres at CERN and Fermilab frequently boast of the applicability of technologies first developed by their scientists, for example the world wide web or the use of particle beams for plastic packaging or food and medical industry uses.

casional liquor store. Every morning I wake up and look out the window at the heavily forested hills across the river before taking photos of insects, the likes of which I've never seen, performing their daybreak rituals on the sliding glass doors leading out to my balcony.

Unlike the thousands of researchers—both temporary visitors and full-time staff—who work at CERN and Fermilab, Kamioka Observatory has but a handful of permanent staff. Rather than reside in the hamlet, most of the Observatory's researchers live in Toyama, the nearest city, an hour's drive away. After 5pm, the only people to be found are the handful of temporary visitors staying in the dormitories to work shifts monitoring the various particle physics experiments. The observatory part of Kamioka Observatory is located in an underground mine a few miles away from the main research building. Once home to Asia's largest zinc mine, the site—one kilometre below granite bedrock—now houses seven physics experiments. After CERN's Large Hadron Collider detectors, Super-Kamiokande is probably the particle physics experiment most likely to be recognised by non-scientists. The extremely photogenic 50,000-ton water tank lined with thousands of golden, glowing orbs has appeared in countless newspapers and magazines around the world. As with all expensive particle physics detectors, Super-Kamiokande's control systems must be monitored twenty-four hours a day. Hence the temporary visitors, who come from all corners of the earth in order to fulfil their terms of participation in the experimental collaboration by spending nine or ten days carrying out their annual shifts.

I'm here as the guest of a particle physics professor from Duke University who I met at a neutrino conference in Germany in the summer of 2018. I had previously been invited to visit Kamioka by one of the Observatory's senior members of staff (who I met at another physics conference in Finland in the summer of 2015), but when the director realised that I wished to visit for more than a standard two-hour tour, my invitation was politely, but firmly rescinded. Although artists have visited Kamioka before, they have rarely, if ever, been granted permission to make long-term visits. I am very persistent. Following this initial rejection, I sought an alternative means to visit. I worked out that, although visits by unsupervised artists are difficult to facilitate, and thus rare, visits by graduate students accompanied by their supervisors are a frequent occurrence. Hence, my plea to the Duke professor. As a member of the Super-Kamiokande experimental collaboration, the professor who agreed to 'supervise' my visit was in fact completing a

ten-day monitoring shift down in the mine. She became my honorary doctoral supervisor, I became her temporary graduate student and Kamioka's administrators were appeased.

At Kamioka, there are three monitoring shifts per day. A daytime shift lasts from 8am until 4pm and there must always be two, though there are sometimes three, people on shift together. Day shift workers meet in the research building in the hamlet at 7.30am. Everyone grabs a construction helmet before heading upstairs to the control room to check in with the overnight shift. Any problems? No? Anything unusual? No? We all tap our ID badges onto the security panel which updates the system and displays the names of the three people who are 'in transit' from the research building to the mine. We drive the twenty minutes to the mine entrance, tap our badges on the console outside to indicate our arrival, before entering the mine and continuing to the underground detector control room. Someone calls the overnight shifters back in the above-ground control room to say we've arrived so that they can head back to the dorms to get some sleep. The same process happens in reverse at around 3.30pm before we leave the mine and head back to the research building above ground. During a shift, workers must carry out basic operational checks every two hours to ensure that all aspects of the detector are operational and that data taking is proceeding as normal. Unless an emergency occurs, which didn't happen once during the ten days of my visit, shift workers mainly work on their own personal computers in front of the bank of experimental monitors, catching up on emails or analysing data for future papers. A security guard brings down bento box lunches at noon. Otherwise, not much happens.

Incidentally, this is the perfect environment in which to find oneself as an unofficial artist-in-residence. I have unlimited access to the underground cavern in which one of the world's great particle physics detectors is housed and, even better, no physicists around to tell me off for snooping, opening boxes and generally being nosy.¹⁸³ I bring my medium format camera into the mine and stage photographs for a series on the use of gendered representations of nature in scientific contexts.¹⁸⁴ Back in the dorm building, I print out a huge copy of the design on the reverse side of the Nobel Prize medal—a female gendered Science unveiling the nude torso of a female gendered Nature—so that it

¹⁸³ And I am extremely nosy. I explored every nook and cranny of the cavern; opened every door, looked in every little room; rifled through tools and papers and boxes of equipment (to find electronics, construction materials, shoes and shoe covers, packs of ramen noodles, small tests or repairs that looked as if they'd only been set aside a moment ago, boxes containing damaged pieces of the detector awaiting repair).

¹⁸⁴ Book 1, 15.

spreads across 30 sheets of A4 paper and attach it to a large cardboard support structure. I bring it to the mine and take various photographs of it on the top of the Super Kamiokande detector. One afternoon, I carry it into the control room just before lunch and the physicists ask what it is. They're surprised, perhaps even a little bit shocked, when I tell them.

One evening in the dormitory dining room, over dinner with three physicists working the day shift, a discussion ensues about climate change by way of a conversation on vegetarianism. The three scientists are eating meals pre-prepared by the dormitory staff while I am eating bag salad and tofu from the supermarket in the neighbouring village. One asks why I'm not eating the dormitory-provided meal and I explain that I am largely vegan and that the staff were unwilling to prepare different meals.¹⁸⁵ This prompts further questioning on my reasons for not consuming animals to which I give my usual vague reply about my ethical concerns with, among other things, inhumane practices and the environmental impact of industrial farming. Quite naturally, the conversation roams to climate change and I have to hide my shock when the physicists express surprise when I mention something about carbon emissions being vastly higher when travelling by plane as opposed to train. The most senior of the physicists casually mentions that they must have flown between Japan and the US at least 100 times during their career and that they had no idea airplanes were such heavy emitters of emissions. I mention Greta Thunberg and not one of the three seems to know who I'm referring to.¹⁸⁶ This is the same month that Thunberg has been giving speeches to the United States Congress and the United Nations climate action summit calling on politicians to listen to the scientists.

These and similar conversations are repeated again and again when I spend time with physicists. While Sharon Traweek memorably described particle physicists as imagining themselves to be unshackled from cultural and social histories, as participants in a 'culture of no culture',¹⁸⁷ the Australian science writer Margaret Wertheim wrote an entire book about the so-called 'priestly culture of physics'.¹⁸⁸ In considering the relation-

¹⁸⁵ 'If you can eat fish, we can offer dorm's meal.

But you can not eat fish, we can't offer it. Very Sorry.

This is because fish are used for all soups and simmered food in Japan.'

An explanation of why even vegetable dishes are not vegetarian in the Kamioka dorm cafeteria from the helpful administrator who made my booking. As an alternative, she very kindly offered to do some grocery shopping for me so that I would be able to have something to eat in the first few days of my visit.

¹⁸⁶ These are American and European scientists.

¹⁸⁷ Sharon Traweek, *Beamtimes*, 162.

¹⁸⁸ Margaret Wertheim, *Pythagoras*.

ship between physics and religion in the discipline's early history, Wertheim notes the consequences of this 'priestly' and quasi-religious culture: among other things, an obsession with transcendental, abstract mathematics; lack of interest in social problems and the production of 'socially useful' knowledge; and, of course, the exclusion of women and non-white people from the field.

In particle physics, an obsessive focus on scientific research to the exclusion of all else has long been considered as much badge of honour as professional necessity —'physicists construct their world and represent it to themselves free of their own agency, a description of an extreme culture of objectivity: a culture of no culture, which longs passionately for a world without loose ends, without temperament, gender, nationalism, or other sources of disorder – for a world outside human space and time'.¹⁸⁹ Interestingly, even when it seems like physicists are starting to take more notice of societal problems, cognitive dissonance remains. For example, at the annual April Meeting of the American Physical Society (APS) in 2019, a tweet from *Physics World* magazine showed a chart which displayed attendee responses to the question, 'Which issues matter most to you?' Of columns labelled 'lab & facility upgrades', 'visas & immigration', 'research funding', 'climate change', 'combatting sexual harassment', and 'nuclear weapons & non-proliferation', climate change narrowly beat research funding.¹⁹⁰ But, recalling my Kamioka-dinner-table conversation, what's fascinating and frustrating in equal measure is that few connections are made between general concerns over climate change—as expressed in the APS attendee questionnaire—and the fact that the vast majority of the thousands of scientists (the annual APS meeting are attended by more than

¹⁸⁹ Traweek, *Beamtimes*, 25. 'It is easy to distinguish between the groups at the cafeteria [at the Stanford Linear Accelerator Complex in Berkley, California]. The physicists are dressed most casually, in shirts with rolled sleeves and jeans or nondescript slacks. They disdain any clothing that would distinguish them from each other. The style to which they conform, furthermore, maintains a carefully calibrated distance from fashion, quality, or fit.'

¹⁹⁰ Issues ranked in order from most to least votes: climate change, research funding, combatting sexual harassment, visas & immigration, nuclear weapons & non-proliferation, lab & facility upgrades. *PhysicsWorld*, 15 April, 2019, Twitter: <https://twitter.com/PhysicsWorld/status/1117907553596264448>.

10,000 physics from around the world) who attend these meetings fly in and fly out, contributing heavily to climate emissions.¹⁹¹

Though evidently a pressing concern for physicists, climate change is something that causes concern outwith of the lab; it's not a concern perceived as having direct relevance to or bearing on the work of particle physics. Physicists, for the most part, do not widely discuss the relationship between their massive experiments and carbon emissions. CERN's Large Hadron Collider alone, for example, has an energy bill as big as that of all the households in the region around Geneva.¹⁹² Nor do particle physicists, outside of a small fringe group, interrogate the fact that existing particle accelerators rely on gasses known to contribute significantly to global warming and seek out alternatives.¹⁹³ Equally concerning, given the explosive rise of machine learning in physics research, is news that training a single AI model can emit as much carbon as five cars in their lifetimes.¹⁹⁴

Given my increasingly obsessive interest in critically examining ethical problems in the culture of physics, one perhaps surprising consequence of the Kamioka dinner-table conversation was a reminder to submit my own research practices and processes to similar scrutiny. Was I questioning my ethics, practices and materials to the same degree as I was questioning those of particle physicists? As much as the Kamioka trip opened up a number of interesting histories related to the experiment's site and provided a valuable cultural comparison with Fermilab in the U.S. and CERN in Europe, perhaps its

¹⁹¹ An October 2011 article in *Physics World* showed that astronomers average 23,000 air miles per year flying to observatories, conferences and meetings, and use 130KWh more energy per day than the average US citizen. <https://physicsworld.com/a/how-big-is-your-foot-print/>

One interesting consequence of the Covid-19 pandemic which began to impact European and North American academics and scientists from March 2020 was an inability to travel around the world to attend meetings, talks, conferences and other workshops. The 2020 Neutrinos conference, which was to have been held in-person in Chicago, for example (I previously attended the 2018 conference in Heidelberg, and a similar conference in 2015 in Finland), was instead held entirely online. In corresponding Slack channels dedicated to the event and at various times during the online conference itself, a number of attendees commented on the fact that the 2020 conference was the most widely attended, with people joining from all over the world, in its history. On the conference slack channel, physicists also addressed the specific question of climate change, listing extensive travel as both a negative (because of the climate impact), but also one of the key perks of the job (free global holidays). Other physicists spoke of the positive impact of the conference being virtual in that it made it more feel more welcoming and inclusive to racialised people. The next iteration of the conference, Neutrino 2022, is scheduled to be held in May in Seoul, South Korea.

It's also worth drawing attention to the fact that, during my own PhD research, I flew return flights to Tokyo and Chicago, and a one-way flight to CERN. The art world is also increasingly reckoning with its dependance on flying; both in terms of artists and curators flying around the world to attend exhibition openings and biennales, but also in shipping art objects around the world in great quantities.

¹⁹² 'Physicists consider their own carbon footprint', *Institute of Physics*, 30 September 2011. <https://phys.org/pdf236579270.pdf>. See Book V, 85.

¹⁹³ Sam Lemonick, 'Scientists at CERN hunt for greener gases for particle detectors,' *Chemical & Engineering News*, April 27, 2019. <https://cen.acs.org/environment/greenhouse-gases/Scientists-CERN-hunt-greener-gases/97/i17>. See Book 5, 85.

¹⁹⁴ Donna Lu, 'Creating an AI can be five times worse for the planet than a car,' *New Scientist*, 6 June, 2019. <https://www.newscientist.com/article/2205779-creating-an-ai-can-be-five-times-worse-for-the-planet-than-a-car/>

most important function was to prompt reflection on ways in which my research might also interrogate the implications of my own practices.

While I was already mindful of a number of ethical aspects, such as attentiveness to citational practices and prioritising overground travel instead of flying, I became more committed to extending such reflection to materials, particularly those of my photographic processes. Since my early experiments with carbon transfer printing, I had always sought to replace gelatine with a non-animal-based alternative (in addition to my substitution of disodium salts for potassium dichloride), but following the discussion in Japan, I became interested in extending these ideas across all of the techniques and processes my practice. As per the designer Thomas Thwaites's project to fully recreate a cheap toaster from scratch,¹⁹⁵ it was not so much that I sought to make technically and ethically perfect alternatives to materials such as rolls of film or photographic developers, but instead to openly address the ethics of my own material-based practices and any related implications as part of the research project.

On returning from Japan, I started reading Lawrence Venuti's *The Translator's Invisibility*, a recommendation from Sarah Maitland after I asked why she hadn't addressed the question of translation as a critical political act in her otherwise excellent book, *What is Cultural Translation?* Reading Venuti, I was particularly struck by the following passage:

No culture should be considered immune to self-criticism, whether hegemonic or subordinate, coloniser or colonised... without such practices as foreignizing translation to test its limits a culture can lapse into an exclusionary or narcissistic complacency and become a fertile ground for ideological developments such as nationalisms and fundamentalisms which may certainly drive emancipatory projects such as anticolonial movements, but which—once autonomy is achieved—may also harden into another form of oppression.¹⁹⁶

What I became aware of at Super-Kamiokande was that focusing so fixedly and critically on the culture of particle physics (to the near-exclusion of everything else) was having a negative impact on my work and research. Although I had begun to appreciate the

¹⁹⁵ In Thwaites' Toaster Project, he attempted to build a £5 toaster from scratch by, among other processes, mining ore for steel and deriving plastic from oil. The project was what one might call a productive failure in which Thwaites realised he would essentially need to recreate civilisation in order to build a toaster from scratch.

¹⁹⁶ Lawrence Venuti, *The Translator's Invisibility* (Abingdon: Routledge, 2018), 20.

importance of ethical self-criticism on my own processes and my own field, I did not yet have a theoretical framework to fold it into a broader discussion. Venuti's insistence that translation practices can, but moreover should, facilitate criticism of the receiving culture as well as the source culture (irrespective of the perceived power differences between the two cultures) opened up a valuable mode of thinking about critiquing my own practices, methods and processes through cultural translation in parallel to my critiques of the culture of physics.

NATURE VERSUS THE LABORATORY

A leaf...

And the world of nature, the environment in which the leaf grows and falls

A smooth steel ball...

And the world of science, its environments the laboratory

Is there any connection between these two, the leaf and the ball? Does the world of the laboratory help explain the world of nature? Or, is there a conflict between nature and the laboratory?

Either shortly before or shortly after—I can't remember and can't find anything in my notes—my April 2019 fieldwork trip to Fermilab, while searching the American Archive of Public Broadcasting, I found an interesting series of television programmes made in the 1950s called 'Of Science and Scientists'. Given my interests in metaphors of nature as used in scientific language, particularly in the early modern period around the time of the founding of the Royal Society in the UK, I thought it might also be worthwhile to seek out modern examples of these metaphors in use. Of the twenty or so episodes, it was the second—entitled 'Nature vs. the Laboratory' that particularly caught my eye.

The scientist is a man studying nature in the laboratory. Everybody knows that. But how is this possible? How can a man in the laboratory tell you anything about nature, nature out of doors.

In grainy black and white, the television programme seemed to encapsulate so much of what I was beginning to think about in relation to the evolution of my research project from a focus on the constructedness of scientific data to the situatedness of science more generally and specifically, to the historical relationship between physics and misogyny.

More immediately, at Fermilab the dichotomy between ‘nature’ and ‘physics’ was everywhere apparent. Wilson Hall, the cathedral-like main building, cast its long shadow over artificial lakes and prairie meadows. A herd of American bison had been introduced to the 6,800-acre site in 1969 by the lab’s first director as a way to ‘give local residents an opportunity to enjoy the natural environments of Illinois’. Intended initially as a way of creating a pleasing natural environment in which physicists might study the building blocks of the universe, the artful management of the bison-dotted landscape served only to reinforce the dichotomy between the two in my mind.

As a physicist, I ought to be interested in the motion of everything. Even the motion of this leaf. And when this leaf falls from a tree, surely, there’s no more natural motion in the world than that. Alright, what can science say about it? Can science describe the motion? Can science describe how the leaf falls and explain why it falls?

During my time at Fermilab, I took the opportunity afforded by the freedom of being a visiting artist rather than an official artist-in-residence to explore the site with abandon. I drove down roads that members of the public aren’t allowed to drive on and wandered through the woods after dark when most of the researchers had gone home for the night. In all of these places, I shot short video clips of Fermilab’s different landscapes, intending to create a new series of visual images with which to overlay the soundtrack from the ‘Nature vs. the Laboratory’ programme. But when I got home and made the first edit, the overall effect was lacklustre, even boring.

So, what I’m going to do now is typical in science. I go one step away from nature. I go away from the event that first caught my eye and attention, and instead of observing the fall of a leaf, I abandon it for the time being and I look instead at the fall of some object which does seem to fall the same way every time. Because this is just where the laboratory comes in.

Perhaps I'd been too fixated on a literal interpretation of nature vs the laboratory and had over-relied on the juxtaposition of the almost-still-photograph video clips of the natural environment surrounding Fermilab with the detached, pseudo-objective presentation of the voices of the male scientists from the TV programme.

Following a number of different, but unsuccessful edits using the Fermilab footage, I devised a plan to shoot some new footage during my second visit to CERN in February 2020. I remembered *Russian Ark*, an experimental film by Alexander Sokurov from 2002 that I've always found technically interesting (if extremely dull) as the entire 87-minute film was shot in a single, uninterrupted take. I thought about the old Intersecting Storage Rings (ISR) collider at CERN, the very first hadron collider in the world, no longer operational but still physically present in the landscape. I decided to walk, above ground, the circumference of the old ISR and film the act of walking around it in a single take. I would then use the footage from this single take as the visual component and overlay the sound from the original television programme on top of that.

I spend far too long researching affordable gimbles before finally making a decision and ordering one. It arrives and I spend the week before my trip to CERN practising how to use it on walks around Edinburgh. To get a good result with a budget gimble, you have to adopt a mannered, slow and deliberate style of walking, slowly rolling the foot from heel to toe with each step.

Well, you say you don't find a vacuum in nature around you. You can only create one in the laboratory. Yes, but if you do you find that Galileo's prediction is right: leaves do fall like stones in a vacuum. Good. So, you can begin to understand now a leaf, but only in vacuum. What of the leaf that we began with out in the open, in the forest?

It's February 2020 and I'm back at CERN. In between breaks from photographing endless computer punch cards for my Jacquard weaving project, I take my camera and my gimble and walk over to the site of the old hadron collider. I start filming the shot from a small pavilion on top of a hill before walking on the sidewalk next to a road that slopes down towards the circular road that traces the perimeter of the collider rings. Although

it's winter, it's a beautiful, sunny day; full of spring-like warmth. I'm getting a lot of lens flare, but that doesn't trouble me.¹⁹⁷ About half-way around the collider my arm starts to hurt. The gimble doesn't weigh very much and neither does my video camera, but holding them both up continuously while walking slowly, with as much control as possible, is making my arm start to shake. But the time I get all the way to the end of the circle of the collider, my arm is shaking from the effort of holding the weight.

Over the week I stay at CERN, I repeat the single take around the collider ring four times in total. It doesn't get any easier and, by the end of every take, my arm is always shaking. I make other video clips from different landscapes at CERN, but I'm now quite attached to the badly-filmed single take. I like that it encapsulates some of the broader ideas that I'm thinking about. It feels very situated. It feels like a fallible body, one with an arm that shakes from the weight of the equipment, has filmed the scene instead of a robotic arm on a moving track that shoots perfectly with no artefacts or visual errors. Although less obvious, perhaps, the act of filming at CERN in this way is also an attempt to insert myself bodily into the work, placing my female body in this male-dominated environment and situating my self in the same way that I'm attempting to situate physics research culture more broadly.

I like that CERN is more of a hodgepodge environment than Fermilab. CERN's site places far less emphasis on a beautiful or manicured landscape, and the landscape feels less obviously separate from the laboratory buildings—it slightly undermines the point I'm interested in making, about the artificially reductive and abstract quality of science as not really that interested in studying nature, and I like that, too. I even like the lens flare.

You might begin to study how the effect of air resistance changes the law of free fall, the effect of the law of free fall, but to be truthful, it's a very tough subject still. There are too many things going on. The fall, the trembling of the leaf, air friction, turbulence, currents of air, all sorts of influences upon the fall of an individual leaf. In trying to figure out the motion of this would become a bit like

¹⁹⁷ Thinking about lens flare makes me think of all the 'rules' we're taught when learning technical skills like photography or videography. Lens flare is 'bad'; don't forget to use the 'rule of thirds' when framing your composition; the 'sunny 16' rule of exposing film. While I certainly believe that it's useful to have a keen understanding of the technical capabilities of one's equipment, the voice of teacher's past in one's mind, repeating the rules ad nauseam, can sometimes act as a stifler to independent, creative thought. Physics has its 'laws of nature', but art has plenty of its own ridiculous laws, too.

trying to predict where a ball would land each time a roulette wheel stops. So, we discover that we can't take that last step on that road back from the laboratory to nature.

It's eight months later. There's something that's still not quite right about the film. It just isn't working. Is it too boring? Yes, I think it's too boring. I attend a talk at Sheffield Hallam University via Zoom. It's Hester Reeve talking about her practice and her philosophy. She says something at one point that I just love, about the messy but creative tactic of 'creating something from nothing'. It's not about literally creating something from nothing, of course, but about working with what's in front of you and restricting yourself to a limited set of choices and materials and processes.

A few days later, I watch a short film by an artist-friend and fellow Northumbria PhD student, Verity Birt, that's being exhibited online at Well Projects gallery in Margate.¹⁹⁸ In the film, Verity uses a set of visual tropes—overlying video clips in geometric shapes and using on-screen text—that are simple, but effective. Her film has a layered quality that's rhythmic and pleasing to watch.

You see, our search for the how and why of simple motions forced us into the laboratory to do experiments. And the full result of these experiments was not only that we now understand a little better what happens in nature, but it also opened up great new insights. For example, that all of nature is connected by simple laws. Or that the minds of man can reveal the deepest secrets of the universe and that one can use these laws to make things which can benefit mankind.

I think about what Hester said, about making something out of nothing. I now have two nothings: the original television programme and the single-take walk around the old hadron collider that I shot at CERN. I think about Verity's film and the way she layers and juxtaposes different clips in time and space. I think about a conversation with my husband, after making him watch the latest version of my film, Verity's film and another brilliant short film by Emma Rae Bruml Norton about the history of the computer mouse—a film that's much funnier than my own.¹⁹⁹ He suggests I think about how I might more clearly undermine the authority of the male voices in the film through visual

¹⁹⁸ Verity Birt, *Crossings*, HD video (12:02), sound, sculpture, (2020). Commissioned for Energy Systems, Well Projects, Margate.

¹⁹⁹ Emma Rae Bruml Norton, *Complication of the Computer Mouse*, HD video (11:18), single channel video, (2020).

means. I realise that cutting the archival footage through my single-take walk at CERN might allow me to create something a bit more playful and less serious, but also more visually compelling.

On Zeroes and Ones

I feel as if I'm doing durational performance art for an audience of one. I am the artist and the audience. Does it count as performance art if the performer and the audience are one and the same? I'm still in my grubby basement workshop at CERN: placing, photographing, removing; placing, photographing, removing; one punchcard after another. Physicists and computer scientists who work in the data centre occasionally stop by to interrupt and enquire what I'm doing. I explain my plan to use the computer punchcards to create a hand-woven Jacquard tapestry and they seem mainly confused. A few wonder why I'm photographing by hand when I could take the punchcards to a museum and have them digitally scanned. I explain that efficiency doesn't much interest me, but I'm pretty sure the scientists are unconvinced. They struggle to understand why I make things so difficult for myself. I recall Michel Serres and his Northwest Passage, the treacherous in-between.²⁰⁰ I don't fully understand why I equate difficult processes with meaningful results, but nevertheless, I do.

Traditionally, in order to create fabric on a Jacquard loom, one creates a drawing of the final textile design which is then converted into the punch cards that control the loom producing the fabric. For my project, I will omit the first stage and proceed directly to the second. Rather than create Jacquard punchcards from an original design, however, my loom punchcards will be created by translating the CERN computer punchcards into a format suitable for a Jacquard loom. Or at least, this is the theory. When I first come up with the idea to create this artwork, I don't know anything about weaving or how looms work. I'm unsure which one is the weft and which is the warp, although I am familiar with the terminology. I've seen Jacquard punch cards before, in museums, but I don't know exactly how they are made, or even how they are used in practice. I know what I want to do, but I'm utterly at a loss as to know how to go about doing it. Once I've been to CERN and photographed all the punchcards, I spend days, so many days, searching

²⁰⁰ See Book 2, 32.

online, trying to figure out how to even begin the process of translation. It's not that what I need to do is difficult, per se; it's that I can't seem to find anyone who has done it before and, given that most weaving design processes have become computerised, very few people are even using physical punchcards in the first place.

After much searching, I come across an interesting project carried out by weaver and designer Rebecca Ough as part of a collaboration between Yorkshire mill, AW Hainsworth, Yorkshire Textiles, and the Future Fashion Factory. Rebecca created a method to translate old Jacquard punchcards held at Leeds Industrial Museum into computing software where they were redesigned for use in new, modern textiles. The project stemmed in part from the fact that a number of museums and mill archives hold thousands of designs in inaccessible punchcards. If it were possible to more easily convert the punchcards into a useable format, it would, among other things, provide a vast back catalogue of design inspiration for commercial mills. It wasn't entirely clear to me how Rebecca actually translated the Jacquard punchcards into the computer software, so I contacted her to see if she might be willing to meet and explain a bit more about her process.

Rebecca kindly agreed to help, and I admit to being genuinely shocked upon discovering that her process was entirely manual. In other words, Rebecca drew out a grid on paper. She then manually read and inputted the binary data from each individual punch card onto her paper grid with a pencil mark—a cross to indicate a hole, no cross to indicate no hole. By reading and outputting in a particular order, the data from one punchcard corresponded to a single line on the grid. Once she'd transferred all of the punchcard data to her paper grid, she then manually inputted the paper grid data into a weaving grid using computer software. Because the method developed by Rebecca relied entirely on manual notation and computation, the process was time-consuming and arduous. Rebecca's punchcards were 4 x 11, i.e. 44 holes per punchcard/grid line. Although a considerable amount of information, my punchcards were 80 x 12, i.e. 960 holes per punchcard and I had 2,131 punchcards from CERN to process. I printed out a grid that was 960 squares long before abandoning the plan after realising that I would have to manually plot binary data for more than two million holes.

Although Rebecca's method turned out to be of no practical use, it was invaluable in enabling me to understand and conceptualise the processes I needed to perform in order to enact my translation. Given that I had already photographed the CERN

punchcards, I assumed it would be easier to extract the binary data from the digital photographs and reconfigure it into a grid for weaving software. After searching on GitHub, I found a script for Python which would (supposedly) do just that, but it was temperamental and my Python skills weren't up to the task. I managed to get as far as I could on my own—to the point where I could read a single card at a time and extract its data, but I wasn't able to automate or batch the process in order to quickly read all the cards and produce the final grid. To that end, I turned to Henry Cooke, who is a senior producer and researcher for BBC Research and Development, as well as an artist and my friend. Henry is also really good at writing and debugging Python scripts. Working with the existing script I'd found, Henry wrote an additional script that batch-processed all of the punchcard photographs and extracted their binary data in the correct format for weaving, before dumping them into a massive grid which we took to calling 'megaloomb'. Henry's work made it possible to create the final grid which could be imported into the software programme for weaving in a matter of weeks rather than the months and months it would have taken had I tried to create the grid manually using Rebecca's method.

Bodies of Work

Just now, I should be standing on the top deck of a ferry sailing from Newcastle to Amsterdam. From Amsterdam, I would have then taken a train to the small town of Tilburg another hour away. It's August 2020. Although across the world COVID-19 is still cause for serious concern, in Europe many governments, including the British, have in recent weeks encouraged citizens to go on summer holiday in order to reboot the tourism economy. On Instagram, after months of nothing but living rooms and local countryside, to my disbelief, images of Greek islands and Italian restaurants begin to reappear.

Despite the widespread resumption of leisure travel, the head of my department refuses to authorise a planned research and production trip to Tilburg, home of the TextileLab—an internationally-renowned centre for textile experimentation and artistic production. The trip is postponed to November. In October, during my annual submission panel, I'm told that I must consider alternative arrangements given continuing uncertainties.

It was the Finnish designer and artist Kusta Saksi who first introduced me to the TextileLab, a few years ago, when I interviewed him about his work. During the interview, we spoke at length about a shared affliction: migraines. But, mainly, we spoke about his passion for creating woven artworks. When Saksi told me that he mostly worked at TextileLab, I filed the name away as a potential site for making weavings of my own someday. When I first imagined the project to create Jacquard woven textiles from the CERN punchcards, TextileLab was always the facility I had in mind. Its master weavers work almost exclusively with artists and designers, and the expectations are of experimentation and risk-taking rather than profit-driven commerce.

Although I wasn't forced to change my production partner, the anxiety caused by the uncertainty—never knowing whether or not it would be possible to travel to Europe prior to the end of my PhD—meant that I resumed an earlier search for a UK-based producer. Alongside TextileLab, I had initially also searched for a partner based in the UK, but was unable to find a Jacquard weaver who was both technically able to produce my project and interested in an artistic collaboration. Resuming my search, however, I unearthed a small weaving company based in Bristol, Dash & Miller. When it became clear that the Netherlands trip might never happen, I contacted them to see whether they might be interested and if they had the technical capacity to realise my project. The response I received from Juliet Miller, a co-owner of the company, was encouraging and sympathetic and so I elected to change producers. Although it meant that I would no longer be part of the TextileLab family, at least I was confident that I would be able to deliver the project as part of my PhD research—albeit with changes, mainly in size, due to new technical limitations.

A short trip to Bristol in December, two travel days and two work days, is approved by the head of my department. From Edinburgh to Bristol is six hours on the train. Normally, travel is a slight irritant on the way to somewhere else. But during a pandemic, being on a long-distance train journey feels both excitingly deviant and incredibly stressful. There aren't many people on the train, but of those people too few are wearing masks. The conductor isn't enforcing the rules. Quite a strange feeling, looking around at one's fellow passengers and wondering if any of them might be host to diseased cells that could infect you or those around you. I think I've never thought so often about bodies.

Over the next two days, thoughts on bodies—as carriers of contagion, ciphers for the virus, as containers of labour—form like soap bubbles, float away and vanish at regular intervals. Paths through the studio are marked out in yellow and black tape and only one person is allowed in the kitchen at a time, windows are open and the temperature inside is frigid. I'm not wearing enough layers. Such tactics are intended to ensure we don't forget about the virus, to ensure we keep our distance and they largely succeed.

Before I arrived, Libby Kates, the weaver tasked with seeing my project to fruition, spent around four days setting up the Jacquard hand loom in preparation for our two days of testing. In order to weave fabric at the maximum possible width of 70 centimetres, the loom is fitted with 1,760 individual hooks. A single yarn is threaded through each of these hooks to create the warp threads—the vertical threads of the fabric—through which the horizontal weft threads are passed using a small device called a shuttle. Despite the fact that, during the weaving process, the hooks are controlled by a computer, in order to enable the computer to do its job, the warp yarn must be threaded by hand.

I've been reading so much about the introduction of the Jacquard system in the early eighteenth century, about the weavers who protest at being replaced by machines, the 'migration of control of a piece of their bodies literally being transferred to the machine',²⁰¹ and about the widespread replacement of weavers for computers in contemporary commercial weaving, that it never occurred to me that even today, some *one*, some *body*, must still thread the warp by hand. And that takes time.

On the second day, as Libby continues to weave various test pieces for my final artworks, Juliet inducts me into the sisterhood of weavers. She teaches me how to set up a small table loom, essentially the starting point for any would-be weaver. Compared to the 1,760 individual threads the Libby is working with, the 120 threads of my table loom seem feeble in comparison. But what most surprises me is that, as I group the threads and separate them again to pull through the reed at the front of the loom, my shoulders begin to burn. I spent most of the time hunched over the table that the loom sits on or crouching over the loom to pull the threads through from back to front. Why is this so painful? I think again about the four days it took Libby to set up the larger loom and the

²⁰¹ Sadie Plant, *Zeroes*, 15. Here, Plant cites Manuel de Landa, *War in the Age of Intelligent Machines* (New York: Zone Books, 1991), 168: 'As a weaving system which "effectively withdrew control of the weaving process from human workers and transferred it to the hardware of the machine," the Jacquard loom was "bitterly opposed by workers who saw in this migration of control a piece of their bodies literally being transferred to the machine." The new frames were famously broken by Luddite rioters to whom, in his maiden speech in the house of Lords in 1812, Lord Byron offered his support.'

two to three weeks that it could take a weaver in the seventeenth century to set up a drawloom for a particular pattern. Despite technological changes and the introduction of computer automation, weaving remains a process inextricably connected to the body and to physical labour; historically, as so often today, to physical labour performed by women.

In 1933, Sigmund Freud pondered the question of why ‘...women have made few contributions to the inventions and discoveries of the history of civilization’.²⁰² Women, according to Freud, lacked both the capacity and the desire to change the world. They weren’t logical, they couldn’t think straight, they flitted around and couldn’t concentrate.²⁰³ ‘There is, however one technique which they may have invented’, Freud conceded, ‘that of plaiting and weaving’. But even then, women could not truly take credit for this invention, for it was not original or creative. ‘If that is so, we should be tempted to guess the unconscious motive for the achievement. Nature herself would seem to have given the model which this achievement imitates by causing the growth at maturity of the pubic hair that conceals the genitals. The step that remained to be taken lay in making the threads adhere to one another, while on the body they stick into the skin and are only matted together.’

Despite Covid-related travel uncertainties, one of the deciding factors in favour of changing to Dash & Miller over TextileLab is that all the weavers I engage with at the latter are men. The only woman I deal with at TextileLab is the administrator. By contrast, Dash & Miller is an entirely female-owned and operated company. In terms of the politics of my project, Dash & Miller is a far better fit. It feels right to be weaving these artworks with women.

After I’ve managed to finish setting up the table loom, I’m ready to start weaving. Emma, another weaver, brings me a couple of pattern books and a pad of graph paper. The table loom has eight shafts, through which the 120 threads pass through in groups of fifteen. When I lift a shaft up, the shuttle with the weft thread passes underneath, and when I pull the shaft down, the weft thread crosses above. Emma draws an eight by eight square on the grid paper and shows me how to draw different patterns and then to translate those patterns into a weave by changing the position of each of the eight shafts. I start out with plain weave, one of the most basic designs, a simple alternating

²⁰² Ibid., 23.

²⁰³ Ibid.

pattern. Then a ‘balanced twill’ and a different twill variation. I start to get carried away and mark out a ‘0’ in my eight-by-eight grid. I translate the grid into a series of numbers corresponding to which shaft should be up or down and weave a few lines. Little rows of jaunty zeros appear and I’m delighted. I’m also amazed, truly a little overwhelmed, as I finally start to appreciate the magnitude of possibilities available. My warp is comprised of alternating black and white threads. My weft is a single colour, a sort of thin maroon wool. I have only eight shafts to work with. But with these three yarns and eight shafts, the number of different patterns and textures I can create feels dizzyingly endless. If I then change or add an additional warp thread, it’s as if there’s an exponential expansion of possibilities. As a writer, I never feel a terror of the blank page, and as an artist, I never feel anxiety at starting a new project; but as a new weaver, I feel overwhelmed by the possibilities of the loom.

Because I’ve spent so much time thinking about the process by which I translate the computer programme punchcards from CERN into Jacquard loom punchcards, thus creating a ‘design’ for weaving, it hasn’t occurred to me that I will also have to make decisions about *how* to weave, not merely *what* to weave. The binary nature of the project, the whittled-down focus on zeroes and ones, has made it easy to limit the palette to two colours—black and white. I’ve also requested that the yarn come from companies using environmentally-sustainable methods and organic materials. But there’s the thickness to consider. There’s also the question of scale. The relationship between my grid and the loom isn’t a precise 1:1 and so the artwork must be scaled appropriately. But when we make the initial tests, we don’t adjust the scale. It’s only when we start to weave the final pieces that it’s apparent the re-scaling process has completely changed the nature of the woven material. I don’t like the way it looks, a bit looser and messier, and so we revert back to the original scale of the tests even though it’s technically wrong.

Because I have only a set of instructions with which to programme the loom and not an initial drawing against which to compare the final results, Sadie Plant’s interest in textiles as objects that communicate in terms much more meaningful than the superficial presentation of simple design rings especially true:

Because there is no difference between the process of weaving and the woven design, cloths persist as records of the processes which fed into their production:

how many women worked on them, the techniques they used, the skills they employed. The visible pattern is integral to the process which produced it, the program and the pattern are continuous.²⁰⁴

As an artist who often privileges process over the end product, Plant's understanding that 'nothing stops when a particular piece of work has been finished off' feels important. 'Even when magical connections are not explicitly invoked,' she writes, 'the finished cloth, unlike the finished painting or the text, is almost incidental in relation to the processes of its production.'²⁰⁵ But Plant also broadens this understanding of weaving as a process of continual production to liken it to an understanding of women's work more generally. Drawing on Luce Irigaray, Plant explores how women are 'in search of "a different alphabet, a different language," a means of communication which would be "*constantly in the process of weaving itself, at the same time ceaselessly embracing words and yet casting them off to avoid becoming fixed, immobilized.*"'²⁰⁶

²⁰⁴ Ibid., 67.

²⁰⁵ Ibid.

²⁰⁶ Ibid., 140.

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Art will not save us

It is 11:43 on the 3rd of April. The year is 2020. Typing it out right now, 2020 elicits the sensation of something futuristic, as if I am a character in a science-fiction novel. The reality is mundane. I write from a computer on my dining room table in my Edinburgh flat. Through my window, I have a view of an ancient, extinct volcano. A small group of seagulls squabble outside over a bag of discarded chips.

It has been twelve days since the UK was officially placed under lockdown by the Prime Minister because of the Covid-19 pandemic, although we—my husband and I—started staying at home nine days before the official announcement. Back in January, I spent ten days in Shanghai, just at the point strict Covid-19 restrictions were being put in place across China. Restaurants and museums closed, the metro ran with empty carriages. With nothing else to do, I spent long days wandering the eerily empty streets of one of the world's megacities. I was extremely lucky to be aboard one of the last flights back to the UK before entry from China was banned. By early March, it was evident that the UK was on a similar trajectory and, not wanting to be a burden to the NHS, public transport workers and others, we made the decision to 'lock down' prior to official government action.

In the days leading up to and immediately following the government lockdown, emails from my University Vice-Chancellor arrive on a near-daily basis. 'Your health, safety and wellbeing remain our number one priority', says one message. 'I hope you are finding ways through that make life a little easier', says another. UKRI, the government agency that manages the funds that appear in my bank account every month, announces an automatic six-month extension for PhD students in their final year. The underlying assumption suggests that only those soon-to-submit must be seriously affected by a pandemic. The rest of us, first and second year researchers, ought to carry on as if nothing has changed. This, despite the fact that our studios are closed, our fieldwork trips and conferences are cancelled, our libraries and archives are inaccessible. Who knows when buildings will reopen or when conferences will be rescheduled.

Acknowledging the complexity and confusion of the current situation, I give myself a week off. I don't think about my PhD, I don't make anything or write anything or even read anything related to my research. At first, I obsessively monitor the news. But this quickly wears me out, emotionally more than anything, and I endeavour to find a more constructive use of my time. I do what everyone else seems to be doing: baking,

yoga, gardening. I order plants, compost and pots from my local garden centre. Although the shop is closed, they organise a delivery to my house. Having drawn and redrawn plans for a simple balcony garden of potted herbs, vegetables and flowers, I spend an entire afternoon mixing compost with vermiculite and coir—aiming at a good balance of water-retention and drainage—for planting out herbs and vegetable seeds.

Afterwards, I sit cross-legged on dirty concrete, surrounded by just-potted plants and read the winter 2020 issue of *The Point*, a philosophy journal recently arrived from America.²⁰⁷ There's an article about Dave Hickey, whose perspectives on art and beauty I once much admired, but whom I haven't seriously thought about in many years. The article is by writer Daniel Oppenheimer, whose fervent admiration—clearly much more substantive than my own—has taken him to Santa Fe to spend time with Hickey, who, frankly, seems as if he doesn't have much time left to live.

'I don't think depth exists—I think it's a German fantasy,' Dave once said to me, and I've spent a lot of time reflecting on what he meant. I think the German Mistake, for Dave, is to assume that what's beneath, behind or beyond us is necessarily any truer or richer than what's on the surface, already visible to anyone willing to really look.

I go inside to get a pencil to mark the passage written out above. Oppenheimer's analysis of Hickey's gnomic utterance relates so unmistakably to one of my favourite Nietzsche aphorisms—essentially an exhortation for thinkers to remain courageously at the surface of things, rather than obsessing about depth—that it seems ironic, given that Nietzsche was German, to refer to it as a 'German Mistake'. Perhaps Hickey, and by extension Oppenheimer, had another German in mind.

Two pages later, I make another pencil mark in the margin:

Whatever justice is made of (and no doubt anger and judgement and maybe even surveillance are elements in the mix), art is not an extension, distraction, evasion or even, in a simple way, a complement to it. It is a rival source of value in the world. Art will not save us, but it might—unstably, unpredictably, miraculously—save us, you and me, for a little while.

²⁰⁷ Architectural historian and academic, Dr. Ruth Lang (who also happens to be my good friend), first introduced me to *The Point*. I often stay with Dr. Lang when working in London and her home is full of many interesting and wonderful publications on topics across a number of different fields.

The question of, or perhaps the possibility of, art as a rival source of value in the world, particularly in opposition to the values of a scientific worldview, has become increasingly urgent to my research. Even when I deliberately seek to carve out breathing space away from my PhD, it seems I cannot escape after all.

Phenol alchemy

A well-known alternative photographic process combines coffee, sodium carbonate (washing soda or soda ash) and vitamin-C (ascorbic acid) to create a developer for black and white film. Referred to as caffenol, the process presumably has a long history—accounts on various photography websites suggest that photographers were experimenting with caffenol-type processing during the Second World War. But the modern resurgence of the technique is typically attributed to Scott Williams, who tested different mixtures with students of his technical photographic chemistry course in 1995 at Rochester Institute of Technology. More recently, caffenol has become popular with photographers seeking to avoid the toxic hydroquinines commonly found in industrially-produced film developers.

Earlier in 2020, I was invited to participate in an artist residency organised by the London Alternative Photographic Collective to be held at Yinka Shonibare's Guest Projects space in Hackney. Themed around the removal of toxic chemicals and plastics from photographic processes, each invited artist was tasked with crafting a mini research project to pursue during the week-long residency.

Curious about the chemistry behind caffenol developer, I wondered what enabled the particular combination of coffee, soda crystals and vitamin C to successfully develop the silver halide crystals in black and white film. Research into chemical structures led to the speculation that it was a particular phenol, namely caffeic acid, in the coffee which, when combined with the soda and the vitamin C, resulted in an agent that could successfully transform the silver halide crystals of the latent image into metallic silver. After consulting a number of phytological databases, it became clear that coffee was actually quite low in caffeic acid. Indeed, a number of other plants contained the phenol in much greater concentrations. Perhaps they would work better? For the residency, I pro-

posed a series of experiments to create and test alternative film developer recipes based on substituting plants high in caffeic acid for coffee in a standard caffenol recipe.

Given the pandemic and government travel restrictions, the residency, due to take place from 5th to 12th April, was moved online instead. Rather than gathering together and working at Guest Projects in person, we met every morning on Google Hangouts to discuss ideas and progress as a group. As none of the group had access to our usual darkrooms, we cobbled together ramshackle and increasingly outlandish substitutions for tools and working methods. And though incredibly frustrating at times, the challenges did seem apt to the theme of our residency.

To provide a degree of structure, I settled on experimenting with one plant per day. Monday, hibiscus flowers; Tuesday, star anise; Wednesday, thyme; Thursday, freshly-picked gorse flowers; Friday, cinnamon sticks and one control test using no plant material at all. While certain ingredients—star anise and gorse flowers—worked better than others—dried hibiscus flowers, which didn't work at all²⁰⁸—every plant made a developer that essentially did its job and developed the film to a degree where negatives could be used for scanning or for darkroom printing. Even the control test, using only washing soda and vitamin c, produced a faint image.

Several of the other participants in the residency, encouraged by my initial research, were intrigued to perform their own experiments with plant-based developers. On seeing their success, some of the participants were quick to claim these new developers—created with spinach from the garden, hedgerow weeds and berries, even mint tea from a teabag—as miraculous new ecologically-sound methods for practice. Much as I might wish to agree, arguing that the process evidences in some small way Hickey's claim for art as a rival source of value in the world, plant-based developers do not, of course, provide a quick-fix solution for photography's numerous problems with extraction, toxicity and waste.

²⁰⁸ It was a blog post by General Treegan on the Alternative Photography website that gave me the idea for using dried hibiscus flowers. General Treegan gave a recipe for a hibiscus developer, presumably using fresh hibiscus flowers, which I copied exactly. <https://www.alternativephotography.com/herbal-developers/>

Refusal of Work

It is 11:04 on the 9th of September.

The year is still 2020.

2020 no longer feels futuristic when I write out the date.

Today, it feels like a void.

I am still writing from a computer on my dining room table in my flat in Edinburgh.

The ancient volcano is still there, the seagulls are not. There are no chips.

I am exhausted, wrung out. I have not had access to my studio or any work space apart from my living room since mid-March. Yet, institutional expectations are such that I—and every other PhD student in the UK—am expected to continue working on my research project. But how can one work as a practice-based artist with no ability to practice, no access to tools, no materials or fieldwork trips, no discussion with other researchers? Perhaps if the pandemic were only a pandemic, merely a temporary confinement to our domestic living spaces because of a deadly virus, it might have been possible to find a new way of working that didn't feel like a crushing, disappointing compromise; a rewriting of the definition of practice to that which one can do from home. But the pandemic coupled with its economic consequences and hugely upsetting and unsettling political and social events has made focus on practice, in whatever form, all but impossible.

When I first started my PhD in late 2018, one of my supervisors suggested that I keep a regular research diary. After making frequent, sometimes daily, entries for the first seventeen months, between 15th March 2020 and 9th September 2020 I made only eight. One was about the politics of citations; one about the Black Lives Matter protests and anger at the ineffectiveness and duplicity of institutional art world politics; a few are bibliographic references to follow up on; and one is a note that simply reads, 'Duchamp and non-production—feels like what want to do and what's ethical to do. But how to do?'

Although perhaps this isn't the place for a lengthy exegesis on my conflicted feelings about tensions between the power of visual art to create positive change and the impossibility of ethical individualism within capitalist systems, the idea of a non-productive art practice is one that genuinely appeals to me. Given all that I know, and all that I value, isn't the only reasonable course of action to do nothing? To make nothing? To abstain from participation by simple, straightforward refusal? Honestly, I don't know.

In May 2018, I gave a talk to MA students at the London College of Communication entitled: ‘Over-simplification, Over-production, the Joy of Research, the Refusal of Work and the Rejection of Production-based Self Worth in the Context of a Research-based Transdisciplinary Art Practice’. To a certain extent, the talk expressed my desire to collectively discuss certain things that trouble me about being an artist. Namely, the huge amount of new *stuff* being produced every year, whether consumable goods or academic knowledge production. Weren’t we artists simply adding to the mass of global landfill with our photographs and installations and sculptures and paintings? And why were we so susceptible to the connection between our sense of self-worth and recognition of success based on the production of art stuff?

But the talk was also part of an ongoing attempt to think through the question of whether or not I can make no art²⁰⁹ and still sustain a professional career as an artist. I’m married to an art writer and critic and intelligent person, and when I was explaining my concerns around labour and non-production and art and he said I should read up on Duchamp.

I’ve never been particularly attracted to Duchamp or his artistic output, but an interesting 2014 essay by Italian philosopher Maurizio Lazzarato (translated into English by Joshua David Jordan), *Marcel Duchamp and the Refusal of Work*, changed my mind. Lazzarato helped me understand that a key strand of Duchamp’s thinking has been forgotten in favour of a more sensationalised understanding of the artist’s work. Contemporary art hagiography has framed Duchamp as the artist who expanded the definition of contemporary art such that literally any *thing* can be art, so long as the thing is presented in a context that provides appropriate artworld legitimacy. The artist merely points his finger at an object and declares it art, like casting a spell. Somewhere along the way, Lazzarato argues, we’ve lost sight of the fact that Duchamp was deeply committed to the idea that the artist could occupy a position of refusing to work or refusing to produce.

Above all, Lazzarato understands Duchamp’s practice as work that isn’t work, and not as per the neoliberal capitalist trope of ‘do what you love and it’ll never feel like work’. Lazzarato explains that the simplest definition that Duchamp gave of the readymade is that it is, “a work with no artist required to make it.” It is above all an, “act of defiance [...] which lowers his status in society instead of elevating him, of

²⁰⁹ While this section refers to ‘making art’ and ‘stuff’ as physical things, it could just as easily extend to seemingly non-material stuff like artist’s websites or social media accounts which are of course underpinned by an expansive material infrastructure.

making him something sacred.” Reading this, I’m excited, intellectually stimulated, but also deflated. 100 years ago, Duchamp offered a compelling alternative to artistic production, but instead became known as the guy who put a urinal in an exhibition and in so doing flung open the floodgates of conceptual art. In part, Lazzarato finds fault with the communist movement which:

had the opportunity to create an anthropology and ethics whose aim was not a present dominated by hard work. It could have invented processes of subjectivation that weren’t centered on producers. In *The Right to Be Lazy* (1880), written as a refutation of Louis Blanc’s “right to work”, Paul Lafargue drew inspiration from the *otium* of classical antiquity. It was precisely the latter that the communists should have considered in light of slavery’s democratization through waged labour. But they failed to see what Marx’s son-in-law Lafargue had rediscovered, namely, the ontological and political implications inherent in the suspension of activity and authority. They thus missed the chance to move beyond the model of *homo faber*, beyond the vainglorious producer and the promethean promise of mastery over nature that the model implies. Duchamp, on the other hand, exploited the radicality of inactivity. For the right to be lazy, “a right, without your having to give an account or an exchange,” challenges the three mainstays of capitalist society [exchange, property & the primacy of labour].

What appeals to me about Lazzarato’s assessment is that he is not necessarily arguing that we should not work. Rather, he holds that capitalistic models (and even communist models after Marx) have been so influential in the way we think about work and the importance we give to work as a society—both in terms of economic productivity, but also other related values like self-worth—that they have completely railroaded other possibilities. In so doing, capitalistic models have seemingly stifled our ability as a culture to imagine other possibilities for work.

But why, if I have so many problems with production of stuff, do I continue to make things as an artist? And why, especially, do I persist in making things that are technically complex, time-consuming and labour-intensive? If I try to give an honest account, I suppose making can sometimes provide access to a certain kind of knowledge. Often, I make to learn something. This is rather a selfish form of learning and probably a bad way to be as an artist, but it resonates with Duchamp’s notion of refusing productive

work, that is, of refusing work considered economically productive according to capitalist labour practices.

I also think that's why Lafargue in *The Right to Be Lazy* (cited in Lazzarato) reaches for *otium*. This is a very complex concept with many different meanings in antiquity—originally it referred to the downtime of soldiers, a kind of boredom associated with waiting around in-between battles—but it later became more famously associated with the idea of the leisure time of the privileged ancient Roman elite. After a senator had completed his period of service to the state, for example, he could withdraw from public accountability to leisure activities. But this isn't like retiring to watch television or play golf all day. *Otium* is associated with an intellectually industrious leisure, primarily related to the study of philosophy. As someone who values thinking over making, research over production, such ideas hold considerable appeal.

Quite unintentionally, the pandemic has engineered a kind of experiment to test some of my ideas about non-production and refusal to work. The lockdown has created a strange situation in which previously 'normal' modes of production are now largely impossible. That said, the economic imperative to produce has not disappeared—most people still have rent, mortgages and bills to pay; they need to eat. Judging by the Twitter and Instagram feeds of most of my friends and colleagues, the economic imperative is as pressing as ever. But more surprising to me is the way the lockdown seems to have inflamed the desire to ²¹⁰. I'm still processing, but all around is an explosion of production. Like a Bacchanalian frenzy, new work appears everywhere: podcasts and video chats, kitchen printmaking, new print publications, zoom lectures, online courses, rehashing old works from the archive and on and on. While the economic imperative is best encapsulated by the #artistsupportpledge hashtag (in which artists sell works for no more than £200 and pledge to buy work from another artist on reaching £1,000), it seemed that all the anxiety and worry suddenly manifested itself as an outpouring, an overflowing of production. Don't stop and think. Just make. Produce away the worry, produce to dull the fear, and produce to hold on to the identity associated with work.

²¹⁰ As my PhD examiners rightly pointed out during the viva, there are undoubtedly many other reasons why artists produced in these ways during the pandemic. Equally rightly, the examiners also pointed out that my own changing habits with social media engagement meant that I was seeing more, therefore there was as much an overflow of visibility as there was an overflow of production.

The Message is Death

In late June 2020, prompted by Black Lives Matter²¹¹ protests around the world following the murder of George Floyd by police in Minneapolis, numerous international art museums and collections announce a joint simultaneous livestream of a work by American artist and filmmaker, Arthur Jafa. The work is entitled *Love is the Message, The Message is Death* and consists of a seven-minute video pieced together from contemporary and historic found footage and set to Kanye West's gospel-inspired song *Ultra-light Beam*.

Although the film dates from 2016, I encountered it for the first time in 2019 at the Museum of Contemporary Art in Chicago. The work is hugely powerful: it's distressing, joyful, and overwhelming in equal measure. Clips cut in and out in quick succession. A man speaks, presumably to a TV cameraperson: 'I knew something was wrong when a little pretty white girl ran into a Black man's arms'. Cut to hundreds of Black arms waving in the stands around an indoor basketball court. Quick cut to a pregnant Black woman walking through what looks like a hospital corridor, trailing behind her, I think, a police officer. Another quick cut to a Black break-dancer, his limbs contort with the fluidity of flowing water. Cut again, to a Black body running away from a police officer. The officer holds up his handgun, both hands on the weapon, arms outstretched in that all-too-familiar pose. The rigid geometry of his body a stark contrast to the fluidity of the dancer in the preceding clip. You don't hear the sound, but the officer shoots and the man running away crumples to the ground. What could have been a dance move, in another context, is in fact murder.

In the large, dimmed gallery space, I sat on a long bench and watched Jafa's film. I cried. The physiological reaction took me by surprise. And they weren't picturesque tears, either, but sobs where I could hardly catch my breath. I had to leave the gallery, go outside and pace the museum's terrace to regain some semblance of equilibrium. In a

²¹¹ Black Lives Matter is a decentralised political and social movement protesting against incidents of police brutality and all racially motivated violence against black people. It was originated in July 2013 by Alicia Garza, Patrisse Cullors, and Opal Tometi through a call to action campaign under the rubric of the #BlackLivesMatter hashtag on social media, prompted largely by the acquittal of George Zimmerman in the shooting death of African-American teen Trayvon Martin 17 months earlier in February 2012.

lifetime spent in and out of museums, biennales, art fairs and galleries, watching this film marks the sole occasion that I have ever cried in front of an artwork.

However, a number of people, most notably Jafa himself, have drawn attention to the problematic nature of my tears and those of other gallery-goers. It turns out that a lot of people have cried while watching Jafa's film. As the artist told *The Guardian* in 2018:

I started to feel like I was giving people this sort of microwave epiphany about blackness. I started [feeling] very suspect about it. After so many "I cried. I crieds", well, is that the measure of having processed it in a constructive way? I'm not sure it is.

It's not difficult to agree with Jafa's criticism of suspect tears. That said, Jafa is also an expert filmmaker and *Love is the Message* deploys the full force of his expertise and sensitivity to craft a seven-minute journey that leads the viewer down a path ending in tears. Perhaps the artist has become as suspicious of his own technical bravura, the ease with which he can successfully manipulate viewer responses, as of the responses themselves.

When the livestream of Jafa's work was broadcast by fifteen institutions over the weekend of 26th June 2020, I didn't watch the film again. In light of the depressingly numerous revelations that emerged around BLM, exposing the reality of ongoing racism in major art institutions and art galleries, the gesture felt hollow, tokenistic even. Later in the year, in November, I see a tweet from Danny Birchall, digital curator at the Wellcome Collection, quoting Dr Errol Francis, artistic director of Culture&. 'It's impossible to decolonise a museum because a museum is a colonial construct'. This makes so much sense to me. I feel myself melting into agreement. But then, I think again about the experience of viewing Jafa's film in Chicago. Although these institutions are deeply embedded in colonial power structures, they do also possess some potential as sites of community, unity or knowledge.

A few years ago, I was told about an interesting scientific study.²¹² The study explained that in a theatre, when the lights go down and attention focuses on the stage, the heartbeats of audience members begin to synchronise. The act of sitting together in a

²¹² During the Edinburgh Fringe Festival, which traditionally takes place in August, I often review theatre performances for *Exeunt*, an online theatre magazine. While waiting to review a show in August 2019, I began chatting with a woman sat beside me. She happened to mention an interesting scientific study she had recently heard of thanks to a newspaper article, but she couldn't remember the name of the newspaper or even the details of the study.

dark space, feeling feelings at the same time, was an experience ‘extraordinary enough to overcome group differences and produce a common physiological experience’. Individual heartbeats transformed into a single beating heart. When I try to think about why I cried while watching Jafa’s video, I remember this study about synchronised heartbeats.

Although the film was exquisitely stitched together for maximum emotional impact, what really prompted tears—what made me feel so heartbroken and so furious—was the context. It wasn’t Jafa’s film alone. It was the fact that I, a disillusioned American migrant now living in Europe, watched Jafa’s film in Chicago, one of the most segregated, racist—historically and today—cities in America on a rare work trip to my homeland. It was the fact that I watched Jafa’s film in a museum in Chicago alongside a large school group of young, Black teenagers. It was the experience of watching the film together with those particular teens in that particular city—thinking about the synchronicity of our heartbeats in the theatre-like space. It was the sudden, completely overwhelming feeling of fury at the crushing injustice of trying to exist in a culture that privileges, often at the cost of individual lives, humans with my skin colour over those with skin the colour of the teenagers sat next to me. That’s why I cried.

That’s also one of the reasons I felt so disappointed in the art world, as revelation after revelation emerged of racial discrimination. On ‘Blackout Tuesday’,²¹³ the 2nd of June 2020, when a number of cultural institutions posted a black square in solidarity with the Black Lives Matter protests, American curator Chaédria LaBouvier called out the Guggenheim after seeing their black square solidarity post. LaBouvier spoke of the numerous ways in which Guggenheim’s chief curator, Nancy Spector, attempted to effectively erase her efforts as curator of the institution’s 2019 Jean-Michel Basquiat show, ‘Defacement: The Untold Story’. Among other things, LaBouvier referred to a panel discussion on the Basquiat exhibition, a discussion hosted by Spector, to which LaBouvier was not even invited.

In the UK, assistant curator Ifeanyi Awachie disclosed on Twitter that a personal programme she created and ran called *Confronting the ICA* had been appropriated by ICA director Stefan Kalmár—without her knowledge or permission—as evidence of

²¹³ Blackout Tuesday was instigated by Jamila Thomas and her former colleague at Atlantic Records, Brianna Agyemang and was intended as a call to action to their colleagues in the music industry to ‘pause the show’ in the entertainment industry in protest against racism and police brutality against black people in the United States. Although Blackout Tuesday’s original hashtag was #TheShowMustBePaused, millions of users on Instagram posted black squares in solidarity and tagged their posts #BlackLivesMatter and #BLM thereby obscuring two hashtags which had been instrumental in sharing important and up-to-date information about protests, legal aid and donations among Black Lives Matter organisers and protestors.

how the ICA had been responding to issues of structural anti-Blackness for the past two years.²¹⁴ Shortly after the William Morris Gallery published a Black Lives Matter statement, on the 12th of June, former employee Teanne Andrews published a lengthy blog-post on weareparable.com outlining how she, the only Black member of cultural staff, had been forcibly pushed out of the organisation after four years working on various temporary contracts.²¹⁵

A few months later, it emerged that the Whitney Museum in America was planning an exhibition comprising a number of artworks which had been acquired at a discounted price at a print sale hosted by the See in Black project, a fundraiser for black mutual aid organisations that launched on Juneteenth (19th June). Many of the artists were notified only weeks before the planned opening date and without their consent being sought. See in Black later released a statement in which they claimed ‘the Whitney’s use of the works [...] constitutes unauthorized use of the works to which the artists do not consent and for which the artists were not compensated’. The exhibition was subsequently cancelled.

Along with innumerable others, I spent the summer writing to museum directors and board members, requesting explanations, apologies and compensation for staff members who had been wrongly treated. Some replied, many did not. Those who did reply most frequently evaded the issue and claimed data protection meant they couldn’t comment further. Our efforts seemed to result in little tangible change. Kalmár refused to make a public apology. Ifeanyi Awachie quit the ICA. As of early November, the William Morris Gallery is still investigating Teanne Andrews’s formal complaint about its racist treatment of her. At least Nancy Spector left the Guggenheim. The disappointment of such feeble responses was further compounded when, shortly thereafter, British cultural institutions began to make huge numbers of their workforces redundant, particularly those on casual contracts—contracts disproportionately offered to Black workers and people of colour—even after receiving Covid-19 pay-outs from the government.

²¹⁴ Kalmár announced in August 2021 that he would be ‘stepping down’ as ICA director. Many articles were published about this story in the art industry press, but none of them mentioned or elaborated upon these accusations. In fact, at least one article said that Kalmár’s decision was in part related to several rightwing complaints made to the institution during his directorship. In that same article, Kalmár seems to tacitly acknowledge some of the ICA’s internal problems, but locates them elsewhere, outside his responsibility or agency as the institutions director: ‘If problems are structural, then change must also be structural,’ Kalmár said. ‘Unfortunately, organizations of this size and scale adapt—rightly or wrongly—too slowly. Or at least, too slowly for me.’ Sarah Cascone, ‘ICA London Director Stefan Kalmár on How British Politics—and Right-Wing Attacks—Sparked His Departure From the Museum’, *artnet*, 10 August 2021 (accessed 30.11.21).

²¹⁵ Teanne’s post ‘Hypocrisy, Fake Solidarity, and Glass Ceilings: My Perspective Working at the William Morris Gallery’ is no longer live: <https://www.weareparable.com/hypocrisy-fake-solidarity-and-glass-ceilings-my-perspective-working-at-the-william-morris-gallery>

Despite my ambivalence about art institutions as forces for good or the idea of art as an alternative source of value in the world, the fact that many museums are large spaces, often in city centres, devoted to display of cultural artefacts and events, means that they have power (and a responsibility to that power) that other institutions do not. This is also partly the reason why I did not re-watch Jafa's film on my computer from my living room. I knew that it would not compare to the powerful, situated and, most importantly, shared experience of watching it at the Museum of Contemporary Art in Chicago.

A few weeks later, *Art Review* published an article on its website, 'Why Art Workers Must Demand the Impossible' by Tai Shani, one of the four Turner Prize co-winners from 2019. Shani's text crystallises a number of my own muddled thoughts on the conflicts between acknowledging the potential of art to stand for alternative values and recognising the impossibility of such potential given the capitalist positioning of so many of the art institutions we work with and in. As much as artists might represent and demonstrate different values, the latter problem gives rise to many of the persistent problems with respect to institutionalised racism and sexism which were so evident around the time of the BLM protests.

Shani describes how the four co-winners had been commissioned to make a new work to be situated in London's Piccadilly Circus. Deciding to focus on the well-known statue atop the Shaftesbury Memorial Fountain, the group created a collaborative text-based piece which mentioned an 1840 invasion of Palestine and used a direct quote from the 7th Earl of Shaftesbury that referenced Palestine. The commissioners worried that mentioning Palestine—not, as Shani makes clear, 'viva Palestine, *not* free Palestine, *not* apartheid Palestine, *not* open-air prison Palestine', simply the word 'Palestine'—could be perceived as anti-Semitic and potentially investigated by the police. Ultimately, rather than change the wording, the four withdrew from the project.

Drawing attention to the 'bewildering ethical paradoxes of the artworld', Shani argues that such paradoxes 'have been sustained by a facade of [...] a liberal centrist political position that has been hardwired into the operational models of galleries, museums, institutions, art schools, and art organisations'. Although Shani justifiably questions whether or not there exists even the potential for radical, transformative politics in art or the artworld, she also arrives at, to my mind, the more important point: the fact

that such questions are utterly ‘irrelevant if the very infrastructures that assist art’s visibility continue to erode its integrity’.

Shani also makes an important connection between the individual ethical positions of artists and the near-impossibility of maintaining those positions in any consistent, meaningful way if professional practice brings regular contact with big-name art-world institutions:

Artists, thinkers, writers, curators, etc. like anyone living in a capitalist world, have no choice but to be ethically inconsistent, but inconsistencies are even more explicit in our smaller artworld, and the proximity of these contradictions to our personal lives is rarely mitigated.

The one hopeful note in Shani’s otherwise depressing critique is the intimation that things are changing as artists realise their power against the institution. As individuals, there’s little to be done, but together—organising campaigns to remove board members, rename buildings, rescind relationships with toxic donors or simply refusing to exhibit in ethically-compromising situations—we are finding ways to have power.

Situated Knowledges III

In the moments in between trying, and mostly failing, to find ways to maintain mental equilibrium during the strict lockdown and the months afterwards, I begin to work on a new artwork. Given that I have already gathered a considerable amount of material related to the history of CERN, Fermilab and Kamioka Observatory and have access to nothing other than my computer, I think about what I *could* do rather than what I *want* to do. Ultimately, I decide on some kind of video-based performance lecture, possibly split into three short chapters.

Back in 2016, when living in Helsinki, I saw a video piece by Laura Horelli at MUU Galleria. Entitled ‘Jokinen’, the film tells the migration story of Finnish communist, August Jokinen. Jokinen became known for a show trial against racism organised by the American Communist Party in Harlem, New York in 1931. The USA immigration authorities arrested him shortly thereafter, and he was deported and moved to Petrozavodsk, USSR in 1933. Although the story is fascinating, what most struck me was

Horelli's approach to her material, self-described as a 'mixture between historical research, detective story, and arts and crafts club'. One of my many pet hates in a contemporary art exhibition is what I refer to as the 'library vitrine', typically a shelf or vitrine in a room, often at the end of the exhibition, in which the artist has laid out a number of books. Some of the books are open to particular pages, maybe others have a specific passage highlighted, or, more regularly, it's just a closed book displaying the cover. Part of my dislike of this trope is that the library vitrine strikes me as an aesthetic performance of knowledge, often an aesthetic gesture in the general direction of 'knowledge' (signified by books as objects) rather than a meaningful engagement with reading. It's as if the artists who engage in this practice feel that the mere presence of the physical book is enough to convey engagement with the ideas or information contained within.

Horelli's film pulls apart the trope of the library vitrine and reconfigures it in a way that is both aesthetically compelling and indicative of a sustained, considered engagement with her source material. The film's narrative unfolds through archive materials—through newspaper clippings and old photographs. But rather than offer a passive representation of her sources, Horelli actively manipulates, reshapes or destroys them. Here, a newspaper article, hemmed in on four sides by coloured pieces of paper, restricting the viewer's focus to the particular area of interest. Read this and only this, Horelli seems to say. Here, a photograph of a group of men. A hand descends from above into shot and paints out the other figures with purple ink, leaving visible only the particular man Horelli wants us to look at. It's compelling and intelligent; the mode of storytelling is perfectly suited to its subject and to the nature of materials deployed in service of the story. It's unfortunate when you like a work so well that all you can think to do is copy it.

But rather than explicitly copy Horelli, which I couldn't do anyway given lack of access to studio equipment and lighting, I think about how to emulate her work with a completely different technique. What tools do I have with which I can make a film? A computer. Right. How can I engineer my computer's desktop screen recording tool to function as a video camera? I run a few tests and it seems like a plausible solution.

First, though, I need a script. I write a draft version, assemble a folder of photographs and documents and video clips, and 'perform' a rough take one. It's terrible. I haven't rehearsed the script, so it's messy and unpolished. The relationship between the

script and the images isn't right. It's not interesting enough. I don't know why anyone would bother to sit through it for 30 minutes. I show this first draft to a moving image curator. Her advice is, rather surprisingly and amusingly, to get incredibly drunk and re-record the video again. She tells me it's missing passion and my point of view.

I don't want to get drunk. But I take her point and attempt another version in that spirit. I make a second recording, chatty and unscripted. I show it to my husband who says it's terrible and that it makes me look stupid. When I first had the idea months ago to make a work like this, I thought it was a good idea, I tell him. But now I've seen so many other artists promoting similar works in the last month and I'm no longer certain. Clearly, many artists, struggling likewise with a lack of studio access and stuck at home, had similar ideas. My husband asks me to show him a desktop lecture made by another artist that I do like.

I open a browser and navigate to Emma Rae Bruml Norton's 'Complication of the Computer Mouse', an eleven-minute-desktop-performance lecture on the history of the computer mouse.²¹⁶ It's funnier than I remembered. And as with Horelli's film, the impact of Norton's work derives from the clever marriage of subject and form. In one video window within the desktop, Norton holds a mouse up to her mouth like a microphone. In a second video window, we see her hand using a second mouse to progress the narrative of the talk by opening and closing images and text notes in a well-rehearsed sequence. The familiar double click of the mouse acts as a strange but soothing soundtrack.

Newly inspired by Norton's video, I write a third version of my script. I subdivide it into sections for structure and incorporate quotations as text notes. Realising perhaps what the curator meant when she advised me to 'just get drunk', I whittle my material down to focus on three key ideas. Because archival research is such an important part of my practice, not to mention something I take pleasure in, I have a tendency to get carried away. I want to impart too much information to the viewer, forgetting that sometimes less material can be more impactful.

Once the third version of the script is finished, I restructure the photographs and video clips and prepare everything to record again. About halfway through the first take of recording the new script, my computer crashes and restarts. All seems fine, so I start

²¹⁶ I first heard about Norton's lecture through a tweet by Professor Shannon Mattern of The New School in New York on 12 May, 2020.

the recording again. The computer crashes for a second time. The problem seems to be something called a kernel panic, when the memory is corrupted or otherwise faulty and so becomes overwhelmed when performing too many simultaneous tasks and causes the computer to crash. Even though it's simply the nature of technology to age and fail, it's difficult not to see this as a sign. Even my computer, my primary tool for artistic practice during the pandemic, is unable to keep it together.

The Empire of Man over Nature [CERN, Kamioka Observatory, Fermilab National Accelerator Laboratory]

It's a video you're watching, but it's a video that's a recording of a computer desktop. A number of windows are open. There's a photograph of a letter, yellowed with age, covered with sweeping signatures. A text window in the middle of the screen, large white letters on slate black reads, 'The Empire of Man Over Nature'. Other text documents are layered over and under images and video clips, a photo of a newspaper clipping just out of sight. A woman with grey hair and red lipstick appears in a small, pop-up window. She begins to speak.

The very first meeting of the provisional European Council for Nuclear Research, now better known as CERN, took place in Geneva on February 15th 1952.

Kamioka Observatory is an experimental physics research facility, located in Hida Prefecture in Japan, about 300 km north-west of Tokyo.

In 1914, Robert Wilson was born in a small town in Wyoming called Frontier.

As the woman speaks she opens and closes files—photographs, texts, videos, letters, maps—moves them around, juxtaposes them on top of one another. Layers upon layers. Histories ignored or long-forgotten have been unearthed and presented. Is it a lecture? A talk? A performance? A reckoning?

And although many scientists like to insist that science is not political and that the political has no place in science, the establishment of an institution such as

CERN is not a purely scientific enterprise and yet it was initiated and carried out by scientists. How is it that such a decision is to be made? Of course, it's through politics, diplomacy and negotiation.

At the same time as physicist Masatoshi Koshiba and his colleagues were testing a small muon experiment at Kamioka in the 1960s to gauge the mine's suitability for the larger Kamiokande experiment, a group of Kamioka residents were engaged in filing a lawsuit against the mine's owner, the Mitsui Corporation.

Many scholars have drawn attention to the catastrophes of frontier rhetoric in relation to the manifest destiny programmes of settler projects of North America, but in this particular case I'm interested specifically in the relationship between Wilson, Fermilab, ideas of frontier and the history of the site itself.

She speaks about scientific laboratories, centres for physics research, mainly, but she speaks about them as places with histories. The land on which these laboratories were built were never blank slates, but sites where people fought bloody battles over the right to live; sites where people were forcibly removed from their land and their homes in order that 'progress' might take place; sites where entire communities had been poisoned from heavy metals leaching into the water because of mines.

To reconsider the numbers, then, of the 1953 referendum vote to determine the fate of CERN's presence in Switzerland, of those 23,860 total votes, not a single one was cast by a woman. And so, no women voted in the referendum to determine the fate of CERN's presence in Switzerland, no women served on CERN's provisional Council; yet, ironically, the institution was conceptualised as feminine—'mother and child are doing well'—at least in the minds of its founding 'Doctors'.

Seven years later, in March 2019, another small museum opened in Kamioka Town. The Hida Space Science Museum features scale models and 1:1 mock-ups of the Super-Kamiokande detector, and backdrops for taking photos with Nobel-Prize winning physicist Takaaki Kajita. The museum's first exhibit is a large piece of metal ore from Kamioka mine, but no mention is made of the role the mine or the Mitsui corporation played in the history of the itai-itai disease. Although some of the thousands of physicists who work on Super-Kamiokande are

aware of the link between their research site and this egregious history of mass poisoning, it's neither widely known nor mentioned.

Today, many of these houses remain, located in neat rows on streets rather inappropriately named after Native American tribes and individuals— Potawatomi Street, Sauk Circle, Blackhawk Boulevard. Houses built by nineteenth-century white settler farmers are now occupied by large numbers of visiting scientists and postgrad students. Not far away, nestled among the graves of nineteenth-century settlers to the area, the buried ashes of Robert Wilson are marked by a tombstone in the “Pioneer Cemetery” that shares land with Fermilab’s site. Wilson, born in Frontier and buried, true to his frontier romanticism to the end, insisted on being buried among other prairie pioneers.

She stops speaking. She is silent. The layers of history sit like sediment. Windows begin closing, slowly, but you can't unhear what you've just heard.

BOOK FOUR

On Physicists and Sexist Imagery

At an after-dinner talk given at a scientific conference in May 2016, Nobel Prize-winning physicist Barry Barish began his slideshow with a photograph taken from an early-twentieth-century Broadway playbill. The photograph ignited a heated discussion among those in attendance and later between members of the LIGO Scientific Collaboration²¹⁷, whom Barish had been representing at the conference.

Apart from the imaginations of those people who were physically present at Barish's talk, however, all traces of the photograph have disappeared from the public realm. Despite months of searching online and making requests for a copy of the image from those present at the talk, the image exists in description only. In a 2016 *Science* magazine article on the likelihood of Barish's winning the Nobel Prize for physics in 2017 (which he eventually did), journalist Adrian Cho describes the image as 'a man writing on a woman's bare back and, next to her, a stage prop in the form of a cartoonish racial caricature'.²¹⁸ On Twitter, the photograph has variously been described as featuring 'blackface and bikini-clad girls'²¹⁹ and 'a horrible racist/sexist slide featuring blackface'²²⁰. Although one can easily conjure up a photograph from any of the individual descriptions, it is rather more difficult to imagine a single image which includes all of them.

Yet after spending much time attempting to source the image used by Barish, it occurred to me that, in many respects, the fact that I *could not* locate the image was almost more interesting than if I were able to find it. While the sexist and racist undertones of the image speak to Barish's individual inability to comprehend its inappropriateness, the fact that I was unable to obtain a copy of the image through my professional and social networks in the physics community hints perhaps at that community's tendency to pull together and close ranks in the face of potentially explosive press for one of the field's leading lights.²²¹

²¹⁷ The Laser Interferometer Gravitational-Wave Observatory, the international experiment which announced detection of gravitational waves in 2016.

²¹⁸ Adrian Cho, 'Will Nobel Prize overlook master builder of gravitational wave detectors?' *Science*, 27 September, 2016. <https://www.sciencemag.org/news/2016/09/will-nobel-prize-overlook-master-builder-gravitational-wave-detectors>

²¹⁹ Matthew R. "Who Owns An Asteroid?" Francis, Twitter post, October 3, 2017, 1.31pm, <https://twitter.com/DrMRFrancis>

²²⁰ MC Stardust, Twitter post, May 23, 2016, 2.47pm, https://twitter.com/Summer_Ash

²²¹ Eventually, after many months of emails to different people in my physics network, I was able to obtain a copy of the image. The image was provided to me on the sole condition that I did not reveal who I obtained it from.

If the philosopher Vilém Flusser holds that ‘[images] are translations of events into situations’, to me Barish’s now-disappeared slide represents precisely such a case.²²² Consequently, it matters not that the image used by Barish has disappeared—the very fact of its having been used to open a speech in May 2016 translated that event into a situation, albeit a situation which perhaps should have been accompanied by more serious repercussions. Following the conference speech, the LIGO collaboration issued a statement—in which Barish was *not* named—disavowing the image as ‘inherently very offensive’.²²³ The only consequence of Barish’s use of the photograph was that LIGO amended its internal regulations such that all future scientific presentations were to be internally vetted prior to any public dissemination.²²⁴

However, rather than a one-off error of judgement, Barish’s self-proclaimed ‘mistaken’ use of racist and sexist imagery is one of a number of recent examples in the long tradition of sexist gender associations in the visual and rhetorical language of science. These examples point to persistent and deep-seated cultural problems with sexism and racism in the so-called ‘hard’ or ‘fundamental’ sciences.²²⁵ Drawing on Evelyn Fox Keller’s theories of gender in science, one could argue that the Barish event and similar recent examples reveal the status of such images as ‘not just ornamental images on the surface of scientific rhetoric, but deeply embedded in the structure of scientific ideology.’²²⁶

Of these ‘ornamental images’ that speak to deeply-embedded scientific sexism, one of the most surprisingly influential is to be found—still today—on the reverse of the Nobel Prize medal for physics. Indeed, the very same medal which Barry Barish was awarded in 2017. The image depicted is that of ‘Science unveiling Nature’, in which one female figure (Science) unveils the bare torso of a second female figure (Nature). Although iconographic representations of Nature as a veiled goddess date back to at least the late first century—as per Plutarch’s recounting of the statue of Isis at Sais bearing the following inscription ‘I am all that has been, and is, and shall be, and my robe no mortal

²²²Vilém Flusser, *Towards a Philosophy of Photography* (European Photography, 1984), 2.

²²³ LIGO press release, 16 May, 2016, ‘LSC Statement on Appropriate Content for Scientific Presentations’ <https://ligo.org/news/archive.php>

²²⁴ Ibid.

²²⁵ For more on the feminist critique of physical science’s problematic use of words such as ‘hard’ and ‘fundamental’, see especially Sandra Harding’s 1986 *The Science Question in Feminism* and Barbara L. Whitten’s 1996 article ‘What Physics Is Fundamental Physics? Feminist Implications of Physicists’ Debate over the Superconducting Supercollider’.

²²⁶ Fox Keller, *Reflections*, 12.

has yet uncovered'²²⁷—the representation on the back of the Nobel Medal more directly descends from motifs of 'science unveiling nature' which proliferated, mainly on the frontispieces to works of natural history, from the seventeenth century onwards. A typical example is provided by the frontispiece to Gerhard Blasium's *Anatome Animalium*, published in 1681, in which the customary representation of Isis as a many-breasted statue is here transformed into a figurative representation of a many-breasted Nature. Standing just behind, Science, also personified as a woman, here lifts Nature's veil.

The version of science unveiling nature that appears on the back of the Nobel Medal was designed by Swedish sculptor, Erik Lindberg. Lindberg received the commission in early 1901 at a time when he was living in Paris. By interesting coincidence, one of the most enduringly popular artistic representations of nature unveiled was created by French sculptor Louis-Ernest Barrias in 1899 in Paris—just prior to Lindberg's arrival in the city. Perhaps Lindberg saw the model of the statue exhibited at the Salon of 1899 and was inspired by Barrias' depiction of Nature-as-goddess for his own design.

Despite the fact that two female figures appear in Lindberg's design for the Nobel medal, only three women have won ever been awarded the physics prize in the award's 118-year history. The most recent woman to be presented with a Nobel Prize for physics was Canadian scientist Donna Strickland in 2018. Strickland received the prize in conjunction with French physicist Gérard Mourou for their work in creating super-bright, super-fast pulses of laser light.

In 2014, four years prior to Strickland's receipt of the prize, another scandal erupted in science that also centred on representation and the female figure. During media appearances organised to discuss the Rosetta mission, when a space probe was successfully landed on a moving comet, British astronomer Matt Taylor was widely criticised for making an inappropriate sartorial statement. While giving television interviews about Rosetta, Taylor wore a button-down bowling shirt in a fabric printed with scantily-clad pin-up figures whose iconography borrowed from 1980's science fiction films such as *Starcrash*, *Saturn 3* and *Galaxina*. While the fierce avalanche of criticism on news and social media painted Taylor as alternately a disgustingly sexist scientist or a brilliant genius and defender of individualism depending on one's political preferences, Taylor himself—echoing Barry Barish—later apologised for his 'big mistake'. Eventually, even

²²⁷ Plutarch, *Moralia*, Volume V, Loeb Classical Library, Harvard University Press (1936), 25.

Taylor's sister waded into the fray, explaining that her brother could be absent-minded and lacking in common sense.

But if one gives Taylor the benefit of the doubt of bad taste and thoughtlessness, rather than aggressive sexism, such thoughtlessness only serves to reinforce Fox Keller's argument that sexism—expressed in part through ornamental and instrumental images of women—is deeply embedded in the structure of science and scientific ideology. Whether in our personal or professional lives, our choice of clothing communicates something about our self-image, our status and situation, perhaps our values. Had Taylor been wearing the bowling shirt in his office, it would have been unlikely to come to the attention of the global news media. That is not to say, however, that it may not have made some of his work colleagues uncomfortable. But when participating in media appearances on national television on behalf of publicly-funded scientific collaborations, what one says matters; whether expressed verbally or non-verbally. In attempting to express his individuality or to perhaps avoid reproducing one discourse (that of scientists as boring geeks), Taylor instead helped to reinforce another discourse that emphasised women as sexualised objects.

Earlier in 2018, prior to the announcement of the Nobel Prize awards, Donna Strickland's co-winner Gérard Mourou was also implicated in a scandal related to sexualised images of women. Following Mourou's joint-nomination for the prize, a German scientific journalist, Leonid Schneider, excavated a 2013 video in which Mourou promoted the research of the Extreme Light Infrastructure project.²²⁸ Along with listing the many laudable goals of the laser facility—'reversing nuclear waste, understanding the universe and wait guys, even heal cancer'—Mourou and his colleague, Jean-Paul Chambaret, dance in their laser lab surrounded by a troupe of young female students.²²⁹ At one point, two of the dancing women fling off their semi-transparent lab coats to reveal white underwear beneath as Mourou strikes poses behind them.

CNRS, the French national laboratory and funding agency, denied funding the video, claiming that not only was it 'made at the sole personal initiative of the researcher and his team', but also that 'many people at the CNRS believe [the video] is inappropriate to promote science'.²³⁰ Hardly a damning indictment, perhaps unsurprising given

²²⁸ Leonid Schneider, 'The Alpha Males of Physics', *For Better Science*, 2 October, 2018. <https://forbetterscience.com/2018/10/02/the-alpha-males-of-physics/>

²²⁹ Laser Fan, *Have you seen ELI 3*, YouTube video (2013). <https://www.youtube.com/watch?v=k6iZA8Plqb8> (accessed 3 February, 2020).

²³⁰ Hannah Devlin, 'Bizarre video of Nobel physics laureate Gérard Mourou surfaces', *The Guardian*, 5 October, 2018. <https://www.theguardian.com/science/2018/oct/05/bizarre-video-of-nobel-physics-laureate-gerard-mourou-surfaces>

existing precedents. A 2012 European Commission campaign, for example, aimed to attract more women into the sciences with a promotional video depicting young women in high heels and short skirts laughing and posing in a chemistry lab working on beauty products, all while being objectified by a male scientist. As with Barish and Taylor before him, Mourou apologised in a statement, not for his role in creating the video, but for the ‘image conveyed by this video’.²³¹ Mourou continued his self-exculpation by explaining that the reasoning behind the video’s creation was to ‘popularise the research being done in the project and to break down the austerity that the field of science can sometimes transmit.’²³²

Following the video’s dissemination, a number of scientists argued that Mourou’s video encapsulated many of the field’s current problems. Among those problems, Jess Wade, a physicist at Imperial College London and instigator of a project to add more women to Wikipedia, cited hero-worship of professors, bizarre power relationships and sexism.²³³ Yet while many claimed the sexist representations of women in Mourou’s video were an error in judgement, none considered the error to be so extreme as to challenge or rescind Mourou’s Nobel Prize award. Or to offer the prize to Strickland alone.

On a Theory of Representation

Of all the pieces that I’ve worked on as part of my PhD project, these artworks feel among the most important. But they’re also the artworks that just aren’t working. Throughout my research, I’ve been collecting images—like the photograph used by Barish, a screenshot of the sexist video starring Mourou, an image of Matt Taylor sporting his pin-up shirt, a screenshot of the sexist promotional video made by the European Commission—that evidence the continuing and underlying sexism of corners of the physics research community, unfortunately particularly prevalent among its leading (mostly male) figures.

²³¹ Mourou’s statement was provided to *Motherboard* (VICE magazine’s technology website) by his research institute, École Polytechnique. Sarah Emerson, ‘Recent Nobel Prize Winner is “Profoundly Sorry” for “Degrading” Video of Women’, *Motherboard*, 4 October, 2018. https://www.vice.com/en_us/article/9k7zm5/physicist-gerard-mourou-inappropriate-music-video-resurfaces-after-he-wins-the-nobel-prize

²³² Ibid.

²³³ Devlin, ‘Bizarre video’.

As with misunderstandings of science, in which non-scientists often misrepresent the pursuit of scientific knowledge as a search for literal truths about nature (as opposed to approximations based on models) verifiable by testable methods, photography suffers from similar misunderstandings—even among its own practitioners. Although photographic manipulation has been widespread for decades, it has been difficult to shake the cultural associations of photography with representational truth. As someone attentive to underlying ethical questions related to representation in photography, I'm frustrated by how little writing I can find in photographic theory responding to these questions. Considering that most outlets for documentary photography, newspapers and news magazines and websites, consume photographic images at an astonishing rate, and are motivated as much if not more so by profit margins and numbers for advertising than with 'truth telling', are we as photographers not contributing to the exploitation of others—their suffering and their misery—by taking our photographs and submitting them to the news media wheel of doom?

A close friend is a documentary filmmaker and we argue over these questions with alarming regularity. He still seems motivated by the idea that documentary work can make a difference, that visual depictions of the suffering of others have the power to prompt meaningful action. I'm far more sceptical, of the motives of documentary practitioners, of their 'objectivity', and probably of their ability to create any meaningful change. But more than that I'm also deeply uncomfortable with the idea that we should be exploiting the suffering of others in this way. Are there not other ways we can draw attention to suffering and to oppression without demeaning human bodies? Without unintentionally repeating or reinforcing visual relationships between racism, sexism and oppression of all kinds. Although it might feel like documentary images are beacons of truth in a dark world, by literally re-presenting violence, poverty, oppression, these types of photographs also serve to normalise violence, poverty and oppression.

While I'm not dealing with images of state-sanctioned violence against racialised bodies or images of starvation in the global south, I am dealing with images that are deeply sexist and sometimes also racist. Although I too have an inclination to want to share these images, to shout, 'look at this, everyone, isn't it shocking!', I certainly do not want to make work that gives in to such inclinations. It is important to me that my work does not directly re-present the sexist and racist images, and therefore re-present the sexism and racism of some white male physicists.

I test various strategies. I decide to cut up the images and reconfigure them so that they are distorted enough for the figures to become unrecognisable. Making connections between the algorithmic processes of things like simulation methods in physics computer models, I think about whether I could make a simple algorithm, a system of rules, for the process of breaking down the images and reconstructing them. I start with a single image printed at A4 size, before cutting it into strips and reconstructing with clear tape. Through the process of following a simple set of instructions, the single image I began with has been transformed into four smaller images—keeping overall to the original A4 size—but stacked on top and next to each other. A sense of the original image is present, but it's vague, undefined and indistinct. If you didn't know what you were looking at, it would be quite difficult to figure it out. Is this good art, I wonder? I really don't know.

I spend a considerable amount of time searching for photographic theory interrogating some of these questions on problems of representation. Arielle Azoulay seems the closest fit. I get a third of the way through *The Civil Contract*, but it's just not quite what I'm looking for. It's interesting, though, how much certain aspects of Azoulay's argument remind me of something I remember from an Ian Hacking essay in *The Disunity of Science*. Hacking points out that postmodern criticisms opposing reason, common among science and technology studies scholars, often stem from frustration with 'an ideology of science that says there is one ultimate reality, one ultimate truth, one road to the truth (the scientific method), one sound mode of reasoning, one rational way of speaking'.²³⁴ Because many of us now view these claims as 'hegemonic, patriarchal, imperial', Hacking argues that it's easy to forget that:

oppressed people in the past, today, and in all the foreseeable future require those very onenesses about which we find it so easy to be lazy. People resisting despotism and its lies need ideas of one truth, one reason, one reality, and on occasion, one science. To be able to be critical of the unities is a luxury, and let us never forget it.²³⁵

Similarly, Azoulay suggests that photography can play an important role in advancing agency for oppressed or colonised people around the world, if one articulates a differ-

²³⁴ Ian Hacking, 'The Disunities of the Sciences' in *The Disunity of Science: Boundaries, Contexts, and Power*, eds. Peter Galison and David J Stump (Stanford: Stanford University Press, 1996), 41.

²³⁵ Hacking, 'The Disunities'.

ence between citizens' photography and political photography. Eventually, I realise that I've been looking in the wrong place; I already know where to find theories of representation, and they aren't to be found in photography studies. Contrary to Susan Sontag's understanding of 'the camera as a weapon', a number of Black communities, in the US in particular, recognise the camera's potential as a tool of self-defence or emancipation against white supremacist violence. After George Floyd's murder, millions of well-meaning people shared the video of Derek Chauvin, a white police officer, kneeling on Floyd's neck for nine minutes and twenty-nine seconds until Floyd was no longer breathing. Millions of well-meaning (mostly white) people also shared videos on social media of violence being done to Jacob Blake, Ahmaud Arbery, Breonna Taylor, Philando Castile, Eric Garner, Terence Crutcher, Sandra Bland, Stephon Clark, Alton Sterling and so many more Black men and women. They did not seem to think about what seeing such videos daily, in a public forum, might feel like for members of that community, let alone for the family and friends of those close to the dead. Even assuming that photographs and videos are capable of bringing about justice for families, or creating broader societal or political change, that doesn't make them any less traumatic viewing. The vast numbers of these videos in circulation on social media platforms serve also to further entrench the systematic dehumanisation of Black people, to traumatise community members, and occasionally to serve as trophies for racist murders. Why should Black people repeatedly be made to experience traumatic images and videos in order that other people might 'gain awareness' and so feel compelled to take action?

In relation to ideas of imaging and imagining, Christina Sharpe writes lyrically about the traumatising and anaesthetising nature of representational violence, particularly violence against black people:

We know that, as far as images of Black people are concerned, in their circulation they often don't, in fact, do the imaging work that we expect of them. There are too many examples of this to name: from the videotaped beating of Rodney King in 1991, to the murder of Oscar Grant, to the brutal murders of twenty-one trans women in the United States as of November 2015, to all of the circulating images of and in the aftermath of Hurricane Katrina and the 2010 earthquake in Haiti, to the ongoing deaths in transatlantic, trans-Mediterranean, and trans-continental crossings extending across the Black global diaspora. This is true even though and when we find images of Black suffering in various publics framed in

and as calls to action or calls to feel with and for. Most often these images function as a hail to the non Black person in the Althusserian sense. That is, these images work to confirm the status, location, and already held opinions within dominant ideology about those exhibitions of spectacular Black bodies whose meanings then remain unchanged.²³⁶

A too-common understanding of traditional photojournalism holds that photographers are ‘passive observers’, standing back from the action and simply recording what happens. Photography produced for news media—whether newspapers or television—is a commercial business. Photographers take images and sell them to anyone who will publish. Although editorial discussions about how to weigh the balance between public good and private pain may take place behind newsroom doors, such discussion tend to take place *after* the potentially-questionable photograph has already been taken. The trope of the photojournalist who records rather than intervenes in appalling situations (for example, sex attacks, starving children, the aftermath of a bomb, even murder) is common enough that *The Guardian* ran an article about ‘the photographers who stood by’.²³⁷ Rather worryingly, most discussions around photojournalistic ethics largely concern questions of truthfulness and objectivity. From news that The Associated Press severed ties with Pulitzer Prize-winning photographer Narciso Contreras in 2014 after it emerged that he digitally manipulated a photograph of a Syrian rebel fighter to outrage after it was discovered that famed photographer Steve McCurry had manipulated dozens of images over his decades-long career, there are numerous examples of documentary image-makers shamed for staging or manipulating photos when this information comes to light. However, there are few conversations on the subject of whether or not some photographs ought never to be taken in the first place, let alone printed on the front page of national newspapers.²³⁸ The underlying assumption seems nearly always to hold that disturbing, shocking, and traumatising images of poverty, violence, racism, sexism, and war help to

²³⁶ Christina Sharpe, *In the Wake: On Blackness and Being* (Durham: Duke University Press, 2016), 116.

²³⁷ ‘I was gutted that I’d been such a coward’: photographers who didn’t step in to help’, *The Guardian*, 28 July, 2012. <https://www.theguardian.com/media/2012/jul/28/gutted-photographers-who-didnt-help>

²³⁸ For example, the codes of ethics of the National Press Photographers Association in America states that its member visual journalists must ‘be accurate and comprehensive, resist being manipulated, be complete, intrude on private moments of grief only when the public has an overriding and justifiable need to see, not intentionally alter or contribute to events, not manipulate images, pay sources, or harass colleagues’. Similarly, the British Press Photographers Association states that its members should: ‘observe the highest ethical, technical and creative standards, not materially alter their images, provide accurate caption information, resist offers of payment from third parties, treat people with respect and oppose discrimination based on race, gender, religion, sexual orientation and any other basis at all times and defend media freedom’.

document injustice, raise awareness, or even simply ‘tell the truth’, rather than, as Sharpe holds, ‘confirm the status, location and already held opinions’.

Although all of these questions are of interest to my research, the kinds of images I discuss above are operating in contexts more politically charged, more urgent, than the kinds of images I am dealing with. This isn’t to lessen or trivialise the demeaning qualities of the images I am working with—sexist representations of women so prevalent and normalised as to be heartbreakingly banal—only to differentiate them from more explicitly violent categories. I do still feel, however, that a feminist reading, particularly one informed by the Black feminist theory of Sharpe and others, of photographic images (in this case, in their relationship to physics and physicists) must ask these kinds of questions about the appropriateness of re-presenting sexist or racist images. On encountering a shockingly sexist image during my research, such as the ‘teaser’ video made for the European Commission’s 2012 campaign, ‘Science, It’s a Girl Thing’, one of my first instincts is to want to share the image with others so that my peers and I can be appalled together. And indeed, this is behaviour that I frequently engage in. However, while I have occasionally shared a sexist image on Twitter or in a lecture to graduate students, increasingly I realise that this is something I neither want to do nor probably should do. I certainly do not want to be representing these sexist images in my work or legitimatising them in a gallery or art institution context.

The algorithmically cut-up photographs have a certain interesting quality to them, but I don’t think it’s the right approach to apply this technique to all seven of the images that I’m working with. I start thinking more carefully about the colour of the images and the paper that I’m using. I’d really like to work with risograph printing—it’s probably the most environmentally-friendly form of digital printing given that it uses vegetable-based inks and its easy to source recycled paper—but it’s best for large print runs and prohibitively expensive when making single prints. Eventually, I decide to make inkjet prints on a paper called ‘extract’ made by G.F. Smith. The paper is made entirely from disposable paper coffee cups that would otherwise be sent to landfill. The paper is available in ten interesting colours which shapes the direction of the work as it evolves. I opt for four different colours to make the seven prints: aqua, shell, moon and mustard.

Scrolling through a pdf catalogue of artworks acquired by Edinburgh University’s Art Collection in 2019/2020, I stop to look more closely at a series of three

prints by the artist Alberta Whittle. Entitled ‘Secreting Myths’, the works are laser-engraved woodblock prints in striking jewel-toned colours, overlaid with a shimmering gold emboss. The central images on Whittle’s prints are taken from a series of engravings by Theodor de Bry, a Belgian engraver noted for his depictions of early European expeditions to the Americas. Clearly not wanting to engage in a direct reproduction of de Bry’s depictions of Columbus’s first arrival and subsequent violent suppression of indigenous peoples, Whittle inverted the original engravings and printed them in bright shades to complement the tones of each paper. In so doing, de Bry’s images are rendered less immediately legible; there’s some difficulty involved in parsing out exactly at what one is looking at. The gold emboss represents a snail trail, referencing the giant African snails in Whittle’s hometown, and references the importance of ‘slippage’ and transience in the artist’s work more generally.

Whittle’s use of inversion feels like a good sister technique, a good complement to my use of the algorithm, as a further tool for transforming my ‘sexist physicist’²³⁹ images. Having left the series in a metaphorical drawer for months and months without looking at it, I return to the images with fresh eyes. I test out inverting some of the images and printing them on the recycled coffee cup paper. With the newly-inverted image, I then try the algorithm process, but it doesn’t work at all. Given that both techniques are obfuscatory, the combination of two such techniques renders the image utterly unintelligible. It’s now so distorted as to be meaningless. Taking a step back, I adjust the colours and reprint. With some of the images, #shirtgate, for example, the inversion provides enough strangeness, enough distance, as to suffice on its own. With other of the images, Mourou’s ‘sexy’ dancers, I don’t invert the image, but printed on blue paper—the colours quite unnatural—and cut up as part of the algorithmic approach, the image becomes illegible, but still interesting. The final image, and one of the most difficult to resolve, is a photograph of a U.S. physics professor accused of sexual harassment, taking a selfie with one of the women he harassed. I invert the image and tinker with the levels and contrast until the image prints, on a silvery grey paper, just as I want it. On impulse, I cut a piece of thick tracing paper and hang in front of the print. The effect is beautiful. It’s hypnotic to look at. I’m a little taken aback by the strength of my reaction to it. I haven’t been trying to make images of beauty out of ugly things, but I worry that’s exactly what

²³⁹ This is what I’ve been calling the series of work since I first conceived of the idea. It really needs a new name, though, but even at the time of submitting this PhD, I still haven’t come up with one.

I've done. That said, I'm pleased with the way the series has turned out. It's taken a long time, but I think the balance between legibility and visual interest without re-presentation is finally right.

On the Possibility of A Feminist Physics

If one subscribes to Evelyn Fox Keller's assessment that sexist images of women, reproduced however naively or innocently, as claimed by the male physicists who use them, are indicative of the deep-seated sexism at the heart of many scientific ideologies, how might one combat such problems? At present, my contemplation of these questions is largely informed by an overlap of thinkers drawn from feminist theory, critical race theory, and science and technology studies. If, as Amy Bug Graves has argued, 'to the uninitiated [many physicists included], demographics is the only issue relevant to women in physics'²⁴⁰, these three fields have long since broadened out from the narrow purview of a purely demographic-based approach. This is not necessarily to suggest that questions of increased gender equality in the sciences, both in terms of science education and professional science, are not important. Rather, that one must consider knowledge structures and ideologies instead of, or in addition to, the social structures and communities of physics.²⁴¹

In recent years, many feminist scholars of science have been occupied with challenging traditional scientific claims to objectivity, or what Sharon Traweek memorably referred to as belief in 'a culture of no culture' among particle physicists.²⁴² One of the most cited theories of objectivity in feminist science is Donna Haraway's 'situated knowledge'.²⁴³ Here, Haraway rejects the omniscience, impartiality, and universality claimed by so-called objective white male scientists to propose instead an objectivity which embraces locality, partiality, and relativity. Similarly, Sandra Harding's concept of 'strong objectivity' proposes dropping the pretence that it is possible for any scientist to be a socially neutral researcher and instead suggests that all analytic frameworks begin

²⁴⁰ Bug Graves, 'Has Feminism', 882. 'See also Banu Subramaniam and Mary Weyer, 'Assimilating the "Culture of No Culture" in Science: Feminist Interventions in (De)Mentoring Graduate Women', *Feminist Teacher* Vol.12, No 1 (1998), who argue that the training of women in STEM is carried out by 'untraining them as women' and assimilating them as scientists.

²⁴¹ Chambers, 'A Different Kind', 8.

²⁴² Traweek, *Beamtimes*, 162.

²⁴³ Donna Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, Vol. 14 No. 3 (Autumn 1988): 575-599.

with an understanding of the social forces that may be at work in the lives and minds of scientists.²⁴⁴

More recently, and emerging largely from theorists working at the intersection of critical race theory and feminist critique of science, a different way of thinking (particularly in relation to physics) has emerged which centres on questions of how a specifically Black feminist theory could change physics, ‘and not just through [questions of] who becomes a physicist but through the actual outcomes of what we come to know’.²⁴⁵ Where scholarly work that acknowledges and critiques the effects of race and gender on scientific knowledge is more prevalent in biology and medicine, it ‘seems to disappear at the boundary of the physics sciences—a field supposedly more objective’, as Lauren Chambers emphasises.²⁴⁶ Where Chambers is more circumspect about whether or not and indeed how gender, race, and ethnicity impact epistemic outcomes in physics, a recent paper by Chanda Prescod-Weinstein argues emphatically that there is indeed a clear connection. In it, she proposes that ‘race and ethnicity impact epistemic outcomes in physics, despite the universality of the laws that undergird physics’ in part because of what she refers to as ‘white empiricism’ where white empiricism is the phenomenon through which ‘only white people (particularly white men) [have] a fundamental capacity for objectivity.’²⁴⁷

Prescod-Weinstein further claims that the lack of women, particularly those of African descent, in physics is symptomatic of ‘antiempiricism masquerading as an empirical approach to the natural world’.²⁴⁸ Here she makes specific reference to the field of string theory and discusses the fact that, in this field, speculative and non-empiric ideas are taken more seriously than the ‘idea that Black women are competent observers of their own experiences’.²⁴⁹ Hence, Prescod-Weinstein argues, such fields essentially turn ‘white supremacist social structures into an epistemic practice in science’²⁵⁰ and, as a consequence, come to influence both the topics of scientific study and the knowledge produced.

²⁴⁴ Sandra Harding, *Objectivity and Diversity: Another Logic of Scientific Research* (Chicago: University of Chicago Press, 2015), 43.

²⁴⁵ Chanda Prescod-Weinstein, ‘Making Black Women Scientists under White Empiricism: The Racialization of Epistemology in Physics’ *Signs*, Vol. 45 No. 2 (2019), 440.

²⁴⁶ Chambers, ‘A Different Kind’, 5.

²⁴⁷ Prescod-Weinstein, ‘Making Black Women’, 421.

²⁴⁸ *Ibid.*, 422.

²⁴⁹ *Ibid.*, 423.

²⁵⁰ *Ibid.*

While these and other related questions lie at the heart of much of my current practice, I also sympathise with the words of American poet and civil rights activist, Audre Lorde, that ‘the master’s tools will never dismantle the master’s house’.²⁵¹ I wonder whether a truly feminist physics is desirable or even possible. To me, there seems to be a profound truth in Kathy Overfield’s argument that the Western sciences are ‘intrinsically anti-female and that no woman can take part in science without acquiescing in her own oppression’.²⁵² Either way, the representations of women so casually and frequently deployed by physicists like Barish, Taylor, Mourou, as well as the Nobel prize iconography, and the continued underrepresentation of women and non-white people in physics testifies to a persistent and deep-rooted sexist-racist culture that, as Chambers argues, ‘also corresponds to a sexist-racist physics epistemology.’²⁵³

Pragmatic Feminists and Intersectional Feminism

Many of the more well-known figures in feminist science circles are quite pragmatic. A number of them were at one time practising scientists and such training has unsurprisingly contributed to a desire to make the physical sciences a more welcoming intellectual and professional environment for women rather than, as Sandra Harding said, to throw the baby of science out with the bathwater. In a 1982 article published in *Signs*, a journal about women in culture and society, Evelyn Fox Keller, who trained as a physicist, articulates some anxiety about conflicts of interest between feminism and commitment to science. Nevertheless, she argues that such conflicts might be productive and that ‘those elements of feminist criticism that seem to conflict most with at least conventional conceptions of science may, in fact, carry a liberating potential for science’.²⁵⁴

Fox Keller’s articulation of feminist relativism here is somewhat disconnected from the understanding of objectivity as argued by Sandra Harding and later Donna Haraway—namely that a feminist objectivity, as theorised in standpoint objectivity or standpoint theory, advocates for a re-defining of objectivity to include questions of so-

²⁵¹ Audre Lorde, ‘The Master’s Tools Will Never Dismantle the Master’s House’, *Sister Outsider: Essays and Speeches*, Crossing Press (2007), 110-114.

²⁵² Kathy Overfield, ‘Dirty Finders, Grime, and Slag Heaps: Purity and the Scientific Ethic,’ in *Men’s Studies Modified: The Impact of Feminism on the Academic Disciplines*, ed Dale Spender (Oxford: Pergamon Press, 1981).

²⁵³ Chambers, ‘A Different Kind’, 37.

²⁵⁴ Evelyn Fox Keller, ‘Feminism and Science,’ *Signs* Vol. 7 No. 3 (Spring 1982), 589-602.

cial relations and the social situations of scientists. Here, Fox Keller suggests that feminist relativism rejects objectivity as a masculine ideal thereby dooming ‘women to residing outside of the realpolitik modern culture’.²⁵⁵ Fox Keller offers a loose programme, which resembles standpoint theory, arguing that feminist critics must move away from an opposition between ‘male objectivity’ and ‘female subjectivity’ to instead reconceptualise objectivity ‘as a dialectic process’ in order to allow for ‘the possibility of distinguishing the objective effort from the objectivist illusion.’²⁵⁶ Only then will women be able to reclaim what has historically been denied to them in the sciences, and to ‘legitimate those elements of scientific culture that have been denied precisely because they are defined as female’.²⁵⁷

Canadian philosopher Alison Wylie adopts a similar approach with regards objectivity and feminism—not only do ‘feminist commitments not displace evidential consideration; if anything, they enhance a commitment to empirical rigour, especially in the critical inspection of the (sexist, androcentric) presuppositions that have framed much otherwise exemplary research in the field’.²⁵⁸ Instead, she argues, many feminists theorising about the sciences are frequently wary of drawing strong constructivist conclusions.²⁵⁹ ‘Even those who recommend a postmodern stance as a resource for feminist research,’ she writes, ‘acknowledge the “dilemma” that this creates for feminists or for any who would use postmodern insights “in the interests of emancipation”’.²⁶⁰ Citing Mascia-Lees, Sharpe, and Cohen²⁶¹ Wylie suggests that some feminists arguments largely reproduce through inversion different forms of ‘Western arrogance’: ‘The postmodern view that truth and knowledge are contingent and multiple may be seen to act as a truth claim itself, a claim that undermines the ontological status of the subject at the very time when women and non-Western peoples have begun to claim themselves as subject’.²⁶²

Although Harding does not explicitly use the term intersectionality, she is one of

²⁵⁵ Ibid., 593.

²⁵⁶ Ibid., 594.

²⁵⁷ Ibid., 593.

²⁵⁸ Alison Wylie, ‘Gender Politics and Science’, in *The Disunity of Science: Boundaries, Contexts, and Power*, eds. Peter Galison and David J Stump (Stanford: Stanford University Press, 1996), 321.

²⁵⁹ Ibid.

²⁶⁰ Ibid.

²⁶¹ Frances E. Mascia-Lees, Patricia Sharpe, and Colleen Ballerino Cohen, ‘The Postmodernist Turn in Anthropology: Cautions from a Feminist Perspective,’ *Signs: Journal of Women in Culture and Society* Vol. 15 No 1. (1989).

²⁶² Wylie, ‘Gender Politics’, 322, citing Mascia-Lees et al.

the few white feminists theorising about the natural sciences in the 1980s and '90s to address interconnected problems of racism and sexuality. Unfortunately, at best, white feminism has regularly overlooked or under-emphasised racism in its fervour for gender-based opposition to patriarchal cultures of science.²⁶³ At worst, white feminism has exploited the work of Black and other minority scholars or privileged their own interpretations of connected issues. Donna Haraway has been repeatedly criticised for such practices, for example, her work on the 'plantationocene'.²⁶⁴ Katherine McKittrick, professor of gender studies at Queen's University in Ontario, Canada, has also pointed out that Haraway's concept of 'situated knowledge' is a direct appropriation of the work of novelist Buchi Emecheta: '[Buchi] is the unspoken backbone of Donna Haraway's "situated knowledge" and made much of Simians, Cyborgs, and Nature possible'.²⁶⁵

In 1989, American lawyer and professor Kimberlé Crenshaw published 'Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics', a paper which later became a landmark text in the field of critical race theory for its instantiation of the term 'intersectionality'.²⁶⁶ While intersectionality is sometimes popularly understood to mean that oppression is scalar—i.e. add Black plus woman to equal a larger form of oppression than just Black or woman alone—my understanding is that the combination of different categories of oppression often lead to complex outcomes which are not adequately expressed by a purely scalar understanding.²⁶⁷ Crenshaw argues that white women writing in a feminist theory context often claim to 'reflect women's experience and women's aspirations' without ever including or speaking to Black women. 'How can the claims that "women are," "women believe" and "women need"', she asks, 'be made when such

²⁶³ Although a number of black feminist writers have touched on this subject, the two accounts that I have found most powerful are those offered by bell hooks in *Feminist Theory: From Margin to Center* and Angela Y. Davis in *Women, Race and Class*.

²⁶⁴ For example: Janae Davis, Alex A. Moulton, Levi Van Sant, Brian Williams, 'Anthropocene, Capitalocene, ... Plantationocene?: A Manifesto for Ecological Justice in an Age of Global Crises', *Geography Compass*, Vol 13 Issue 5 (2019).

²⁶⁵ Katherine McKittrick, Tweet, 26 Jan, 2017. <https://twitter.com/demonicground/status/824424767268782080>

²⁶⁶ Kimberlé Crenshaw, 'Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics,' *University of Chicago Legal Forum* Vol. 1989 Iss. 1, Article 8 (1989): 139-167. Of course, while Crenshaw may have coined and popularised the term 'intersectionality', a number of other writers and activists—such as black writer Anna Julia Cooper or the women of the Combahee River Collective, Barbara Smith, Beverly Smith and Demita Frazier—were analysing the experiences of black women in this way without specifically referring to the term.

²⁶⁷ Here, I am paraphrasing a beautiful articulation of this idea as expressed by Leah Velleman on Twitter: 'Oppression isn't scalar, or even vector. It's a vector field. It pushes along some paths and against others. Intersectionality isn't "Add two quantities of oppression to get a larger one." It's "The wind and the current together will send you places neither could send you alone"' (11:01 PM, July 16, 2021).

An example of the complexities implied by an intersectional analysis is provided by Crenshaw: 'Although patriarchy clearly operates within the Black community, presenting yet another source of domination to which Black women are vulnerable, the racial context in which Black women find themselves makes the creation of a political consciousness that is oppositional to Black men difficult', 'Demarginalizing', 162.

claims are inapplicable or unresponsive to the needs, interests and experiences of Black women?’²⁶⁸ Furthermore, Crenshaw argues, white women feminists are often guilty of re-producing many of the oppressive behaviours perpetuated against them by patriarchal empiricism and objectivity in the way that their theorising tends to exclude the voices and lived experiences of women of colour.²⁶⁹ ‘When feminist theory attempts to describe women's experiences through analyzing patriarchy, sexuality, or separate spheres ideology, it often overlooks the role of race,’ Crenshaw writes. ‘Feminists thus ignore how their own race functions to mitigate some aspects of sexism and, moreover, how it often privileges them over and contributes to the domination of other women’.²⁷⁰

When I first began this PhD project, although intersectionality was a term I had previously encountered, I was not familiar with any of the academic literature on the subject and I certainly didn't have it in mind when thinking about issues of sexism in the sciences. I wasn't thinking very far beyond gender politics and patriarchal cultures in physics. My introduction to Black feminist criticism of the physical sciences stemmed largely from my dissatisfaction with the arguments I was encountering in well-known feminist STS texts written by white women. In searching for points of view that were more critical, radical and inclusive, it wasn't until I went looking that I found what I was looking for. And I largely found what I was looking for in the writings of Black feminists and Black women scientists.

In STS and philosophy of science circles, particularly online, it was impossible to miss the 2019 publication of Chanda Prescod-Weinstein's paper, ‘Making Black Women Scientists under White Empiricism: The Racialization of Epistemology in Physics’.²⁷¹ Reviled on Twitter by people with biographies that read ‘apolitical’ and ‘against totalitarianism and supremacy of all kinds’, and lauded by cultural studies and STS scholars, it caused a social-media sensation. More notably, Prescod-Weinstein's paper was the first time I had encountered a feminist theorist, but also an astrophysicist, argue emphatically and unashamedly that race and ethnicity—and by extension, gender—has an impact, not merely on demographics, but on epistemic outcomes in physics.²⁷² The central thesis of Prescod-Weinstein's paper hinges on the argument that the domin-

²⁶⁸ Ibid., 154.

²⁶⁹ Ibid.

²⁷⁰ Ibid.

²⁷¹ Prescod-Weinstein, ‘Making Black Women’.

²⁷² Ibid., 424.

ant demographic in physics, namely white men, ‘construct the figure of the observer to exclude anyone who does not share the attending social and intellectual identities and belief’.²⁷³ Given that the entire history of discourse surrounding the idea of objectivity in physics rests on the relationship between the observer and objectivity, Prescod-Weinstein’s point is that people who aren’t white men, but especially Black women, are denied the possibility of participating in science through their exclusion from the category of objective observer. ‘White empiricism,’ Prescod-Weinstein argues, ‘is therefore a form of antiempiricism masquerading as an empirical approach to the natural world.’²⁷⁴ As Black women are not taken to be experts of their own lived experiences, particularly with respect to discussions of racism, white empiricism acts to essentially prevent the full participation of Black women in physics (though presumably this extends to any number of other fields as well). White supremacy, as Prescod-Weinstein writes, ‘produces Black physicists as a permanent ontological Other’.²⁷⁵ Prescod-Weinstein’s powerful concluding argument is not that physicists should work harder to encourage more Black women into physics (although she elsewhere makes the point that representation is important, and that Black women’s presence in the physical sciences is political), but that ‘Black feminist theory intersectionality should change physics—and not just through who becomes a physicist but through the actual outcomes of what we come to know’.²⁷⁶

More recently, Prescod-Weinstein has expanded on some themes from her white supremacy paper, alongside autobiographical reflections on a career as a Black Jewish woman and agender person, in *The Disordered Cosmos: A Journey into Dark Matter, Spacetime, and Dreams Deferred*.²⁷⁷ As a non-physicist and disciplinary outsider, it has been important for me to reflect on that fact that, as someone working externally to the field, my desire to (partially) dismantle or reshape physics as it currently exists in no way conflicts with my desire to be accepted by other physicists—which is undoubtedly the case for some people of marginalised races, genders and sexualities working in physics. Although this point is somewhat different to that made by Ian Hacking with respect

²⁷³ Ibid., 422: ‘These beliefs can limit investigations of what constitutes a reasonable physical theory, whether the scientific method should be brought to bear on this physical theory, and the capacity to understand how incidents of racism disrupt the potential for objective discourse.’

²⁷⁴ Ibid.

²⁷⁵ Ibid., 424.

²⁷⁶ Ibid., 440.

²⁷⁷ Chanda Prescod-Weinstein, *The Disordered Cosmos: A Journey into Dark Matter, Spacetime, and Dreams Deferred*, Bold Type Books (2021).

to the privilege of being able to criticise unity in science²⁷⁸, there are similarities. Prescod-Weinstein believes that it is important to recognise the power of Black people being able to wonder about astrophysical phenomena, space, the sublime, and other phenomena in the natural world through the lens of physics and related fields. ‘I believe we can keep what feels wondrous about the search for a mathematical description of the universe,’ she wrote, ‘while disconnecting this work from its historical place in the hands of violently colonial nation-states’.²⁷⁹ Prescod-Weinstein’s mother puts it another way. When confronting a period of doubt about the point of her work, Prescod-Weinstein’s mother suggests to her that: ‘people need to know that there is a universe beyond the terrible things that happen to us’.²⁸⁰ Although this way of thinking doesn’t entirely sit comfortably with me, I can certainly empathise with the point of view and acknowledge that there must be space for a multiplicity of understandings about such complex issues.

Prescod-Weinstein also elaborates on her belief that ‘science does not need to be inextricably tied to commodification and colonialism’.²⁸¹ Echoing the language of her white empiricism paper, she again reiterates that her point isn’t about ‘changing ourselves so we can be included in science—it means changing institutionalized science, so that our presence is natural and our cultures are respected’.²⁸² Practically-speaking, this means changes on an individual (professional) level, changes to physics, but also changes to society. On the individual level, this means, as Prescod-Weinstein writes, that ‘we’ [by which she specifically means Black physicists] have a choice about how we participate. We do have a choice about whether we are part of anti-Indigenous activities in astronomy and about the extent to which we try to avoid complicity in America’s imperial wars’.²⁸³ Prescod-Weinstein uses the example of access to a dark night sky for a thirteen-year-old Black kid to map out what it means to call for a Black feminist physics

²⁷⁸ Ian Hacking, ‘The Disunities’, 41: ‘It is easy nowadays to be flippant about unity. It is also possible to be angry. Some of the current rage against reason is directed at an ideology of science that says there is one ultimate reality, one ultimate truth, one road to the truth (the scientific method), one sound mode of reasoning, one rational way of speaking. Because unity now rings in our ears as hegemonic, patriarchal, imperial, it is important not to dismiss the old virtues and values of unity. Oppressed people in the past, today, and in all the foreseeable future require those very onenesses about which we find it so easy to be lazy. People resisting despotism and its lies need ideas of one truth, one reason, one reality, and on occasion, one science. To be able to be critical of the unities is a luxury, and let us never forget it.’

²⁷⁹ Prescod-Weinstein, *The Disordered Cosmos*, 18.

²⁸⁰ *Ibid.*, 256. Compare with page 214: ‘This caused me to have an intense crisis about my identity as a scientist. I found myself asking, What is the point of science if I have suffered so much for it? What is the point if it makes others suffer unnecessarily too? It was not astronomers who provided a way out of the crisis for me, but rather the people they were demonizing. It was kanaka ‘ōiwi (Native Hawaiian) cultural knowledge holders who—through challenging my status quo—forced me to look at science critically and imagine alternative ways of locating myself in science and science in the world.’

²⁸¹ *Ibid.*, 226.

²⁸² *Ibid.*, 227.

²⁸³ *Ibid.*, 252.

in terms of broader societal concerns. It's just not about stepping outside of the home and looking up: 'what health care structures, what food and housing security are needed? What science communication structures? What community structures? What relationship with the land do they need?'²⁸⁴

Here, I think, is the problem with most of the white feminist physics literature I've been reading. The framing of the question of a sexist, racist physics, the long history of sexist, racist science that underpins it, and what to do about it are so often framed without any recourse to questions this deeply embedded in the fabric of society. We live in a sexist, racist society. It's not enough to simply look at the structural problems in the sciences as if they are completely disconnected from society at large; in order to effect change in the sciences, we must also call for societal change.

Another key difference I noticed, and welcomed, between Black feminist thinkers and white feminist thinkers engaged with the physical sciences is an acknowledgement that racism and sexism might impact the production of scientific theories as well as more indirect issues such as values and methodologies.²⁸⁵ For example, Evelyn Fox Keller (writing in 1985) insists that 'gender ideology does not operate as an explicit force in the construction of scientific theories', but only and always indirectly, expressed 'in the formation and selection of preferred goals, values, methodologies, and explanations'.²⁸⁶ By contrast, Lauren Chambers, an astrophysicist and feminist science studies scholar, questions such assumptions, asking instead why, if 'physicists can accept the axiom of subjectivity inherent to quantum particles while so vehemently rejecting their own subjectivities; can they not also accept the suggestion that 'racism and sexism have an effect on physical theory?'²⁸⁷ Chambers's broader point is that the absence of women and non-white scientists from physics is 'evidence of a sexist-racist culture that not only excludes non-white non-males, but that also corresponds to a sexist-racist physics epi-

²⁸⁴ Ibid., 254.

My husband, who is obsessed with cricket, makes a note in one of my drafts: 'reminds me of C.L.R. James on cricket!'. I learn, through listening to a Cite Black Women podcast conversation between Chanda Prescod-Weinstein and Christen Smith, that C.L.R. James was Chanda's grandfather!

²⁸⁵ This is also a differentiation made by many physicists, as Amy Bug Graves writes in 'Has Feminism Changed Physics?', *Signs*. Vol. 28, No. 3, 881: 'Among practitioners, there is an inclination to distinguish sharply between issues of "physics" and issues of "physicists." Thus, on the one hand, most physicists concede that the gender and racial composition of physics students is in need of balance. This is correlated with a mainstream movement to create race- and gender-friendly "niches" in the university for students who are "different" and with efforts by women physicists to network, mentor, recruit, and retain more women and help each other build healthy careers within the mainstream. On the other hand, most physicists presume that feminist critique is incapable of generating ideas that will make a superfluid colder, a plasma hotter, or a particle beam more intense.'

²⁸⁶ Fox-Keller, *Reflections*, 137.

²⁸⁷ Chambers, 'A Different Kind', 27.

stemology that pervades even physics theory'.²⁸⁸ Reflecting on Latour's philosophy of science, Chambers articulates perhaps one of the more fundamental problems with physics particularly, and the sciences more broadly. Namely, that the 'entire structure of modern science is attempting a sort of epistemological domination over the natural world'.²⁸⁹ Given that the physical sciences, like modern Western scientific ideologies more generally, are built atop foundational values of consumption and extraction, Chambers argues, they are intimately bound up with ideas of insatiable desire, possession of knowledge, mastery over nature—'we desire to fully understand something simply so we can set it aside and turn our attention to the next thing'.²⁹⁰ Fundamentally, Chambers asks whether it is truly possible to have a science that is anti-racist. Where Prescod-Weinstein sees value in preserving fields like astronomy, but in recreating them as more humane, less racist and sexist, less anti-indigenous, Chambers wonders if 'the ultimate result of an anti-racist movement in science [will be] the eventual eradication of basic physics and astronomy: hierarchical academic fields often without human application that consumer resources and minds?'²⁹¹

On Material Ethics

In Lawrence Venuti's landmark study of the often-unacknowledged politics of translation, *The Translator's Invisibility*, he argues that translation enacts two simultaneous processes of identity formation: that of the culture being translated, as well as that of the culture receiving the translation.²⁹² 'No culture should be considered immune to self-criticism,' he writes, 'whether hegemonic or subordinate, coloniser or colonised.'²⁹³ Venuti elaborates that:

without such practices as foreignizing translation to test its limits a culture can lapse into an exclusionary or narcissistic complacent and become a fertile ground for ideological developments such as nationalisms and fundamentalisms which

²⁸⁸ Ibid., 37.

²⁸⁹ Ibid., 41 Another note from my husband, this one reads: 'Reminds me of Rebecca Solnit "Science is how capitalism knows the world"'.
²⁹⁰ Ibid.

²⁹¹ Ibid., 49-50. Also: 'Or less radically, perhaps an anti-racist science requires the gross deprioritization of physics and astronomy, in return for elevation of work that directly benefits humanity?'

²⁹² Venuti, *Translator's Invisibility*, 20.

²⁹³ Ibid. See Book Two, 43.

may certainly drive emancipatory projects such as anticolonial movements, but which-once autonomy is achieved – may also harden into another form of oppression.²⁹⁴

In appropriating cultural translation theory as a method for how I consider and approach—both practically and theoretically—the field of physics, sites of physics research, and indeed physicists themselves, Venuti’s exhortation to turn a self-critical gaze on one’s own culture (both general and individual; in my case, the field of fine art and my own artistic practice) has been of significant importance. Through the act of directing a constant critical gaze on the culture of particle physics, I increasingly began to feel that I should direct that same critical gaze on the culture of my own field, and indeed on my own practice (my own life?).

In real terms, this has meant a heightened attentiveness to the ethics underpinning the materials and material ecologies of my principle artistic processes. For example, when working on the suite of four textile pieces connected to the CERN punch cards, I made decisions about the production process which privileged certain ethical preferences. The company I selected to carry out the hand-weaving was a business owned and operated entirely by women. All of the yarns selected for the weavings were either recycled from textile-industry waste or organically grown using low-environmental-impact methods. In some cases, these choices were made despite my aesthetic preference for alternative materials which were not as ethical in terms of sustainability.²⁹⁵

I also made a number of ethically-driven material changes to my analogue photography practice. In connection with the artworks produced in relation to the case studies of sexist images, outlined in an above section, I think a great deal about both the representational aspects of the photographic images, as well as the material ethics of the photographic processes being used. In my attempt to combine the two, I devise a new—extremely experimental—vegan silver bromide film emulsion which replaces the original recipe’s base of gelatine with a non-animal-based polyvinyl alcohol, and uses silver

²⁹⁴ Ibid.

²⁹⁵ In terms of look and feel, I strongly preferred a black cotton that was used in our original tests. However, this cotton was a ‘virgin’ i.e. newly-fabricated, water-intensive material made in Egypt and so we sought out an alternative material that was a cotton thread made of offcuts from the garment industry and fabricated in Italy.

from traceable sources.²⁹⁶ It takes months of experimenting to get the emulsion to work, and even then it's far from perfect. The emulsion is full of bubbles, little scratches and defects from where it hasn't properly adhered to the glass plate. Given that I'm essentially making things up as I go along (accompanied by fastidious note-taking and documentation), I also don't know whether I'm fixing or washing the plates long enough. I have no idea how long they'll last. Some of them are already starting to yellow.

I use the dry glass plates to try out another idea I have in connection with the 'sexist physicist' series. Given that I don't want to re-present the original images, I think instead about translating the images into words. What if I show only the captions, or an image of the captions, instead of the images themselves. I use the plates to photograph the 'captions' I print in typed text, backwards, so that the images will read the right way round. Although I love the plates—I love the imperfections in the emulsion that highlight the difficulties of making it in the first place, and I love the idea of text as image—I'm not convinced that they're successful artworks. I find myself thinking a lot about what constitutes success in an artwork.

Although I had already embarked on the process of making gelatine-free photographic emulsion by the time I encountered the text, Nicole Shukin's book *Animal Capital* became very important to my thinking in terms of articulating certain theoretical questions related to the use of animal (and other ethically questionable or otherwise environmentally toxic) products in photography and, by extension, any creative practice.²⁹⁷ Shukin's subtitle 'rendering life in biopolitical times' pithily encapsulates a key aspect of her argument: that, in the photographic arts, rendering is both the making visible of images, and the denial of visibility to the many animal lives which must be rendered (literally, melted down) in order for the former to function. 'The double entendre of rendering is deeply suggestive of the complicity of "the arts" and "industry" in the conditions of possibility of capitalism,' Shukin writes. 'It suggests a rubric for critically tracking the production of animal capital, more specifically, across the spaces of culture and eco-

²⁹⁶ The emulsion was created over a long period of trial and error from about November 2019 to March 2020, until which time the first national lockdown meant I no longer had access to my regular darkroom. The successful emulsion was an ammonium bromide emulsion (the first time I used ammonia hydroxide, I didn't have a proper gas mask and nearly passed out), in which I effectively substituted the required amount of gelatine for a polyvinyl alcohol (PVA) specially treated with silane groups which allowed the PVA to better adhere to the glass plates).

²⁹⁷ Nicole Shukin, *Animal Capital: Rendering Life in Biopolitical Times* (Minneapolis: University of Minnesota Press, 2009). Photography historian, visual artist and seed saver, Dr. Rowan Lear, recommended Shukin's book to me. In turn, I have subsequently recommended it to a great many people. For another example of a text on material ethics, one that considers the relationships between industrial chemistry, synthetic paint and dye colours, and twentieth-century chemical warfare see Esther Leslie's fascinating book, *Synthetic Worlds: Nature, Art and the Chemical Industry*, Reaktion Books (2005).

nomy and for illuminating the supplementarity of discourses and technologies normally held to be unrelated'.²⁹⁸

Shukin is particularly persuasive on the relationships between photographic materials and animal products, specifically the gelatine used to make almost all film emulsions, and the myths surrounding so-called 'waste' products. 'Among the many cultural mythologies thrown into question by a study of rendering,' she writes, 'is one that valorizes recycling as a redemptive, subversive retort to capitalism (a mythology with currency in many contemporary green social movements)'.²⁹⁹ In that way, Shukin suggests, many of our conservation discourses around resource and animal use 'inadvertently advance rather than antagonise the hegemony of capital'.³⁰⁰ Rather than understanding recycling and the creative use of 'waste' products as supplementary to capitalism, we must understand that they are intrinsic to it. By enabling the use of 'waste' in this way, many artists serve only to further supplement this 'wasteful hyperproduction and consumption of commodities with an ecological ethic of material efficiency and waste recovery that surreptitiously supports the sustainability of capitalism.'³⁰¹

An excellent example of such logic can be found on the Adox website, a German manufacturer of film, photo paper and processing chemistry. The company has posted a statement addressing the question, 'May I use film if I am a vegan?', in which they firstly state: 'This is a philosophical question and we cannot answer it for you'. The first paragraph of the statement insists that it is impossible to find any coated product in the entire imaging industry that doesn't use gelatine; 'moreover, there never were such films available and there never will be'. This is not entirely true, and the paragraph's final statement gestures towards a partial truth: 'In the 50s and 60s millions of dollars were devoted to research projects trying to find alternatives in the US, Germany, Japan and Russia but after 20 years everyone gave up with no result'. As historians of photography are well aware, Kodak and other photography companies did spend time and money attempting to perfect alternatives for commercial distribution but elected not to largely because they had abundant sources of gelatine widely available at very little cost. The second paragraph of the statement focused on the issue of sustainability. 'Gelatine is also the product of choice,' it reads, 'if you are generally interested in this planet and sustain-

²⁹⁸ Ibid., 20.

²⁹⁹ Ibid., 70.

³⁰⁰ Ibid.

³⁰¹ Ibid.

ability'. Why? Because gelatine is a natural product which is biodegradable and easily dissolvable in water. Were Adox to use an alternative colloid, such as a plastic, they would need to use toxic solvents during the manufacturing process which would end up released into the environment. More importantly, Adox states, gelatine is a *waste* product:

Gelatine is manufactured from skeletons of dead animals -yes- but after all animals will die at a certain point and for sure no animals are killed especially for making gelatine. Rather they are killed for their meat and byproducts arise in large amounts. Not eating meat really helps you in achieving [sic] your goals of reducing human kettle [sic] raising but not using film will have no impact at all. The photographic industry today is so unimportant that we are using less than 1/1.000.000.000 of the animal byproducts which arise from the meat industry.³⁰²

Although it is true that plastics are more polluting than gelatine—which was a problem I encountered, too, in my use of PVA as a gelatine substitute—research on bioplastics as substitute colloids has advanced significantly in recent years. Were companies to carry out their research today, rather than rest on the decisions made by companies in the 1950s and '60s (who were largely exploring plastic-based polymers), they might find successes with bioplastics derived from sugar cane, corn, potato starch, lignin or even seaweeds. Adox's logic, that the gelatine it uses for film manufacturing is simply a byproduct of another industry and, moreover, an insignificant amount used compared to other industries, is *precisely* the logic that Shukin spears in *Animal Capital*. To restate Adox's justification in Shukinian terms, the photographic industry (in part) *enables* the meat industry to continue raising and slaughtering animals in extremely large numbers *because* it ensures that even the so-called waste products are commercially useful.

And while it may appear at first glance that the use of gelatine in the photographic industry is a relatively small link in the larger chain of environmentally-toxic, ethically-dubious materials and processes implicated in broader chains of capitalist manufacturing and production, as Shukin points out, 'Gelatine is among those seemingly negligible but in fact significant points of entry into the material unconscious of culture.'³⁰³ The conversion of 'animal stock strained from the boilers of rendering plants...into gly-

³⁰² 'May I use film if I am vegan?', Adox website statement published on 12 January, 2014. This link is no longer active: <https://www.adox.de/Photo/may-i-use-film-if-i-am-a-vegan/>

³⁰³ Shukin, *Animal Capital*, 91.

cerine, gelatine, bone meal, soap’ are ‘seemingly amorphous substances that are in fact deeply implicated in mediating both the material and the symbolic hegemony of cultures of capitalism’.³⁰⁴ By way of example, Shukin discusses the use of soap—specifically in California in the 1850s—made from rendered hides of cattle as a symbol of colonialism and ‘material signifier marketing a gospel of white supremacy to the so-called dark corners of the globe’.³⁰⁵ As white feminism has often historically neglected to include the voices and lived experiences of non-white women, white environmentalism has historically neglected to include the voices and lived experiences of non-white folks who may, for example, be less committed to caring for animals when their own basic needs are not being met. Shukin rightly points out, however, that the two have often been inter-related historically and that ‘the discourse of speciesism that the modern rendering industry institutionalises underpins the economic and cultural power of a white European humanity over “others of whatever sort”’.³⁰⁶

Does Physics Have a Material Ethics?

On an annual basis, CERN’s CO₂ emissions are roughly equivalent to those of a large cruise ship. In numeric terms, that’s about 200 metric kilotons of CO₂ per year, or as a CERN press release says, ‘only 0.000005% of the global total’.³⁰⁷ The majority of these emissions stem from CERN’s use of fluorinated gasses, which are known to contribute significantly to global warming. The gases are either vented into the atmosphere intentionally or they leak from instruments. In some of the LHC gas-filled detectors, as much as 10% of the gas is lost to leaks, and new gas is constantly being added to top up the losses. In order to mitigate these losses, CERN scientists are installing recirculation systems and exploring replacing the refrigerants in their detectors with less environmentally-harmful gases.

Although CERN only released its first public environment report in 2018, covering the years 2017 and 2018, discussions about the environmental impact of the Large

³⁰⁴ Ibid., 74.

³⁰⁵ Ibid., 75.

³⁰⁶ Ibid.

³⁰⁷ <https://hse.cern/environment-report-2017-2018>

Hadron Collider have been ongoing since its early design stages in the 1990s.³⁰⁸ Back then, however, refrigerant pollution was thought of mostly in terms of the gas's 'potential to destroy ozone molecules,' CERN's director for accelerators and technology, Frédérick Bordry says. 'The gases were chosen to minimize ozone-layer influence'.³⁰⁹ At that time, CERN decided to eschew chlorofluorocarbons (CFCs), which are now widely banned after being identified as a major contributor to ozone-layer damage. Instead, decision makers chose to use hydrofluorocarbons (HFCs) for the LHC. Today, scientists know that although HFCs aren't a threat to the ozone layer, they are greenhouse gases with global warming potentials that can be thousands or tens of thousands of times as high as those of carbon dioxide.

Today, a small number of CERN physicists are working to improve the gas problem by seeking various strategies to reduce the site's carbon emissions. Physicist Paolo Petagna, for example, is leading a team that is developing a pumped-loop CO₂ cooling system for some of the LHC's detectors. That said, Bordry cautions that people shouldn't expect a miracle from this round of improvements to the LHC's environmental footprint. The facility's detectors were designed as early as the 1990s, he says, and because of their age only so much can be done to reduce their climate impact. Bordry hopes that the CMS detector will achieve a 10% reduction in greenhouse gas emissions following the current shutdown and perhaps as much as 50% after the next shutdown, planned for 2023.³¹⁰ The facility has set itself an objective of reducing its direct greenhouse gas emissions by 28% by the end of 2024.

Given the forward-looking nature of most CERN physicists, rather than attempt to significantly improve current detectors, many are already looking ahead to the next generation of detectors and how CERN's efforts could inform their design. For Bordry, such is the underlying purpose of the current research, to develop new technologies that can reduce future greenhouse gas use. 'The mandate of CERN is not just for research but also for developing technology,' Bordry points out. He is thinking not only about the problems of emissions at CERN, but about what solutions he and his collaborators can offer in the global fight against climate change. 'It has provoked debate and increased the environmental awareness of all the people who work here as well as our user com-

³⁰⁸ <https://hse.cern/environment-report-2017-2018>

³⁰⁹ Sam Lemonick, 'Scientists at CERN hunt for greener gases for particle detectors', *Chemical & Engineering News*, 27 April, 2019: <https://cen.acs.org/environment/greenhouse-gases/Scientists-CERN-hunt-greener-gases/97/i17>

³¹⁰ Ibid.

munity, and made us think hard about what we do now and how we design the next generation of accelerators,’ says Bordry, CERN.³¹¹

While institutions such as CERN are seemingly, if in some sense belatedly, awake to the more obvious environmental repercussions of their experiments—such as carbon emissions and energy use—they are far less willing to recognise other problematic environmental connections such as appropriative land use and extraction. The mythologies of the founding of institutions like CERN and Fermilab tend to foreground the ‘great [white] men’ who came together to establish spaces for large-scale, internationally-collaborative scientific research. Unsurprisingly, these mythologies focus much less on the histories of how institutions came to be sited in their current locations, or the political machinations that enabled the land to be made available for scientific use.³¹²

One interesting space of overlap between histories of land use and environmental impact can be found in materials used in the lab. Although materials was a question of interest for me in relation to histories of physics knowledge—for example, the relationship between the widespread use of tritium in particle physics experiments today stemming partly because of the extensive knowledge of tritium gained from its use in twentieth-century atomic weapons research—I admit I hadn’t given enough thought to materials in relation to extractivism until I read the MA thesis of Emma McKay.³¹³

McKay points out that, despite the ubiquity of metals in physics labs, when they are written about in, for example, journal articles, ‘their origin is not discussed at all’.³¹⁴ By way of example, McKay traces the way that indium—a soft, malleable rare-earth metal often used in manufacturing—is written about in scientific journals. Their findings reinforce the notion that most physicists view indium as ‘nothing more than the metal which has 49 protons’.³¹⁵ More importantly, McKay argues, the persistence of this view of the material as originating from nowhere continues to support broader understandings of indium—and, by extension, any other material used in lab experiments—as problem-free, as a material which requires no sense of moral responsibility or questioning when bringing it into the lab or creating new technologies with it.

³¹¹ ‘CERN’s emissions equal to a large cruise liner, says report’, *PhysicsWorld*, 19 September, 2020: <https://physicsworld.com/a/cerns-emissions-equal-to-a-large-cruise-liner-says-report/>

³¹² See Book 3, 65.

³¹³ Emma McKay, ‘Extraction and Land in Physics’ (MA thesis, York University, Toronto CA, 2020). I first came across Emma’s thesis while searching for various combinations of ‘physics’, ‘ethics’, ‘extraction’, ‘land’ and ‘feminism’ on Twitter.

³¹⁴ *Ibid.*, 9.

³¹⁵ *Ibid.*

Although new materialist thinkers such as Karen Barad have argued for a more expansive inclusion of phenomena as part of the apparatus of experiments—for example, the cigar smoke which accidentally developed the plate Stern and Gerlach used to catch electrons—Barad’s argument, as McKay points out, is not grounded in an ethics of extractivism or land use.³¹⁶ Instead, Barad, who trained as a theoretical physicist, is deeply committed to the epistemic authority of quantum physics—one of the key reasons I do not cite their work more prominently in this thesis. McKay suggests that, in order to prioritise the ‘relational framework of land’ the epistemic authority of physics must be diminished in certain ways.³¹⁷ As McKay so crucially argues, if physicists did not have access to land on which to build their laboratories and experiments and materials extracted from lands elsewhere, ‘not only would their experiments not exist, but the phenomena of a lab which are so nicely observable and quantifiable and separated from the messy stuff of the world—the objects of study of physics—would not exist’.³¹⁸

And while McKay’s perspective is rooted in their interest in the politics of land use, it is interesting that their outlook for the future of physics triangulates with that of Lauren Chambers, whose perspective is rooted in a Black feminist outlook, as well as my own. Like Chambers, McKay is adamant that physics would change entirely were their critique to be taken seriously. ‘If we took land very seriously, the practice of physics would change drastically,’ they write. ‘I’m not sure it could be called ‘physics’ at all. We could be not just inter-disciplinary, but anti-disciplinary. Loosening our grip on a need for a well-defined physics could be necessary for responsible action for a liveable world’.³¹⁹

Given the nature of their research, McKay has an interest in the state of relations between physics and ethics. A survey, based largely on the work of S.C. Greer’s *Elements of Ethics for Physical Scientists*, relates that most approaches to ethics in physics are based on the value system of the individual:³²⁰ namely, ethical violations connected to personal misconduct in a lab setting, or research misconduct such as misrepresenting data in publications. As McKay notes, there is very little in the literature about science and society or science and the environment. As was so evident in the public statements

³¹⁶ Ibid., 10. Or, why I’m not talking about Karen Barad.

³¹⁷ Ibid.

³¹⁸ Ibid.

³¹⁹ Ibid., 11.

³²⁰ Ibid., 34ff. An instructive comparison here is S. C. Greer’s *Elements of Ethics for Physical Scientists*, MIT Press (2017), 35.

made by scientists who worked on the US's atomic weapons programmes in the 1940s and 50s, many physicists are happy for the ethical implications of their research to be the problem of "the public", politicians or other public policy-makers. McKay's broader point, however, is that the question of ethics in science—in physics in particular—cannot simply be limited to questions of the consequences of research output or even demographics. Rather, they remind us, it is important to consider that these questions are only part of the ethical problems of physics research; 'land is the root from which to consider ethics [...] we must consider where [science's] resources come from'.³²¹

McKay explores the example of indium and carries out an analysis of papers where the metal is mentioned, mainly in the fields of materials science and nanoscience; only one paper in the field of "fundamental" research (a paper looking into nuclear structure) mentions indium.³²² None of the papers discuss how the indium was acquired or where it came from, despite the fact that various pieces of equipment such as lasers, tape, oscilloscopes are frequently mentioned by their brand names. There is also no mention of waste disposal procedures. Among other things, the lack of attentiveness of the lab workers to the origins of their indium, McKay argues, extends the work of mining companies to make invisible the environmental impact and often-terrible labour practices of ore mining. In so doing, the physicists 'help make it appear as if the indium came from nowhere, or [that] its origin is completely irrelevant to their work or the consequences thereof.'³²³

McKay returns to Barad's idea of no hard and fast boundaries between the physical and discursive elements in a phenomena—e.g. the object being measured, the apparatus, which includes the physicist—but not before articulating a more precise criticism of Barad's framework. 'Though [Barad] attends to specificity,' McKay writes, 'they make far more reference to being in the universe than to being on earth or in a particular place. The way that they prioritize an ontology of quantum physics serves to reproduce assumed epistemic authority of physics, which isn't necessarily more valuable than an ontology based on culturally specific ecology'.³²⁴ One of the reasons why McKay finds these assumptions of Barad's to be so problematic is because they overlook the fact that physics research is carried out in specific places and, correspondingly, the phenomena

³²¹ Ibid., 37.

³²² Ibid., 38.

³²³ Ibid., 45.

³²⁴ Ibid., 72.

which are produced as part of this research practice essentially do not exist outside of this practice.³²⁵ Although, much of McKay's thinking dovetails with the anti-realist position of philosophers of science such as Bas van Fraassen—who are interested in physics phenomena as measurable or not measurable, and not, as realist philosophers are concerned, with whether or not the phenomena can be said to represent reality—her arguments are not articulated in the language of this ongoing debate.

Barad has become surprisingly popular in visual and media arts circles for their theories of diffraction (which has been borrowed from and built upon the work of Haraway and Minh-ha), entanglement and agential realism, an argument that the universe comprises phenomena which are 'the ontological inseparability of intra-acting agencies'. Agential realism has been particularly popular in gender and identity studies, where its proponents take Barad's theory to undermine a number of dichotomies, such as nature and culture, animal and human, female and male, and so on. However, like McKay, I share a certain feeling of discomfort at the way much of Barad's work both draws upon, and seems to promote, the epistemic and ontological authority of physics. While Gregory Hollin, Isla Forsyth and Eva Giraud argue that Barad 'does not intend to draw on the authority of physics', McKay rightly points out, that, regardless of their intentions, this is precisely what they do.³²⁶ What's more, 'surely, part of the reason their work has been so widely taken up is the socio-epistemic authority and mystical draw of quantum mechanics'.³²⁷ Given their focus on land, McKay finds Barad's theory of entanglement, which prioritises the scale of quantum interactions, particularly wanting:

The language of entanglement prioritizes the scale of quantum dynamics. The ontology of physics—classical and quantum both—has been prioritized for far too long. It is too easily universalized. Since quantum dynamics have genuine differences from earth-scale dynamics, this universality based on quantum ontology doesn't hold enough room for the durability of land as objects. Barad writes about us being a part of the universe. We are more a part of the earth. A single ontology elides the existence of land.³²⁸

³²⁵ Ibid., 75.

³²⁶ Ibid., 84. Gregory Hollin, Isla Forsyth, Eva Giraud, '(Dis)entangling Barad: Materialisms and ethics', *Social Studies of Science* Vol. 47 No. 6 (2017): 918-941.

³²⁷ Ibid.

³²⁸ Ibid., 83.

Returning to the Stern-Gerlach experiment, which Barad used as an example of their new-materialist perspective through the inclusion of the cigar smoke, McKay points out that, despite Barad's seeming inclusivity and attentiveness to both the non-human and non-machine, they still omit to acknowledge 'that the magnets or the screen or the silver atoms came from somewhere before they were constructed into this apparatus' and that these materials and their origins are not considered suitable for inclusion within conceptualisations of the apparatus.³²⁹ McKay argues that a fuller version of this attentiveness must include ALL the materials which make experiment possible, but particularly those with meaningful connections to land use and politics of labour. Were there no silver, no magnets—likely made of iron—no screen, the Stern-Gerlach experiment would not have taken place. 'It is not,' as McKay says, 'so much that this silver or that silver changes the experiment, but *that the presence of silver at all creates the possibility for the experiment*'.³³⁰ Moreover, silver is not an object that arrives to the lab—or to the photographic darkroom or the artist's studio—free of value or meaning; rather, it arrives having followed a specific history of geological creation and exploitative extraction. Without these and other materials, physicists like Stern and Gerlach would not be able to construct research environments in which 'silver atoms and magnets and cigar smoke and screens acted together with the experimenters to produce something which could be read as the bi-directional nature of the magnetic moment of atoms'³³¹ McKay emphasises that this is more than a platitudinous statement of thanks for these materials. Rather, it is 'an assertion that the objects of study of physics exist only because of apparatus made from the fruits of extraction. Physics enfolds into being together with these metals. We see with earth-made eyes'.³³²

The conclusions McKay draws from their analysis, their emphasis that the 'actual stuff of physics is landed [... rather than] unrelated to the rest of the world', is not only that the practice of physics must be changed, but perhaps the best thing to do is 'let go of there needing to be a physics at all'.³³³ Given both the history of the field of physics and its 'current structures of education, research, publishing, military & government funding, venture capitalism, and demarcation from other fields', I agree with McKay

³²⁹ Ibid., 90.

³³⁰ Ibid., 91, emphasis mine.

³³¹ Ibid., 92.

³³² Ibid.

³³³ Ibid., 93, 112.

that it seems difficult, if not impossible, to decontaminate the field and make it less toxic and more socially responsible.³³⁴ McKay states it starkly but compellingly when they write that:

We do not need a physics that seeks to build a quantum computer. We do not need a physics that must know exoplanets. We do not need axions. We do not need particles. What we need is a planet on which life thrives. There is no doubt that the practice of seeking knowledge can be kind and just. Neither exoplanets nor electrons are responsible for the unjust ways that they become legible to us. It's not that nothing good comes from our current search for knowledge [...] As it currently stands, practices within physics generally support extractivism. Extractivism, along with militarism, colonialism, and capitalism, is hanging the world out to dry. The climate catastrophe is upon us. The discipline is not exclusively responsible for everything bad that it is involved in, yet everyone involved must act responsibly. The world doesn't need the physics that currently exists. It needs physics workers who resist, for everyone's sake.

³³⁴ Ibid., 112.

BOOK FIVE

Two Cultures: Redux

It is a truth universally acknowledged that every article written about the relationship between art and science since 1960 must begin with a reference to C.P. Snow's 1959 Rede Lecture entitled, 'The Two Cultures and the Scientific Revolution'. The two cultures of the title were those of the natural scientists and of what Snow sometimes referred to as the 'literary intellectuals'. Having started his career as a research scientist at Cambridge University, before gaining a modicum of success as a novelist, Snow was taken to speak with authority on both cultures. The crux of his lecture's argument was that science and technology offered the best hope for human progress, but that such progress was being hindered by the gulf of ignorance between the two cultures and the structures of education—particularly in the UK—that perpetuated this divide. For Snow, the blame for this situation was largely to be laid at the door of literary intellectuals. Scientists, Snow proclaimed, had 'the future in their bones'; literary intellectuals were 'natural Luddites'.³³⁵

Although Snow considered himself a bridge uniting the cultures, he worried that in most cases the two were drawing apart. Scientists and literary intellectuals spoke different languages, and knew different things. In short, they couldn't communicate with each other. Scientists had not read Jane Austen, and humanists could not describe the second law of thermodynamics. This mutual incomprehension prevented solutions to social problems. 'When these two senses have grown apart,' Snow said, 'then no society is going to be able to think with wisdom'.

In C.P. Snow's most celebrated work of fiction, *The Masters*, published in 1951, the following passage appears. Luke, a scientist, has just achieved a breakthrough:

'It's wonderful', he burst out in a voice that carried up and down the table, 'when you've got a problem that is really coming out. It's like making love – suddenly your unconscious takes control. And nothing can stop you. You know that you're making old Mother Nature sit up and beg. And you say to her 'I've got you, you old bitch.' You've got her just where you want her. Then to show there's no ill-feeling, you give her an affectionate pinch on the bottom.'³³⁶

³³⁵ C.P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge: Cambridge University Press, 1959).

³³⁶ C.P. Snow, *The Masters* (London: Macmillan Publishers, 1951), 295.

Those who casually include Snow's lecture in art/science think-pieces for popular science magazines often neglect to mention its contextual history (or that Snow wrote dreadful, misogynistic fiction). In fact, Snow's was simply the latest in a line of provocations stretching back to John Tyndall's 1874 address delivered to the British Association at a meeting in Belfast. Tyndall's topic was the relationship of science, past and present, to philosophical materialism. His address effectively laid the groundwork for scientism as we understand it today. On demarcating the boundaries between religion and science, Tyndall asserted that, although religion gave 'inward completeness and dignity to man', it did so only in the 'region of poetry and emotion'.³³⁷ Claiming the realm of objective knowledge for science alone, Tyndall emphatically wrested 'the entire domain of cosmological theory' away from religion. 'All schemes and systems, which thus infringe upon the domain of science,' he concluded, 'must, *in so far as they do this*, submit to its control and relinquish all thought of controlling it'.³³⁸

In 1880, Thomas Henry Huxley's address on 'Science and Culture' at the opening of Mason Science College, now the University of Birmingham, echoed many of Tyndall's assertions. As the college had declared it would teach only the sciences to the exclusion of all other subjects, Huxley took the opportunity to claim the right of the sciences over culture. 'I hold very strongly by two convictions', Huxley said to the assembled audience:

The first is, that neither the discipline nor the subject-matter of classical education is of such direct value to the student of physical science as to justify the expenditure of valuable time upon either; and the second is, that for the purpose of attaining real culture, an exclusively scientific education is at least effectual as an exclusively literary education [...] We cannot know all the best thoughts and sayings of the Greeks unless we know what they thought about natural phenomena. We cannot fully apprehend their criticism of life unless we understand the extent to which that criticism was affected by scientific conceptions. We falsely pretend to be the inheritors of their culture, unless we are penetrated, as the best minds among them were, with an unhesitating faith that the free employment of reason, in accordance with scientific method, is the sole method of reaching truth.³³⁹

³³⁷ John Tyndall, 'Address Delivered Before the British Association Assembled at Belfast, With Additions', Longmans, Green and Co., (1874), 61.

³³⁸ *Ibid.*

³³⁹ Thomas Henry Huxley, 'Science and Culture', an address given at Mason Science College, Birmingham on 1 October, 1880.

Two years later, critic Matthew Arnold—who Huxley had singled out by name in his “Science and Culture” address—refuted Huxley’s claims by arguing that an education exclusively comprising natural sciences was of little value to anyone other than the student who wished to work exclusively as a professional scientist.³⁴⁰

Today, Snow’s view of the gulf between the arts and sciences persists, nowhere more so than in popular culture. Google image searches for ‘artist’ and ‘scientist’ reveals that the popular perceptions of both disciplines are laden with outdated clichés. According to the image search results, ‘artist’ is synonymous with painter, mostly of portraits, though I’m surprised to see that most of the painters are women and three are black. The photos all have a warm tone to them. ‘Scientist’ on the other hand seems to mean chemist. Everyone wears a white lab coat and is either peering through a microscope or using a pipette with brightly-coloured liquid. Again, to my surprise, nearly every photo (of 23) includes a woman and two include a black man and one includes a black woman. These photos all have a cool, blue tone to them. Art is warm, subjective; science is cool, objective.

In art-science circles, however, the situation is a little bit different. Here, the most frequently-encountered argument is that art and science are more alike than not. In a 2020 *Guardian* opinion piece, ITV chair and former Arts Council England chair, Peter Bazalgette, commented favourably on the ‘rebranding’ of the arts and humanities in the UK as an attempt to more clearly articulate the value of what they do:

The British Academy, the Arts Council and the London School of Economics have got together with others to remarket their endeavours as Social Sciences, Humanities and the Arts for People and the Economy – or Shapre, in short [...] Sixty years ago, CP Snow, a scientist *and* novelist, bemoaned what he saw as the two cultures and the gulf between science and the arts. But when Stem and Shape come together, as they increasingly do in well-organised governments and intelligently run companies, we find a healthy symbiosis that would astonish Snow.

³⁴⁰ Matthew Arnold, ‘Literature and Science’, an address given as the Rede Lecture at Cambridge University on 14 June, 1882: ‘If then there is to be separation and option between humane letters on the one hand, and the natural sciences on the other, the great majority of mankind, all who have not exceptional and overpowering aptitudes for the study of nature, would do well, I cannot but think, to choose to be educated in humane letters rather than in the natural sciences.’ See also: ‘Let us, all of us avoid as much as possible any invidious comparison between the merits of humane letters, as means of education, and the merits of the natural sciences. But when some President of a Section for Mechanical Science insists on making the comparison, and tells us that “he who in his training has substituted literature and history for natural science has chosen the less useful alternative,” let us say to him that the student of humane letters only, will at least know also the great general conceptions brought in by modern physical science; for science, as Professor Huxley says, forces them upon us all. But the student of the natural sciences only, will, by our very hypothesis, know nothing of humane letters; not to mention that in setting himself to be perpetually accumulating natural knowledge, he sets himself to do what only specialists have the gift for doing genially. And so he will be unsatisfied, or at any rate incomplete, and even more incomplete than the student of humane letters.’

In his book *Originals*, Adam Grant cites a study of this century’s brilliant, Nobel prize-winning scientists. These breakthrough innovators are significantly more likely to be involved in the arts than their peers. Imagination, self-expression and sheer humanity inspire their discoveries.³⁴¹

And such views are not exclusively held by those who identify as arts professionals. In science, analogies between art and science practices, methods, even aims are surprisingly frequent. Writing on *Quora*, Professor of Biology and Neuroscience at University of Illinois at Chicago, Dave Featherstone, insisted that ‘Science = art. They are the same thing’. Featherstone justified this statement by reasoning that ‘both science and art are human attempts to understand and describe the world around us. The subjects and methods have different traditions, and the intended audiences are different, but I think the motivations and goals are fundamentally the same’.³⁴²

In a CERN internal policy document related to its artist-in-residence programme, ‘Great Arts for Great Science’, a similar argument is set out. ‘Both arts and science are ways of exploring the world we live in and our place in the universe,’ the document reads. ‘Science demonstrates its effectiveness through tests, equations and proof thus creating new knowledge and certainty, the arts demonstrates its impact through the senses, transporting people to see the world and relate to each other with a sense of wonder through the power of the imagination’.³⁴³

Absent from CERN’s statement, though frequently deployed elsewhere in scientific rhetoric, is an appeal to ‘creativity’ as a quality as essential to the practice of science as to art. A news piece published on *Phys.org*—a physics news website—outlines claims made by Professor David Cropley that ‘creativity in STEM fields is very similar to creativity in the arts’.³⁴⁴

On Twitter in February 2020, an artist I know retweets a neuroscience PhD student. The tweet reads:

³⁴¹ Peter Bazalgette, ‘Why the arts must shape our future’, *The Guardian*, 21 June, 2020: <https://www.theguardian.com/commentisfree/2020/jun/21/why-the-arts-must-shape-our-future>

³⁴² ‘Why Art and Science are More Closely Related Than you Think’, 16 March, 2016: <https://www.forbes.com/sites/quora/2016/03/16/why-art-and-science-are-more-closely-related-than-you-think/>

³⁴³ This document is no longer available online, but this statement is repeated on page 7 of a presentation on art and science given at the 2012 International Conference on High Energy Physics. I don’t know who gave the presentation. But given that the included examples of scientists and artists are exclusively male, my guess is that the person who put the presentation together and delivered it was also a man. https://rstein.web.cern.ch/sites/test-static-05.web.cern.ch/files/Presentations/2012-07-04_ICHEP_Melbourne/Art_and_Science/ICHEP12_Art_and_Science_as_presented.pdf

³⁴⁴ ‘Research confirms creativity is key for both arts and science’, *Phys Org*, 22 July, 2020: <https://phys.org/news/2020-07-creativity-key-arts-science.html>

As a trained scientist and a self-taught artist, the strongest commonalities I see between science and art are the ways they teach and enable us to understand the world around us. Drawing hard lines between the disciplines denies their overlap. Many great scientists were artists. And all artists are experimenters. The final goals of art and STEM may be divergent, but to dismiss the many similarities, especially when learning/teaching the iterative processes that both often demand, is a disservice.³⁴⁵

Below the tweet is inserted a hand-drawn Venn diagram. ‘Art’ represents one circle and ‘Science’ the other with a space of overlap in-between. Written in black ink in the Art circle are ‘self-expression’, ‘abstractions, exaggerations, over-simplifications welcome’, and ‘No rules!’. On the science side, also in black ink, there’s ‘discover unknown rules of the universe’, ‘contribute to consensus on workings of the world’, and ‘MUST be repeatable by others’. In the overlapping centre of the two circles, here written in a thicker ink in shades of orange, yellow, pink, and blue, are the words ‘creativity’, ‘push boundaries’, ‘lens to observe world’, ‘curiosity’, ‘wonder’, ‘repetition and refinement’, ‘experimentation’, ‘mastery of techniques’, ‘making something totally new’, ‘describe and depict’, and ‘obsession’.

During my time at Fermilab, I had a brief conversation with an engineer about a piece of equipment related to the beamline. When I mentioned I was a visiting artist, the engineer informed me that his wife was also an artist; she painted watercolours in the garage at the weekend. Granted that this is but one anecdotal example, it’s indicative of the fact that, while most people have some idea of what professional scientists are and do, their ideas about what professional artists are and do are largely stuck in outdated notions of artists as painters in a nineteenth-century romanticised vein. Although, as Snow argues, some scientists have artistic tendencies—perhaps they paint watercolours, or are au fait with Shakespeare or Escher, the artist seemingly most beloved by scientists—that doesn’t mean they have any knowledge of contemporary art as a profession or discipline, its practices, structures or politics. It’s interesting that the neuroscience student who spoke about the overlapping creativity between art and science started off by describing herself as a ‘trained scientist and a self-taught artist’. Imagine the responses

³⁴⁵ Tweet by @christineluuart, 1 February, 2020.

to someone starting off a similar claim, or even a contradictory claim, by stating ‘as a trained artist and a self-taught scientist’.

To return to creativity, a majority of professional contemporary artists working today are well-versed in contemporary art theory and discourse which understands traditional concepts such as ‘creativity’ and ‘beauty’, a concept constantly mentioned by scientists and mathematicians in relation to their work, as extremely problematic not to mention often downright irrelevant. In a scientific context, these terms are frequently used with no appreciation for or seeming understanding of the fact that they are not simply neutral words but concepts with charged cultural and political histories. Leaving beauty to one side, creativity has increasingly been recognised as a problematic term because artists now exemplify—have perhaps provided the model for—precarity in the postcapitalist work universe.³⁴⁶

But even were we to allow scientists some leeway in their use of creativity to self-describe scientific working methods, the philosopher of science, Paul Feyerabend, acerbically points out the absurdity of such actions given the larger professional context in which science operates. ‘Today’, Feyerabend writes in *The Tyranny of Science*, ‘many scientists want to make use believe that scientific research is not as tight-assed as the Monod quotation³⁴⁷ seems to indicate. There is an artistic-spirit, they say, there is “creativity”, “imagination”, there are metaphors, analogies, “aesthetic dimensions”—and so on.’³⁴⁸ He continues:

Moreover there are now scientific theories that seem to be applicable both to matter and to the movements of the spirit. All this sounds very nice but has little influence on the day-to-day practice and the institutional ramifications of research. *Where is the research team that gets a prize for its aesthetic achievements? Where is the journal that accepts articles because of the creative insights they contain?* [emphasis mine]³⁴⁹

³⁴⁶ For an interesting counterpoint, Sarah Kember and Joanna Zylińska, in their book chapter ‘Reclaiming Creativity’, talk about how ‘creativity’ might be reclaimed by artists and media theorists from its neoliberal contexts. In *Life After New Media: Meditation as a Vital Process*, MIT Press, (2012), 173-201.

³⁴⁷ ‘By a single stroke [science] claimed to sweep away the tradition of a hundred thousand years, which had become one with human nature itself. It wrote an end to the ancient alarmist covenant between man and nature, leaving nothing in place of that precious bond... With nothing to recommend it but a certain puritan arrogance, how could such an idea win acceptance? It did not’ it still has not. It has however commanded recognition; but that is because, solely because of its prodigious power of performance.’ Jacques Monod, *Chance and Necessity*, 1972.

³⁴⁸ Feyerabend, *Tyranny of Science*, 7.

³⁴⁹ Ibid. See Book 1, 29.

Feyerabend's point remains valid, perhaps all the more so in light of the continuing strain between the two cultures in the post-Sokal period. Since Sokal's famous hoax—in which physicist Alan Sokal submitted a paper, 'Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity', to *Social Text*, a humanities journal (not peer-reviewed at the time) before revealing it to be entirely fabricated—Snow's original 'two cultures' divide moved largely to one side of a new, perhaps more heated debate in the 'Science Wars'. One side of the debate, comprising mainly those working in the humanities and social sciences, argued for a form of disciplinary unity, where science and literature were both forms of 'discourse' with equal epistemological validity, i.e. the 'one culture' argument. The other side of the debate, predominately made up of natural scientists, argued for the separateness of science and the uniqueness of its knowledge claims, i.e. the 'two cultures' argument.

The Spirit of Alchemy

It's the 27th of October, 2017. I'm in a hotel room in the Dutch town of Utrecht, lying on the bed, curtains closed to block out the light. Today is the second day of the Impakt Festival, curated by my friends and colleagues, Tobias Revell and Natalie Kane, who work together as Haunted Machines. They've invited me to give a talk about alchemy and the ways in which narratives related to the history of alchemy can be used to reassess our current relationship with materials, transformation, and power. I'm supposed to be giving the talk in an hour's time, but I've got a terrible migraine—hence lying on the bed in my hotel in the dark rather than attending the morning session of the conference. Luckily, I've practiced the talk so many times that it's largely memorised. I've never given a talk with a migraine before and it goes better than expected. It's as if there's an autocue in my memory that my mind reads and my mouth speaks in spite of the terrible pain on the right side of my head.

To be honest, I'm still not entirely sure why Tobias and Natalie asked me to give a talk about alchemy. I knew very little about the subject and, as far as I can remember, hadn't expressed a great passion for its history. But I'm a diligent and dedicated researcher and, as they gave me six months' notice to prepare, I took full advantage and basically crammed an entire degree's worth of the history of alchemy into those few

months. Just as I started to piece together the structure and argument of my talk, I encountered an essay by the Italian chemist Giuseppe Del Re entitled ‘Technology and the Spirit of Alchemy’. The essay resonated with much of what I had been thinking about, and I borrowed his idea of the ‘spirit of alchemy’ for the title of my talk. Del Re argues that although the transition from the ‘mysticism’ of alchemy to the rigour of chemistry is often credited to the abandonment of its religious aspects, the elimination of this ‘spirit of alchemy’ has been a key contributing factor in relation to the widespread misuse of science and technology. ‘Those who develop technology without even a trace of the spirit of alchemy, i.e. without a parallel upgrading of their spiritual standards, particularly their sense of responsibility,’ De Re wrote, ‘may be contributing to the devastating ills of our society which no vaccine can prevent.’³⁵⁰

In keeping with many of the early-modern alchemists he sympathises with, De Re seems to buy quite uncritically into narratives of technological progress—narratives which I find hugely problematic. But there’s something appealing about his insistence that science and technology lost something of grave importance when they jettisoned the alchemist’s sense of moral responsibility to privilege technological know-how above all else.

In twentieth-century physics, one saw precisely such arguments deployed in relation to the development of atomic weapons in the United States as part of both World War II and the subsequent Cold War. Edward Teller, the so-called ‘father’ of the hydrogen bomb, famously claimed that moral opposition to the hydrogen bomb was ‘a fallacy’ largely because ‘if the development is possible, it is out of our powers to prevent it’. Teller continued by suggesting that all physicists could do was ‘to retard its completion by some years’.³⁵¹ Although physicists today are somewhat more circumspect about participating in the creation of weapons of mass destruction, the same logic—that of pursuing science to its furthest reaches no matter the cost or consequences—is frequently deployed as justification for increased public funding for things like ever-larger particle colliders or sending unmanned rovers to Mars.

When I try to imagine what physics would look like today if it was committed to ‘the spirit of alchemy’ or an upgraded sense of social responsibility, I don’t imagine a discipline that resembles the one we currently have. As Margaret Wertheim has argued,

³⁵⁰ Giuseppe Del Re, ‘Technology and the Spirit of Alchemy’, *HYLE—International Journal for Philosophy of Chemistry*, Vol. 3 (1997): 51-63.

³⁵¹ Edward Teller to Enrico Fermi, 31 October 1945. Cited in Peter Galison, ‘Computer Simulations and the Trading Zone’, in *Disunity of Science*.

physicists' obsession with a theory of everything is socially irresponsible. 'In a world reeling with problems of pollution, overpopulation, starvation, land degradation, deforestation, and loss of biodiversity, we cannot avoid asking: Is it responsible to spend billions of dollars looking for a theory that, no matter how beautiful, is unlikely to have any application to daily human life?'³⁵² Although Wertheim asks important questions—surprisingly, perhaps, she's also one of the few feminist critics of physics to pose such questions—those posed by Lauren Chambers, who writes at the intersection of science criticism, black feminism, and critical race theory, are equally powerful. 'Is the ultimate result of an anti-racist movement in science the eventual eradication of basic physics and astronomy?,' Chambers asks. 'Or less radically, perhaps an anti-racist science requires the gross deprioritization of physics and astronomy, in return for elevation of work that directly benefits humanity?'³⁵³

Two Cultures: Values?

So, ok, how can we talk about the relationship between these two things, art and science, today? Or, how can I talk about them, by which I also mean, what do I think about them and what do I do about them? As someone who has for a long time felt distress about the slow then fast creep of specialisation into professional research—I used to have science-fiction writer Robert Heinlein's quote about specialisation being for insects in huge typeface on the homepage of my website³⁵⁴—I've nevertheless come to appreciate the need to draw lines. Because of the nature of rapid specialisation across all fields of knowledge, particularly in terms of higher education, it is naïve at best and destructive at worst to elide fundamental differences between disciplinary power structures and epistemologies by making over-exaggerated claims to shared creativity.

If I think again about Snow, I think that he didn't really appreciate that the two cultures used to be more occupied with facts that brought us closer to truths, but that the culture of arts is now much less interested in objective knowledge. Increasingly, I'm far

³⁵² Wertheim, *Pythagoras*, 237-238.

³⁵³ Chambers, 'A Different Kind', 49-50.

³⁵⁴ 'A human being should be able to change a diaper, plan an invasion, butcher a hog, conn a ship, design a building, write a sonnet, balance accounts, build a wall, set a bone, comfort the dying, take orders, give orders, cooperate, act alone, solve equations, analyze a new problem, pitch manure, program a computer, cook a tasty meal, fight efficiently, die gallantly. Specialization is for insects.' This statement is uttered by the character Lazarus Long in Robert Heinlein's *Time Enough for Love*. I've never actually read the book.

more interested in looking at the relationship between arts and sciences through the lens of values. Art is currently much more comfortable with having a moral purpose: it's interested in critiquing aspects of the world seemingly-unthinkingly created by science and technology in the name of social progress. Snow was too quick to assume that 'the division between the cultures simply reflected ignorance, which factual knowledge would ameliorate. The cultures have different purposes'.³⁵⁵

To draw on an interesting example that is of increasing relevance within the academy, consider the place of interdisciplinary or transdisciplinary research. Though there have been considerable efforts to make space for 'interdisciplinary' research projects within higher education institutions, these projects still take place within a framework that privileges disciplinary silos and departmental hierarchies. As Jim Malazita has highlighted, people in higher education institutions 'love interdisciplinary work, BUT they love interdisciplinary work that is structured hierarchically'.³⁵⁶ Malazita notes that this is what Georgina Bonn called the 'subordination-service' model of power imbalances in interdisciplinary work, where one discipline ends up serving to 'round out' another. But when work taken from one discipline to another begins to challenge fundamental epistemological or ontological assumptions, suddenly interdisciplinary work becomes far less appealing. Responding to Malazita, Jenna Burrell confirms that not only are there 'fundamental, maybe irreconcilable epistemological differences' between disciplines, but that there are also power asymmetries at play too.³⁵⁷ For example, funding disparities between the disciplines are significant and striking.³⁵⁸

And so it's not only about differentiating between different forms of knowledge or the methods by which that knowledge is obtained, i.e. the artist's studio versus the scientist's laboratory, but also where we draw lines in searching for and constructing knowledge; what kinds of research projects are deemed valuable; who benefits from the knowledge produced and who doesn't; what are the environmental or material impacts of our research, how do we treat our researchers, research staff, and non-academic col-

³⁵⁵ John O. McGinnis, 'Bridging C.P. Snow's Two Cultures', *City Journal* (Spring 2018). <https://www.city-journal.org/html/bridging-c-p-snows-two-cultures-15837.html>

³⁵⁶ JMalazita, Tweet, 20 August, 2020 <https://twitter.com/JMalazita/status/1296479907531366401>

³⁵⁷ Jenna Burrell, Tweet, 20 August, 2020 <https://twitter.com/jennaburrell/status/1296493217580556289>

³⁵⁸ In 2021, for example, the difference between the UK government approving 50% funding cuts for arts and design across higher education institutions in England compared to large research funding grants for science and technology—£4 million funding to research biomass production or £24 million funding for industrial studentships at English universities. Alternatively, compared to the 2017 figures for UK government expenditure on science, engineering and technology—£12.2 billion—the same year's government spending on cultural services amounted to a mere £4.05 billion ([statista.com/statistics/298899/united-kingdom-uk-public-sector-expenditure-cultural-services/](https://www.statista.com/statistics/298899/united-kingdom-uk-public-sector-expenditure-cultural-services/)).

leagues; where does our funding come from? And this is not necessarily to say that science is bad at answering or addressing these questions and that art isn't. Despite broad left-leaning political views and outspoken interest in political and social concerns, art as a discipline can be exceptionally obtuse when it comes to confronting its own bad behaviour (e.g. Zabludowicz, the Whitworth, the Guggenheim, the ICA, William Morris Gallery, Goldsmiths redundancies and so on and so on).

That said, I do still believe that in terms of broader disciplinary frameworks, there is far more evidence to suggest that contemporary artists privilege values and questions of value over the obsession with objective knowledge production so prevalent in physics. Perhaps one of the reasons for this is that, as Karin Knorr Cetina discusses in *Epistemic Cultures*, the world of high-energy physics is an internally referential system.³⁵⁹ Although one can certainly trace internal references throughout art history, perhaps most particularly through painting, contemporary art more clearly demonstrates an interest in external references, whether social practices, political events, natural histories, etc.

By contrast, the structures of the modern sciences are constructed atop a foundation that has, historically, intentionally avoided engagement with making moral judgments in relation to society. Frances Yates summarises the importance of such value-free thinking on the development of the Royal Society in England in the seventeenth century:

As the natural philosophers moved towards the consummation of the Royal Society, they had to be very careful... A permanent Society for the advancement of natural science had arrived... [But] it was very restricted in its aims compared with earlier movements. It did not envisage the advancement of science within a reformed society, within a universal reformation of the whole world. The Fellows of the Royal Society were not concerned with healing the sick, and that gratis, nor with schemes for the reform of education.³⁶⁰

Rather than seeking to reform the world, the fellows of this new society were simply seeking a niche within it.³⁶¹ And, broadly speaking, that tradition continues to have a strong foothold in the sciences today.

³⁵⁹ Karin Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge: Harvard University Press, 1999), 47.

³⁶⁰ Frances Yates, *The Rosicrucian Enlightenment* (Boulder: Shambala Press, 1978), 188-190. Cited in Fox Keller, *Reflections*, 47.

³⁶¹ This is a paraphrase of Wolfgang Van den Daele from 'The Social Construction of Science: institutionalisation and definition of positive science in the latter half of the seventeenth century', *Sociology of the sciences yearbook*, Vol 1 (1977), 41; cited in Fox Keller, *Reflections*, 47.

Two Cultures: Science versus Feminist Science

In pitting the sciences against the humanities and art as the original ‘two cultures’, Snow and others like Sokal who have theorised in his wake, have framed the nature of the debate in such a way as to occlude the fact that science is not a homogenous field. Feminist scholars have long preferred ‘sciences’ to ‘science’ as a small, but important nod to the distinction of differences in methods and epistemologies across different scientific disciplines and sub-disciplines. Physics, for example, does not share the same histories, tools, methods, procedures, cultures and beliefs as biology or chemistry. To take a more interesting comparison, physics does not share the same histories, methods, cultures and beliefs as feminist physics.

As Sandra Harding has argued, science (along with art) is a field that is co-produced by society and vice-versa. Thus racist, sexist and imperial societies will tend to sponsor sciences that, in turn, provide resources for racist, sexist and imperial societies.³⁶² To this end, Harding notes that ‘women have been more systematically excluded from doing serious science than from performing any other social activity except, perhaps, front-line warfare’.³⁶³ As I have previously demonstrated, the absence of women from the sciences in general, but from physics in particular, with its emphasis on obscure abstraction and a mathematical approach to nature, has been part of the field since its establishment.³⁶⁴ This exclusion of women from the practice of physics at its seventeenth-century inception continued through to the eighteenth century where, according to Margaret Wertheim, the ‘public-private, male-female dualism provided fresh impetus for the old clerical prejudice that the study of nature’s laws was a task for men alone’.³⁶⁵ If women, Wertheim supposes, had a ‘natural’ association with the private sphere and men were ‘naturally’ omnipresent in the public sphere, then surely the ‘laws of nature’ came under male dominion.³⁶⁶ Unsurprisingly, such reasoning continued to appear frequently in nineteenth-century rhetoric around the exclusion of women from the sciences. In an 1897 questionnaire, the noted German scientist Max Planck wrote that it was not man’s actions that prevented women from participating in scientific research, but ‘nature herself’. After all, he argued, ‘the laws of nature cannot be

³⁶² Harding, *Objectivity & Diversity*, 17.

³⁶³ *Ibid.*

³⁶⁴ See Book 1 & Book 4

³⁶⁵ Wertheim, *Pythagoras*, 149.

³⁶⁶ *Ibid.*

ignored'.³⁶⁷ Planck was not alone in these views. Other late-nineteenth-century physicists used the principle of energy conservation to argue that women could not both pursue a rigorous intellectual career and have strong, healthy babies.³⁶⁸

Today, although, in theory, barriers to entry for women who want to participate in physics research are non-existent, in practice things have not significantly improved for women, let alone for Black people and other people of colour. Overt sexism abounds among Nobel-Prize winning physicists, as do anecdotes about the undesirability of women in labs and on research teams. A memorable example appears in Lee Smolin's 2007 book, *The Trouble with Physics*. Smolin tells an anecdote about an informal hiring committee where they said 'hell no' to the female candidate, which was never overtly explained, but immediately understood by all involved as no women. Smolin's book is about the perils of 'group think' in physics, particularly in relation to the lingering obsession among theoretical physics community with the highly popular, but so-far unsuccessful theory of string theory. Smolin makes a half-hearted attempt to call for greater diversity in physics as a way of combatting such problems, but his overarching motivation seems mainly to encourage funding bodies and hiring committees to fund theoretical programmes that deviate from string theory. Smolin's entire book is damned, however, by its author's association with convicted sex trafficker, Jeffrey Epstein, who, it transpires, funded Smolin's independent research and is gushingly thanked in the book's acknowledgements. In addition to funding Smolin, Epstein also bankrolled the EDGE Foundation—a by-invitation membership-only group (unsurprisingly, 80% of EDGE's 900 contributors were male) that includes 'the most interesting minds in the world' according to its founders—whose members include Richard Dawkins, Steven Pinker and Lawrence Krauss, another prominent physicist accused of multiple sexual harassments (who also defended Epstein following his arrest). When news of the connection between EDGE and Epstein was made public following Epstein's arrest in 2019, only Carl Zimmer, a leading science writer and *New York Times* columnist, raised protest. Zimmer posted on Twitter days after Epstein's arrest that he had been in contact with EDGE and asked to have his profile and contributions removed from the site.³⁶⁹

³⁶⁷ The full quote: 'Generally, it cannot be emphasized enough that nature herself prescribed to the woman her function as mother and housewife, and that the laws of nature cannot be ignored.' See Book 1, 28.

³⁶⁸ Dorit Heinsohn, 'Thermodynamik und Geschlechterdynamik um 1900', *Feministische Studien*, Vol 18. No. 1, (2000) 52-68; quoted in Maralee Harrell, 'On the Possibility of Feminist Philosophy of Physics', *Meta-Philosophical Reflection on Feminist Philosophies of Science*, Springer, (2015), 24.

³⁶⁹ Carl Zimmer, Tweet, 12 July, 2019 <https://twitter.com/carlzimmer/status/1149704633092366336>.

Unlike Lauren Chambers or Margaret Wertheim, who suggest that the cultural problems with physics are too deep-seated to be resolved by demographic overhaul—a view I share—many feminist critics of physics are interested in looking at how to change the field by ‘levelling the playing field’, encouraging more women and people of colour into the discipline, and hoping that such changes will in turn bring feminist epistemologies to bear on the practice of physics. But even this seems to cause some anxiety over whether it is indeed possible to bridge the gap between the two. In assessing the principles of feminist science and comparing them to the orthodox practice of physics, for example, Amy Graves suggests that ‘feminist principles may be so at odds with physics that to be true to both fields is to profoundly distort both of them’.³⁷⁰

Two Cultures: Orpheus vs Prometheus

To conclude, I want first to return to Pierre Hadot’s mode of framing two historically prominent attitudes to investigating ‘nature’ as either Promethean or Orphic: the former, a more aggressive unveiling, inspired by ‘audacity, boundless curiosity, the will to power, and the search for utility’; and the latter a more sensitive approach defined by ‘respect [for nature] in the face of mystery and disinterestedness’.³⁷¹ Although it’s tempting to make the obvious analogies and map Promethean onto the sciences and Orphic onto the arts, such temptations must be resisted. When it comes to beliefs about the best methods for understanding the world, approaches taken by the arts and the sciences converge and diverge in unexpected and contradictory ways.

Instead of leaning on Hadot’s binaries or Snow’s overly-simplistic argument, about one-third of the way through this research project, I concluded that a more meaningful ‘two cultures’ analysis would foreground ethics, prompted in part by my perception that physics (as a professional discipline) had never concerned itself with ethics and

³⁷⁰ Graves Bug, ‘Has Feminism Changed Physics?’, 890.

Feminist scientists	Physicists
Acknowledge their values and beliefs	No
Explore how these affect their perspectives	No
Are explicit and honest about assumptions and methods	Yes
Are responsible in language	Yes(math), No (metaphors)
Eliminate research leading to exploitation of nature	No
Aim for diversity among participants	Yes
Recognize the complexity of nature	Yes
Resist single-cause explanations stripped of social context	No

³⁷¹ Hadot, *Veil*, 96. See Book 1, 20.

that art (as a professional discipline) often did. It occurred to me that if I considered disciplinary differences in terms of ethics and values, rather than trite and supposed similarities such as ‘creativity’ or ‘the shared search for truths about the world and our place in it’, I would be able to parse power structures and other relationships between the two fields in a more productive way; perhaps even ultimately to be able to argue for art as a ‘better’ model for the production or synthesis of knowledge. But the global events that took place during the making of this PhD upended my ability to make such distinctions between art and science on ethical grounds.

Throughout this PhD, I frequently felt frustrated and angered by physics and physicists—their inability (or intractability) to confront the ethical, social and political ramifications of their research and research culture—but in the end, my anger was largely redirected to the art world’s moral hypocrisies. While physicists seem unable to free themselves from an obsession with ‘value-free objectivity’, one which has haunted their discipline since its earliest days, many powerful art-world actors—in both commercial and institutional spaces—often see little wrong in publicly proclaiming ethical values only to directly contravene said values when it is more convenient to do so.³⁷²

I still want to believe in Dave Hickey’s idea of art as an ‘alternative source of value in the world’ and in Hester Reeve’s notion of the ‘artist as a moral agent’, but I feel less and less convinced that art does genuinely represent an alternative source of value, or that artists can have meaningful moral agency in an art world that constantly justifies its ‘bewildering ethical paradoxes’ as institutional necessities.³⁷³

Is it possible to inhabit these contradictions, the idea that the artist can be a moral agent working in or between amoral disciplines and institutions, and remain sane? In the twilight of this project, I admit that the shine of Hickey’s and Reeve’s concepts has been diminished by waves of frustration, disgust, and anger in light of the reprehensible behaviour displayed by too much of the art world in recent years. Yet, I cannot help but appreciate that this pessimism provides a necessary counterbalance: my understanding of the situation has become considerably, and necessarily, more complex. Although the almost utopian idealism of Hickey’s and Reeve’s ideas retains its pull, I no longer feel

³⁷² Of course, there remain a number of artists and art collectives, as well as certain art institutions, which have historically paid and continue to pay far greater attentiveness to values, ethics and other forms of social-politico-economic impact while supporting rather than undermining the moral agency of the artists they work with. And even if I no longer completely agree with Hickey, certain figures in various corners of the art world remain committed to demonstrating that art still has the potential to act as an alternative source of value in the world—more so when compared to the few individuals in physics, which as a discipline, lags frustratingly behind on questions of values.

³⁷³ Shani, ‘Why Art Workers Must Demand the Impossible’. See Book 3, 95.

fully convinced of their utility or truthfulness with respect to the contemporary art world. Perhaps some art can still offer an alternative source of value in the world, but the professionalised, institutionalised, ethically-compromised, financialised contemporary art world that I participate in often chooses not to. Likewise, the idea that the artist can be a moral agent in this same art world feels almost wilfully naive. Yet acknowledging all of this has provided me with a valuable corrective. Even an almost overwhelming sense of fruitlessness does not mean that it's no longer worth trying. It isn't that I jettison the ideas completely, throw my hands in the air, and walk away. Instead, I persist in my efforts to keep hold of these contradictions, gently grasped in opposite hands, while accepting the futility of the effort—idealism and realism; hopes and frustrations; moral agency in one hand, amoral professional worlds in the other.

Seeking shelter from emotional storms, I return in the end to Serres, Hermes, and the spaces in-between. In *Hermès V Le Passage du Nord-Ouest*, Serres seeks a safe-ish passageway between the physical sciences and the arts and humanities.³⁷⁴ While both disciplines endeavour to explain the world in accordance with their own particular methods, according to Serres (and echoing Snow), they also turn their backs on each other. Serres invokes the North-West Passage between the Atlantic and Pacific as a metaphor for this fraught in-between space that links and connects, but also divides, these two explanatory approaches to understanding the world. It is here, in this treacherous passage, that Hermes acts as a kind of spirit figure—the bearer of messages between humans and the gods, between one discipline and another, but a mischievous bearer with agency to translate the message as he sees fit. Or, perhaps, to choose not to translate any messages at all. While I will undoubtedly wrestle with frustrations and with unanswered (unanswerable) ethical questions across the arts and sciences for years to come, the in-between is a space where I have always found comfort. Instead of constructing a permanent dwelling on either the shore of art or science to answer these and other questions, I am drawn again and again to the North-West Passage—a complex, digressive, irregular, unpredictable, unstable and endlessly changing space between the different modes of knowledge represented by scientific and artistic cultures.

³⁷⁴ Serres, *Hermès*. See Book 2, 31.

REFERENCES

- Adorno, T. W., Bob Hullot-Kentor and Frederic Will. 'The Essay as Form'. *New German Critique*, No. 32: 151-171.
- Ahmed, Sara. 'Making Feminist Points', *feministkilljoys*, 11 September, 2013. <https://feministkilljoys.com/2013/09/11/making-feminist-points/>
- Ahmed, Sara. *Living a Feminist Life*, Durham: Duke University Press, 2017.
- Arnold, Matthew. 'Literature and Science', an address given as the Rede Lecture at Cambridge University on 14 June, 1882.
- Azoulay, Ariella. *The Civil Contract of Photography*. New York: Zone Books, 2008.
- Bachmann-Medick, Doris. 'Introduction: The Translational Turn.' *Translation Studies*, Vol 2 No.1 (2009): 2-16.
- Barad, Karen. *Meeting the Universe Halfway*. Durham: Duke University Press, 2007.
- Bassnett, Susan, and André Lefevre. *Translation, History and Culture*. London: Cassell, 1995.
- Bassnett, Susan. 'The Translation Turn in Cultural Studies.' In *Constructing Cultures: Essays on Literary Translation*, edited by Susan Bassnett and André Lefevre, 123-141. Bristol: Multilingual Matters, 1998.
- Bazalgette, Peter. 'Why the arts must shape our future.' *The Guardian*, 21 June, 2020. <https://www.theguardian.com/commentisfree/2020/jun/21/why-the-arts-must-shape-our-future>.
- Beech, Dave. *Art and Postcapitalism: Aesthetic Labour, Automation and Value Production*. London: Pluto Press, 2019.
- Benjamin, Walter. 'The Task of the Translator'. Translated by Harry Zohn. *Illuminations*. New York: Harcourt Brace Jovanovich, 1968.
- Bennes, Crystal, and Thomas Jeffreys. 'Conversations on Art and Science: Parts 1 - 4', *Roman Road Journal*. <https://romanroadjournal.com/author/crystal-bennes-and-tom-jeffreys/>
- Boudreau, Joseph F. And Eric S. Swanson, *Applied Computational Physics*. Oxford: Oxford University Press, 2018.
- Bronowski, Jacob. *Science and Human Values*. London: Faber, 2008.
- Brown, Steven D. 'Michel Serres: Science, Translation and the Logic of the Parasite.' *Theory, Culture & Society* Vol. 19, no 3 (2002): 1-27.
- Carrier, Martin, Günter Küppers, Johannes Roggenhofer, Philippe Blanchard. *Knowledge and the World: challenges Beyond the Science Wars*. Berlin: Springer-Verlag, 2004
- Cartwright, Nancy. *How the Laws of Physics Lie*. Oxford: Oxford University Press, 1983.

CERN Human Resources. 'CERN Annual Personnel Statistics 2019'. Human Resources Department website. May 2020. Accessed 23 July, 2020. <https://cds.cern.ch/record/2719035/files/CERN-HR-STAFF-STAT-2019-RESTR.pdf>

Chambers, Lauren. 'A Different Kind of Dark Energy: Placing Race and Gender in Physics.' BA thesis, Yale University, 2017.

Cho, Adrian. 'Will Nobel Prize overlook master builder of gravitational wave detectors?' *Science*, Vol. 27 (September 2016) <https://www.sciencemag.org/news/2016/09/will-nobel-prize-overlook-master-builder-gravitational-wave-detectors>

Crapanzano, Vincent. 'Hermes' Dilemma: The Masking of Subversion in Ethnographic Description'. In *Writing Culture: The Poetics and Politics of Ethnography*, edited by James Clifford and George E. Marcus. Berkeley: University of California Press, 1986.

Crenshaw, Kimberlé. 'Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics.' *University of Chicago Legal Forum*, Vol. 1989, Issue 1, Article 8 (1989): 139-167.

Daston, Lorraine and Peter Galison. *Objectivity*. New York: Zone Books, 2007.

Darwin, Charles. *The Works of Charles Darwin, vol. 19: The Variation of Animals and Plants under Domestication* (1875). London: Routledge, 2016.

Davis, Angela. *Women, Race and Class*. London: Penguin Classics, 2019 (originally published 1981).

Del Re, Giuseppe. 'Technology and the Spirit of Alchemy.' *HYLE—International Journal for Philosophy of Chemistry*, Vol. 3 (1997): 51-63.

DuPlessis, Rachel Blau. 'f-Words: An Essay on the Essay.' *American Literature*, vol. 68, no. 1 (1996): 15-45.

Ede, Siân. *Art & Science*. London: I.B. Tauris, 2004.

Essinger, James. *Jacquard's Web: How a Hand-loom Led to the Birth of the Information Age*. Oxford: Oxford University Press, 2004.

Feyerabend, Paul. *The Tyranny of Science*. Cambridge: Polity Press, 2011.

Flusser, Vilém. *Towards a Philosophy of Photography*. European Photography, 1984.

Flusser, Vilém. *Into the Universe of Technical Images*. Minneapolis: University of Minnesota Press, 2011.

Forbes. 'Why Art and Science are More Closely Related Than you Think.' *Forbes*, 16 March, 2016: <https://www.forbes.com/sites/quora/2016/03/16/why-art-and-science-are-more-closely-related-than-you-think/>

Fox Keller, Evelyn. 'Feminism and Science.' *Signs*, Vol. 7 No. 3 (Spring 1982): 589-602.

Fox Keller, Evelyn. *Reflections on Gender and Science*. New Haven: Yale University Press, 1985.

Frieze. 'John Akomfrah: On Essays, Identities and Stuart Hall.' Published February 7, 2014. Accessed 15 July, 2019. <https://frieze.com/media/john-akomfrah-essays-identities-and-stuart-hall>.

Galison, Peter, and David J. Stump. *The Disunity of Science: Boundaries, Contexts, and Power*. Stanford: Stanford University Press, 1996.

Galison, Peter, and Bruce Hevly. *Big Science: The Growth of Large-scale Research*. Stanford: Stanford University Press, 1992.

Galison, Peter. 'Computer Simulations and the Trading Zone.' In *The Disunity of Science: Boundaries, Contexts, and Power*, edited by Peter Galison and David J Stump. Stanford: Stanford University Press, 1996.

Graves (formerly Bug), Amy. 'Has Feminism Changed Physics?' *Signs* Vol. 23, no. 3 (2003): 881-899.

Guldin, Rainer. *Translation as Metaphor*. Abingdon: Routledge, 2016.

Gupta, Aditya , Ninareh Mehrabi, Goran Muric, and Kristina Lerman. 'The Leaky Pipeline in Physics Publishing.' *Physics and Society* Vol 1 (18 October, 2020) <https://arxiv.org/abs/2010.08912>

Gusterson, Hugh. 'Becoming a Weapons Scientist.' In *Technoscientific Imaginaries*, edited by George Marcus. Chicago: University of Chicago Press, 1995.

Hacking, Ian. 'The Disunities of the Sciences.' In *The Disunity of Science: Boundaries, Contexts, and Power*, edited by Peter Galison and David J Stump. Stanford: Stanford University Press, 1996.

Hadot, Pierre. *The Veil of Isis: An Essay on the History of the Idea of Nature*. Translated by Michael Chase. Cambridge: Harvard University Press, 2006.

Hammerman, Robin, and Andrew Russel. *Ada's Legacy: Cultures of Computing from the Victorian to the Digital Age*. San Rafael: Association for Computing Machinery and Morgan & Claypool Publishers, 2016.

Haraway, Donna. 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective.' *Feminist Studies*, Vol. 14 No. 3 (Autumn 1988): 575-599.

Haraway, Donna. 'Modest Witness: Feminist Diffractions in Science Studies.' In *The Disunity of Science*, edited by Peter Galison and David Stump. Stanford: Stanford University Press, 1996.

Harding, Sandra. *The Science Question in Feminism*. Cornell: Cornell University Press, 1986.

Harding, Sandra. *Whose Science? Whose Knowledge? Thinking from Women's Lives*. Ithica: Cornell University Press, 1991.

Harding, Sandra. *Objectivity and Diversity: Another Logic of Scientific Research*. Chicago: University of Chicago Press, 2015.

Harrell, Maralee. 'On the Possibility of Feminist Philosophy of Physics', In *Meta-Philosophical Reflection on Feminist Philosophies of Science*, edited by M.C. Amoretti and N. Vassallo, 15-34. Boston Studies in the Philosophy and History of Science: Springer International Publishing, 2016.

Harvey Regan, Daniel. 'Interview Darren Harvey Regan - "The Erratics" @Unseen'. Interview by Brad Feuerhelm. *American Suburb X*, 16 September, 2015. <https://www.americansuburbx.com/2015/09/an-interview-with-darren-harvey-regan-the-erratics-unseen.html>.

Greer, S. C. *Elements of Ethics for Physical Scientists*. Cambridge: MIT Press, 2017.

Harvey, David. *Justice, Nature and the Geography of Difference*. Oxford: Blackwell, 1996.

Heinsohn, Dorit. 'Thermodynamik und Geschlechterdynamik um 1900.' *Feministische Studien* Vol. 18 No. 1 (2000): 52–68.

Heisenberg, Werner. *The Physicist's Conception of Nature*. Translated by Arnold J. Pomerans. London: Hutchison & Co, 1958.

Hoddeson, Lillian W., Adrienne W Kolb and Catherine W Westfall. *Fermilab: Physics, the Frontier, and Megascience*. Chicago: University of Chicago Press, 2009.

Holert, Tom. *Knowledge Beside Itself: Contemporary Art's Epistemic Politics*. Berlin: Sternberg Press, 2020.

Hollin, Gregory, Isla Forsyth and Eva Giraud. '(Dis)entangling Barad: Materialisms and ethics.' *Social Studies of Science*, Vol. 47 No. 6 (2017): 918-941.

hooks, bell. *Feminist Theory: From Margin to Center*. London: Pluto Press, 2000.

Huxley, Thomas Henry. 'Science and Culture', an address given at Mason Science College, Birmingham on 1 October, 1880.

Hvidtfelt Nielsen, Kristian, and Sujeevan Sivasundaram. 'Surveying the Attitudes of Physicists Concerning Foundational Issues of Quantum Mechanics.' Published 2 December, 2016. <https://arxiv.org/pdf/1612.00676.pdf>

Institute of Physics. 'Physicists consider their own carbon footprint.' Last modified 30 September, 2011. <https://phys.org/pdf236579270.pdf>

Karshan, Thomas, and and Kathryn Murphy. *On Essays: Montaigne to the Present*. Oxford: Oxford University Press, 2020.

Kember, Sarah and Joanna Zylinska, *Life After New Media: Meditation as a Vital Process*. Cambridge: MIT Press, 2012.

Knorr-Cetina, Karin. *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge: Harvard University Press, 1999.

Knowles, Kim. 'Politics of Process: Gestures of Material Understanding in Contemporary Film Practice.' Paper presented at the Light | Sensitive | Material conference, University of West London, 1 November, 2019.

- Koek, Ariane. 'In/visible: the Inside Story of the Making of Arts at CERN.' *Interdisciplinary Science Reviews* Vol. 42. No. 4 (2017): 345-358.
- Kosso, Peter. *Reading the Book of Nature: An Introduction to the Philosophy of Science*. Cambridge: Cambridge University Press, 1992.
- Lafargue, Paul. *The Right To Be Lazy BEING A REPUDIATION OF THE "RIGHT TO WORK" OF 1848*. Translated and adapted by Dr Harriet Lothrop. New York: International Publishing Co, 1898.
- de Landa, Manuel. *War in the Age of Intelligent Machines*. New York: Zone Books, 1991.
- Latour, Bruno. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge: Harvard University Press, 1987.
- Lazzarato, Maurizio. *Marcel Duchamp and the Refusal of Work*. Translated by Joshua David Jordan. Los Angeles: Semiotext(e), 2014.
- Lemonick, Sam. 'Scientists at CERN hunt for greener gases for particle detectors.' *Chemical & Engineering News*, 27 April, 2019. <https://cen.acs.org/environment/greenhouse-gases/Scientists-CERN-hunt-greener-gases/97/i17>.
- Leslie, Esther. *Synthetic Worlds: Nature, Art and the Chemical Industry*. London: Reaktion Books, 2005.
- Longino, Helen. *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton: Princeton University Press, 1990.
- Lorde, Audre. 'The Master's Tools Will Never Dismantle the Master's House.' In *Sister Outsider: Essays and Speeches*. Trumansburg: Crossing Press, 2007.
- Lu, Donna. 'Creating an AI can be five times worse for the planet than a car.' *New Scientist*, 6 June, 2019. <https://www.newscientist.com/article/2205779-creating-an-ai-can-be-five-times-worse-for-the-planet-than-a-car/>.
- Maitland, Sarah. *What is Cultural Translation?* London: Bloomsbury Academic, 2017.
- Marton, A.M. *A New Treatise on the Modern Methods of Carbon Printing*. Bloomington, 1905.
- Mascia-Lees, Frances E., Patricia Sharpe and Colleen Ballerino Cohen, 'The Postmodernist Turn in Anthropology: Cautions from a Feminist Perspective.' *Signs*, Vol. 15 No 1. (1989).
- McCain, Kevin and Kostas Kampourakis. *What is Scientific Knowledge? An Introduction to Contemporary Epistemology of Science*. New York: Routledge, 2020.
- McGinnis, John O. 'Bridging C.P. Snow's Two Cultures.' *City Journal* (Spring 2018) <https://www.city-journal.org/html/bridging-c-p-snows-two-cultures-15837.html>.
- McKay, Emma. 'Extraction and Land in Physics.' MA thesis, York University, Toronto CA, 2020.

- McKittrick, Katherine. *Dear Science and Other Stories*. Durham: Duke University Press, 2021.
- Menabrea, Luigi Frederico. *Notions sur la machine analytique de M. Charles Babbage*. Bibliothèque Universelle de Genève, 1842. Translated by Augusta Ada Lovelace. Published in *Scientific Memoirs* Vol. 3 (1843): 666-731.
- Merchant, Carolyn. *The Death of Nature: Women, Ecology, and the Scientific Revolution*. New York: Harper One, 1980.
- Merchant, Carolyn. 'Secrets of Nature: The Bacon Debates Revisited.' *Journal of the History of Ideas*, Vol. 69 No. 1 (January 2008): 147-162.
- Midgley, Mary. *Can't We Make Moral Judgements?* Bristol: Bristol Classical Press, 1991.
- Midgley, Mary. *Science as Salvation: A Modern Myth and its Meaning*. London: Routledge, 1992.
- Midgley, Mary. *The Myths We Live By*. London: Routledge, 2004.
- Mitchell, W.J.T. *Picture Theory: Essays on Verbal and Visual Representation*. Chicago: University of Chicago Press, 1995.
- Monod, Jacques. *Chance and Necessity: Essay on the Natural Philosophy of Modern Biology*. Translated by Austryn Wainhouse. New York: Vintage Books, 1972.
- Montaigne, Michel. *The Complete Essays*. Translated by M. A. Screech. London: Penguin Books, 1991.
- Nelson, Robin. *Practice as Research in the Arts: Principles, Protocols, Pedagogies, Resistances*. London: Palgrave Macmillan, 2013.
- Nietzsche, Friedrich. *The Joyous Science*. Translated by R. Kevin Hill. London: Penguin Classics, 2018.
- Oppenheimer, Robert 'Oppenheimer's Farewell Speech', Atomic Heritage Foundation. Accessed 19 July, 2019, <https://www.atomicheritage.org/key-documents/oppenheimers-farewell-speech>.
- Overfield, Kathy. 'Dirty Finders, Grime, and Slag Heaps: Purity and the Scientific Ethic.' In *Men's Studies Modified: The Impact of Feminism on the Academic Disciplines*, edited by Dale Spender. Oxford: Pergamon Press, 1981.
- Phys Org. 'Research confirms creativity is key for both arts and science.' *Phys Org*, 22 July, 2020: <https://phys.org/news/2020-07-creativity-key-arts-science.html>.
- Physics World. 'CERN's emissions equal to a large cruise liner, says report'. 19 September, 2020: <https://physicsworld.com/a/cerns-emissions-equal-to-a-large-cruise-liner-says-report/>
- Plant, Sadie. *Zeroes and Ones: Digital Women and the New Technoculture*. London: Fourth Estate, 1997.
- Plutarch, *Moralia, Volume V*. Translated by Frank Cole Babbitt. Loeb Classical Library: Harvard University Press, 1936.

- Polizzotti, Mark. *Sympathy for the Traitor: A Translation Manifesto*. Cambridge: MIT Press, 2018.
- Prescod-Weinstein, Chanda. 'Making Black Women Scientists under White Empiricism: The Racialization of Epistemology in Physics.' *Signs*, Vol. 45 No. 2 (2019).
- Prescod-Weinstein, Chanda. *The Disordered Cosmos: A Journey into Dark Matter, Spacetime, and Dreams Deferred*. New York: Bold Type Books, 2021.
- Rhodes, Richard. *The Making of the Atomic Bomb*. New York: Simon & Schuster, 1986.
- Røstvik, Camilla. 'At the Edge of their Universe: Artists, Scientists and Outsiders at CERN'. PhD diss., University of Manchester, 2016.
- Roy, Arpita. 'Ethnography and Theory of the Signature in Physics.' *Cultural Anthropology*, Vol. 29. Issue 3. 479-502.
- Rubenstein, Daniel. 'Philosophy and Photography.' Paper presented at the Light | Sensitive | Material conference, University of West London, 2 November, 2019.
- Russell, David. 'The Best Books on The Victorian Essay: A Five Books Interview.' Interview by Schneider, Leonid. 'The Alpha Males of Physics.' *For Better Science*, 2 October, 2018. <https://forbetterscience.com/2018/10/02/the-alpha-males-of-physics/>
- Stephanie Kelley. *Five Books*. Accessed 4 August, 2019. <https://fivebooks.com/best-books/victorian-essay-david-russell>
- Salisbury, Laura. 'Michel Serres: Science, Fiction and the Shape of Relation.' *Science Fiction Studies* Vol 33, no 1 (2006):30-52.
- Sarukkai, Sundar. *Science and Narratives of Nature: East and West*. Milton Park: Routledge, 2017.
- Schiebinger, Londa. *Has Feminism Changed Science?* Cambridge: Harvard University Press, 1999.
- Seneca, Lucius Annaeus. *Epistles, Volume III: Epistles 93-124*. Translated by Richard M. Gummere. Loeb Classical Library: Cambridge: Harvard University Press, 1925.
- Serres, Michel. *Hermès*. 5 vols. Paris: Les Éditions de Minuit, 1968-1980.
- Serres, Michel. *Hermès V. Le passage du Nord-Ouest*. Paris: Les Éditions de Minuit, 1980.
- Shani, Tai. 'Why Art Workers Must Demand the Impossible.' *Art Review*, 1 September, 2020.
- Sharpe, Christina. *In the Wake: On Blackness and Being*. Durham: Duke University Press, 2016.
- Shukin, Nicole. *Animal Capital: Rendering Life in Biopolitical Times*. Minneapolis: University of Minnesota Press, 2009.
- Sismondo, Sergio. *An Introduction to Science and Technology Studies*. Oxford: Wiley-Blackwell Publishing, 2010.
- Snow, C.P. *The Masters*. London: Macmillan Publishers, 1951.

- Snow, C.P. *The Two Cultures and the Scientific Revolution*. Cambridge: Cambridge University Press, 1959.
- Stengers, Isabelle and Ilya Prigogine. *Order Out of Chaos: Man's New Dialogue With Nature*. London: Verso, 2017.
- Stengers, Isabelle. *Another Science is Possible: A Manifesto for Slow Science*. Cambridge: Polity Press, 2018.
- Subramaniam, Banu, and Mary Wyr. 'Assimilating the "culture of No Culture" in Science: Feminist Interventions in (De)mentoring Graduate Women.' *Feminist Teacher* Vol. 12, 1 (1998): 12-28.
- Sundberg, Juanita. 'Decolonizing posthumanist geographies.' *Cultural Geographies* Vol. 21 No. 1 (2014): 33-47.
- Traweek, Sharon. *Beamtimes and Lifetimes*. Cambridge: Harvard University Press, 2009.
- Tyndall, John. 'Address Delivered Before the British Association Assembled at Belfast, With Additions', Longmans: Green and Co., 1874.
- Van Fraassen, Bas. *Scientific Representation: Paradoxes of Perspective*. Oxford: Oxford University Press, 2008.
- Venuti, Lawrence. *The Translator's Invisibility*. 1st reprint edition. Abingdon: Routledge, 2017.
- Wade, Jess. 'Why we need to keep talking about equality in physics', *PhysicsWorld*, August 2019. <https://physicsworld.com/a/why-we-need-to-keep-talking-about-equality-in-physics>
- Wessling, Janneke. *See it Again, Say it Again: The Artist as Researcher*. Valiz: Antennae, 2008.
- Wertheim, Margaret. *Pythagoras' Trousers: God, Physics, and The Gender Wars*. London: Fourth Estate, 1997.
- Whitten, Barbara L. 'What Physics Is Fundamental Physics? Feminist Implications of Physicists' Debate over the Superconducting Supercollider.' *NWSA Journal*, Vol. 8 No. 2 (Summer 1996): 1-16.
- Whitten, Barbara L. '(Baby) Steps Toward Feminist Physics.' *Journal of Women and Minorities in Science and Engineering*, Vol. 18 No. 2 (2012): 115-134.
- Williams, Raymond. *Keywords: A Vocabulary of Culture and Society*. Revised ed. Oxford: Oxford University Press, 1985.
- Wylie, Alison. 'Gender Politics and Science.' In *The Disunity of Science: Boundaries, Contexts, and Power*, edited by Peter Galison and David J Stump. Stanford: Stanford University Press, 1996.