Vital Assemblages: A Fashion-Led Research Investigation into Collaboration Between Fashion Design Research and Biology

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For Eamonn John Michael Geaney

24.07.1954 – 20.11.2019

With all my heart

L y m XXXX

SUBMISSION COMPONENTS

This submission takes the form of:

A thesis;

A volume containing processual documentation of six collaborative projects;

and

A volume containing tables.

RESEARCH QUESTIONS

Research Question 1: *What can collaborations between a fashion-led researcher and biologists contribute to fashion design research?*

Contribution 1: This thesis contributes to understandings of the potential of relationships between fashion-led research and biology, in particular. This project demonstrates the agility of fashion's role within collaborations between a fashion-led researcher and biologists, specifically in response to actors, materials and context.

Research Question 2: *What types of distinctive and shifting roles can fashion-led researchers take on in interdisciplinary teams?*

Contribution 2: This thesis contributes to understanding the potential of fashion-led research to play a distinctive role in interdisciplinary teams, in general. This project identifies a typology of roles that the fashion-led researcher takes on within interdisciplinary teams, including ways in which they are negotiated in the process, in the context of materiality, agency and assemblage.

ABSTRACT

This practice-led PhD contributes to understanding the potential of the relationship between fashion-led research and biology, asking: *What can collaborations between a fashion-led researcher and biologists contribute to fashion design research?* The project also focuses on understanding the types of distinctive roles taken on by fashion-led researchers within interdisciplinary teams, asking: *What types of distinctive and shifting roles can fashion-led researchers take on in interdisciplinary teams?* This study provides new insights into the types of roles, value and agential relations of fashion-led research in these forms of interdisciplinary interaction.

While the mechanisms of interdisciplinary collaboration have been more widely explored within other design disciplines, there is a gap for studies into the role of fashion in collaboration with biology. Fashion, by its very nature, is collaborative (Kawamura, 2018:2), and has often worked with fields both inside and outside its own discipline. In this study, collaboration offered a way for fashion to approach interdisciplinarity in working with biologists, bacteria and living systems. This is important for fashion design research – in building understandings of fashion's role in today's interdisciplinary context, particularly for fashion practitioners operating in emergent disciplinary spaces such as biodesign, biofabrication and biofashion.

I employed a qualitative multi-method fashion-led research approach to examine two case studies, a series of collaborative projects, scientific collaborator interviews and a series of workshops. Underpinning this research, my theoretical context drew on assemblage, agency and materiality from new materialisms. This methodology and theoretical context enabled me to understand the types of roles a fashion-led researcher can play, and how these roles are agile in response to agential shifts and assemblage configurations.

This thesis highlights the range of roles a fashion-led researcher can assume in interdisciplinary teams, including: intuitive and sensory, curious, translator, facilitator, provocateur and risk-taker, seducer and societal or public-facing communicator. Vitally, these roles are understood as negotiated – formed through interactions with humans and nonhumans – including myself as a fashion-led researcher, bacteria, fabric and biologists. By understanding the potential of these emerging roles, this research project acts to broaden the possibilities for fashion practitioners to operate as future fashion-led researchers.

INTRODUCTION

This thesis provides new insights into the relationship between fashion-led research and biology[1] during interdisciplinary collaboration.[2] It offers new understandings of the potential of fashion-led research to play a distinctive role within interdisciplinary teams with biologists, primarily in academic and cultural contexts.[3] This is important at a time when boundaries are blurring and new opportunities for fashion increasingly lie in collaborating outside the discipline. This fashion-led research account shares knowledge and understanding of the types of roles, agential relations and practices that can arise during the process of interdisciplinary collaboration.

I employed a bespoke, multi-method fashion-led approach, led by the practice, to examine collaborative approaches between fashion and biology, where fashion practitioners hold agency from the outset. I developed a series of six collaborative projects from a fashion practitioner's perspective. Interview analysis, a case study methodology and reflexivity were used to draw out new understandings of the relationship between fashion and biology from plural perspectives by questioning practitioners working across the disciplines of fashion design, microbiology and synthetic biology. A series of interdisciplinary workshops uncovered new insights into the potential of fashion-led research to play a distinctive role in interdisciplinary teams.

This research shares how a combination of practice-led research – working directly with bacteria – and theoretical framing – drawn from assemblages, agency and materiality,[4] as understood in relation to new materialisms – shaped the roles of a fashion-led researcher. This enabled wider understandings of the function and value of fashion-led research in team environments – through an expanded understanding of teams as human and nonhuman assemblages. Within the enquiry, this notion of collaboration evolved in response to working

[1] As per the Glossary, in this thesis, the terms biology and biologists, (science and scientists), are used more broadly to encompass working with biology and biological systems, including microbes (microbiology and microbiologists) and engineering using DNA to create new biological systems (synthetic biology and synthetic biologists).
[2] Interdisciplinary collaboration is understood as the combination and interaction of at least two disciplines, producing an integrative approach that works towards a shared purpose (Darbellay, 2015:165–166).
[3] Situating collaboration in an academic context removed the requirement for innovation in the form of commercial outputs for fashion and allowed an emphasis on the process of collaboration and fashion's role within it. This emphasises the practice-led – or fashion-led – nature of the study, with shared knowledge production emanating from the process rather than outcomes.
[4] Assemblage, agency and materiality are discussed in further depth in the Theoretical Context chapter and are the key terms of analysis used to examine the case studies and collaborative projects within the Data Discussion chapter.

with bacteria and experiencing the interplay between human and nonhuman agency. This project started with an approach more closely aligned to a top-down, problem-solving mindset. Growing, culturing and exploring the bacteria led to a shift in my perspective: from initially viewing bacteria as research subject, to seeing it as a co-actor within the collaborative assemblages. This expanded my understanding of fashion practices as preoccupied with bodies – both human and nonhuman – and distinctive as a result of the reciprocal agential relationship between these bodies and the cloth. This, in turn, led to a key shift in my understanding of the role of a fashion-led researcher as less hierarchical and more agential.

This project therefore understands collaboration in combination with biology and living systems as assemblages, encompassing human and nonhuman actors, inclusive of myself as a fashion-led researcher, biologists, bacteria, fabric and garments. Viewing the collaborations in this way – as flat ontologies – and positing the fashion-led researcher, biologist and bacteria as key actors, exposed and shaped understandings of the distinctive, multiple and shifting roles of a fashion-led researcher.

The thesis uses collaboration as a method to enable a closer demarcation of own disciplinary boundaries. This enabled new understandings of the role and practices of the fashion practitioner in fashion-led research. My role as a fashion-led researcher was in flux and shifted as part of these human–nonhuman collaborative assemblages. Fashion-led research in collaborative assemblages is identified as distinctive in its encouragement and allowance of discursive, shared approaches inclusive of roles such as active observer, facilitator, provocateur and co-creator. Understanding and sharing these practices and roles shows how fashion can integrate, infiltrate, provoke, question, lead, share and co-create when working in interdisciplinary teams.

Fashion-led research is argued as a research lens and perspective, related to fashion design practices and therefore bodily and sensory aspects, which focuses on sharing new knowledge gained through its methods and processes. This exposes a key shift from fashion-based studies, where the main emphasis lies on knowledge gained from final outcomes. My research shows the value a fashion practitioner can bring during collaborative approaches with biologists. It reveals how fashion-led research can offer material sensitivity, fluidity and a space for dreaming, while also being practical, communicative and outward-facing to society.

Contributions of the Investigation

Contribution 1: This thesis contributes to understandings of the potential of relationships between fashion-led research and biology, *in particular*. This project demonstrates the agility of fashion's role within collaborations between a fashion-led researcher and biologists, specifically in response to actors, materials and context.

Contribution 2: This thesis contributes to understanding the potential of fashion-led research to play a distinctive role in interdisciplinary teams, *in general*. This project identifies a typology of roles that the fashion-led researcher takes on within interdisciplinary teams, including ways in which they are negotiated in the process, in the context of materiality, agency and assemblage.

Context

The project is situated in a climate of heightened interdisciplinarity, coming at a time that fashion designers and microbiologists alike describe as a biological paradigm (Freemont, 2016). Emerging interdisciplinary areas between art, design and science, such as biological design, biological art and biofabrication,[5] are gaining increasing cultural traction (Collet, 2015a:12; Lee, 2019b; Lee et al., 2020:5; Broach, 2019). Biofabrication and the concept of producing living biological materials using microbiology, synthetic biology and bacteria offer seductive visions for catalytic shifts for fashion – in the way we think about, produce, consume and wear fabrics and clothing (Collet, 2015a:12). Understanding the potential roles of fashion practitioners within teams comprising biologists is relevant in the context of the emerging areas of biofabrication and biofashion. My study highlights the value of fashion-led research and its thinking as part of an emerging collaborative landscape within and beyond fashion design.

[5] Lee et al. (2020) state that: 'The last 5 years have seen a pronounced increase in excitement around "biomaterials" for the fashion industry' and they define biofabricated materials as: "produced by living cells (e.g. mammalian) and microorganisms such as bacteria, yeast and mycelium"' (Lee et al., 2020:7.). This study remains cautious about making a direct link between biologically produced materials and sustainability, instead focusing on examining the processes and approaches of interdisciplinary collaborations that can allow a space for wider voices and disciplines to join interdisciplinary conversations.

CONTEXTUAL[6] REVIEW

Introduction

In this chapter I examine the existing literature on interdisciplinary collaboration between designers and biologists to set out how fashion, in particular, operates and the types of roles that its practitioners assume in collaboration. I draw on specific accounts of interdisciplinary collaboration between designers, artists and biologists by Peralta (2013), and Benony and Maudet (2020), with reference to Collet (2012a:7), and Agapakis and Lee (2019). I selected Peralta (2013) and Benony and Maudet (2020), as their research specifically explores the types of roles that designers can take on and therefore their value in interdisciplinary collaborations, between design and biology (Peralta & Moultie, 2010:1643). I selected Collet (2012a:7), Agapakis and Lee (2019), as they discuss the importance and value of designers working from the inception of interdisciplinary projects with biologists and, in the case of Collet and Lee, come from a fashion and textile practitioner perspective. This allowed me to set out a framework of proposed roles for designers and design researchers, and their groundwork enabled me to expand upon their findings through my own workshops and collaborations (as set out in the Data Discussion chapter) in sharing some of the types of roles that fashion-led researchers assume in interdisciplinary teams when working from project inception.

Definitions of the forms of collaboration are much contested and debated in the literature. For example, definitions of the terms cross-disciplinary, interdisciplinary, multidisciplinary and transdisciplinary are widely argued and used interchangeably in the field by design research scholars (Stember, 1991:4; Bremner & Rodgers, 2013:9–12). Within this enquiry, I focus on interdisciplinary collaboration, which I discuss briefly here and in further detail in the Interdisciplinary Collaboration as Method section of my Methods chapter. Interdisciplinary collaboration is understood in this thesis as the synthesis and incorporation of elements of the practice of at least two disciplines for a shared purpose (Darbellay, 2015:165–166). My understanding of interdisciplinary collaboration is set within the context of fashion-led research and biology – specifically microbiology, synthetic biology and bacteriology – and involves the

[6] A contextual review is understood, according to Gray's articulation, as a characteristic of practice-led research established in generation 3 by the extension of a literature review into a contextual review, encompassing both literary and non-literary references and sources available in the public domain (Gray, 1996:23). Here, I draw on Gray's definition and take into account both literature and practice, including digital sources.

integration of methods of collaboration and cooperation between these two disciplines. I draw on Darbellay's form of interdisciplinary collaboration, which combines practitioners who are specialised and experts in their own disciplines and principally undertaking their own disciplinary roles (2015:165–166). This form enabled me to operate as a fashion-led researcher, in collaboration with biologists so that, together, we held the requisite disciplinary knowledge to produce bodily related[7] bacterial-material outcomes.

Definitions of the terms 'practice-based' and 'practice-led' are still relatively unsettled within the design research and fashion design research literature (Candy & Edmonds, 2018:63). Linda Candy[8] and artist and researcher Ernest Edmonds propose this distinction:

> '1. If a creative artifact [*sic*] is the basis of the contribution to knowledge, the research is practice-*based*.
>
> 2. If the research leads primarily to new understandings about practice, it is practice-*led*' (Candy & Edmonds, 2018:64).

It is this definition that I extend into the context of fashion. Therefore, definitions of fashion-led research and fashion-led researchers in this thesis are:

> Fashion-led: If the research leads primarily to new understandings about fashion practice, it is fashion-*led* (drawing from: Candy & Edmonds, 2018:64).
>
> Fashion-led researcher: a fashion-led researcher whose work leads primarily to new understandings about fashion practice.

Candy elucidates that practice-led focuses on the practice itself and its processes, and contributions to knowledge are valuable for operations, such as new methods (Candy, 2006:1).

[7] I expand the notion of the term 'bodily' as I understand the interactions through the theoretical context of the new materialisms. The term here is an expanded understanding of bodies, referring not just to human bodies but to bacterial and nonhuman bodies.
[8] Dr Linda Candy is a researcher who has written extensively on the topics of practice-led and practice-based research within the creative arts. primarily focusing on practice-based (for example: Candy, 2006; Candy & Edmonds, 2018).

This understanding of practice-led supports Archer[9] and Frayling's[10] early categories of 'Research through'[11] and Savin-Baden and Major's proposal of an arts-based inquiry (2013:293–294), where the process of the practice leads to the production of knowledge. Practice-based design research differs, as the knowledge is transmitted via the object itself – in accordance with Frayling's 'Research for' (Frayling, 1993:5). These definitions are useful in understanding the origins of the terms; however, none of these terms have come from and through fashion design research itself. In this chapter I argue that fashion-led research is distinctive – therefore warranting expansion in terms of understanding its value to interdisciplinary teams.

In the following section of the Contextual Review chapter, I argue that there is one main gap and three related gaps in the literature, leading to the rationale and space for my study. First, I provide an overview of these gaps below, in the Gaps in the Literature section, before expanding upon them in the Evidencing the Gaps section. I then investigate the literature and practice to set out the pre-existing roles of designers identified during collaborations between designers and scientists. I discuss how fashion-led research is distinctive, and how fashion has been largely excluded or marginalised in the existing literature of accounts of design and biology in collaboration. Lastly, I show how existing literature and practice has primarily centred on practice-based dissemination, offering a gap for practice-led research approaches

[9] Professor Bruce Archer was a mechanical engineer, academic and design theorist who worked at the Royal College of Art as Research Fellow from 1961, before running his own Department of Design Research (DDR) from 1971 to 1984. The DDR was specifically for postgraduate design research students and was crucial for establishing contemporary modes of design research in formally academising the discipline (Frayling, 2005; L. Bruce Archer archive, 1960–2005). Archer described plural meanings of research, distinguishing between research in the science tradition and research in the humanities tradition (Archer, 1995). He identified key differences in the art and design traditions of research: 'practice', 'scholarship' and 'research into', terming them 'research about practice; research for the purposes of practice; and research through practice' (Archer, 1995:8–11).

[10] Christopher Frayling set out three modes of art and design research as 'Research into', 'Research through' and 'Research for'[10] (Frayling, 1993:5). Frayling's 'Research through' is closest to contemporary understandings of practice-led (Mottram, 2009:235). It uses applied methods, such as researching materials, methods of process and production and new uses or adaptions of technology, highlighting the importance of the communication of the results of these projects (Frayling, 1993:5).

[11] There is debate regarding the coining of these three modes: although Frayling's paper predates Archer's, it is claimed that Archer coined the terms: 'Research about practice; Research for the purposes of practice; and Research through practice' (Archer, 1995:8–11) during the 1960s, which Frayling may have built upon (Pedgley & Wormald, 2007:72). It is also argued that Frayling adapted these groupings from Herbert Read's model for art education as categorisations for art and design research (Read, 1958; Rust et al., 2007:11). Nonetheless, Frayling's paper distinguished 'Research into' as a form of contextual research, investigating the history, aesthetics or theories surrounding art and design practice (Frayling, 1993:5). Frayling described 'Research for' as a form of knowledge where the research is bound in the object itself, and thus information is communicated visually rather than via verbal or linguistic means. 'Research for' is therefore closest to definitions of practice-based research, in which the designed object is also viewed as a form of knowledge transmission. Furthermore, Frayling differentiated between research 'with a little r' (Frayling, 1993:1) and 'Research with a big R' (ibid.), which I adhere to by capitalising Frayling's references to Research, in accordance with his definitions. Frayling argues that 'Research through' is closer to research with a capital R, in comparison to research '*for* art and design' (Frayling, 1993:5), which he states is closer to dictionary definitions of research with a small r. The capital R is argued by Frayling as a professionalisation of research via the development of art and design research, for example, via the production of postgraduate research degrees and PhDs (Frayling, 1993:1).

such as this study. I summarise this chapter by highlighting that there is a gap for, and therefore value in, unfolding collaborative processes between fashion and biology, and examining the potential of the roles of a fashion-led researcher in interdisciplinary teams.

Gaps in the Literature

In this section I provide an outline of the gaps identified in the literature, which paved the way for my own doctoral research study.

The main gap identified is that there are few existing accounts of interdisciplinary collaboration between fashion designers or practitioners and biologists. Existing literature has largely focused on design in collaboration with biology from the perspective of other design disciplines, such as product or industrial design (see: Benony & Maudet, 2020; Maudet et al., 2020; Driver et al., 2011; Peralta & Moultie, 2010) or on art and science in collaboration (for example: Snow, 1998:2; Ede, 2005:5). Fashion has been less prevalent or excluded from seminal literature in the contemporary design and biology field, such as *Synthetic Aesthetics*, *Biodesign* and *Bioart* (Ginsberg et al., 2014; Myers & Antonelli, 2012; Myers, 2015). Four projects closest to a material practice included in *Biodesign* (Myers & Antonelli, 2012) are: Suzanne Lee's *Biocouture* project, artists Oron Catts and Ionat Zurr's *Victimless Leather* project, textile researcher Amy Congdon's *Biological Atelier* and Natsai Audrey Chieza's *Design Fictions*. What is important is what they share: methods of growing bacterial cellulose and images of the kombucha SCOBY (symbiotic culture of bacteria and yeast) and Lee's final garment outcomes (Myers & Antonelli, 2012:109); and information and imagery on Congdon and Chieza's concepts, future provocations, research questions and collaborator details (Myers & Antonelli, 2012:172–177). Only Catts and Zurr's section alludes to the inner workings of the collaborative relationship between themselves and the organisms, and their role – as 'agitators or provocateurs[12] who set up contentious situations and objects, and welcome critique' (Myers & Antonelli, 2012:133). Moreover, of the four, only Suzanne Lee has a fashion background.

This key gap for studies on fashion in collaboration with biology provides a space for my doctoral research. My doctoral study and collaborative projects offer a distinct perspective for

[12] The provocateur role is also ascribed to designers in design and science collaborations: 'designers can act as provocateurs in the early stages of interdisciplinary work' (Rust, 2007:69).

fashion-led researchers in understanding our role and how it plays out in fashion and biology collaborations. My enquiry is therefore important in adding to the literature on collaboration between fashion and biology, as I contend that fashion-led research is distinctive from other areas of design and design research in terms of its roles and relationship when collaborating with biology.

Where fashion design in collaboration with biology accounts exist, there are two gaps: first, although there are few existing first-hand fashion designer accounts of the processes of collaboration between fashion and biology, there is a gap in first-hand fashion-led researcher studies. Social scientists, scholars of fashion theory and fashion studies have discussed fashion in collaboration with science, but they do not employ a first-hand practice-led approach (such as: Balmer et al., 2015; Calvert & Schyfter, 2017; Evans, 1998; Evans, 2003; Lee, 2005; Granata, 2017). Fashion designers have discussed their collaborations, but principally in terms of outcomes (focusing on practice-based) rather than on the processes and mechanisms of the collaborations (focusing on practice-led). My study looks first-hand at how collaboration between fashion and biology operates from a fashion-led research perspective.

Second, within the existing literature on fashion design in collaboration with biology, there is a gap in literature focusing on the roles a fashion-led researcher can play in collaboration with biologists. Fashion and textile design researchers discussing biology and science have previously focused on aspects such as material research, novel directions and innovations (Congdon, 2020; Dade-Robertson et al., 2017; Ivanova, 2015; Ng & Wang, 2016), sensory or artistic experimentations and outcomes (Tillotson, 1997; Franklin, 2014), biomimetics (Kapsali & Vincent, 2020; Scott, 2018; Scott, 2015; Kapsali, 2009) and fashion or textile design and biology in relation to sustainability, ecological design and circular systems (Ribul, 2019; Ellams, 2016; Congdon & Albert, 2016; Collet, 2012a, 2012b, 2015a, 2015b). This presents a gap for my study, which focuses on the potential roles of a fashion-led researcher, within fashion and biology collaborations.

To provide evidence and argue for these gaps, it was necessary to draw on accounts of collaboration from design disciplines outside fashion, in this case with biologists from other design disciplines, such as textile, industrial and product design. It was necessary to search wider than fashion because of the scarce literature on the roles and relationships of practitioners during interdisciplinary collaboration between fashion and biology. I thereby draw on literature

on design and biology collaborations to identify existing roles assumed by designers and design researchers.

Evidencing the Gaps: Interdisciplinary Collaboration

There is a large body of literature on collaboration, co-design,[13] participatory practice and interdisciplinarity within both art and science, and design and science (for example, see: Barry et al., 2008; Born & Barry, 2010; Barry & Born, 2013; Inns, 2010; Fairburn et al., 2016; Shumack, 2015; Sanders & Stappers, 2008). There is also sufficient research into textile design practice and collaboration, whether between science, technology, engineering and mathematics (STEM) subjects or industrial stakeholders (see: Morgan & Matthews, 2017; Earley & Hornbuckle, 2017; Richardson, 2013). However, there are few specific examples of literature discussing a congruence of fashion and science, and even fewer on collaborative approaches between fashion-led researchers and biological practice. Therefore, although there is a distinction between fashion-led researchers and designers, I largely draw on approaches from designers within this section of my review.

In the existing literature on interdisciplinary collaboration between designers and biologists, there is a gap for fashion design accounts. Fashion design has typically been less prevalent in the literature on interdisciplinary collaboration between design and biology, arguably as there are fewer examples of fashion in collaboration with biology. For example, the book *Synthetic Aesthetics* discusses the 2009 project of the same name, which brought together artists and designers to collaborate with synthetic biologists (Calvert & Schyfter, 2017:195). In this sense, it offers a rare and important account of collaborations between the areas of synthetic biology, art and design.[14] However, *Synthetic Aesthetics* highlights a principally practice-based approach. The book's chapters are largely written around key concerns and themes arising from the collaborations, and matters regarding synthetic biology and design, rather than offering

[13] The science fashion approaches illustrated in this study differ in their employment of integrated fashion and science methods and the amounts of shared dialogue between the separate actors. I argue that this takes it away from co-design methods and into a separate interdisciplinary space where each practitioner works as an expert in their field. Co-design typically employs a range of participants, which may include non-experts, to collaboratively shape design outcomes using their 'everyday perspectives' (Shumack, 2015:237). In contrast, the projects illustrated in this thesis highlight the culmination of expertise from differing disciplines, separating them from both co-design and a singular fashion design or scientific approach (where expertise may be drawn purely from within one's own discipline).

[14] The project leaders were interdisciplinary, comprising: artist and designer Ginsberg, science and technology studies (STS) researchers Calvert and Schyfter, and synthetic biologists Elfick and Endy. This group led the project, selecting participants and pairing them with collaborators (Calvert & Schyfter, 2017:197).

details and first-hand accounts of the inner workings, roles or methods utilised within the collaborations.[15]

Most importantly to my study, none of the participants were from fashion design backgrounds. *Synthetic Aesthetics* is an example of how key literature on interdisciplinary collaboration between design and synthetic biology has omitted fashion. This gap offers the space for my study, which focuses on fashion to share new understandings of the role and value of fashion-led research in collaboration with biologists. My research enquiry is therefore useful for future fashion designers and fashion researchers entering an increasingly interdisciplinary landscape.

Where literature on interdisciplinary collaboration in synthetic biology has focused on design, this has been mainly explored by researchers in disciplines outside the design field – such as science and technology studies (STS). Calvert and Schyfter (2017) offer an account of the collaborations in *Synthetic Aesthetics*, giving further insights into their operations. However, the paper is written from the authors' perspectives as STS researchers, and they set out to compare their STS research methods with the concerns of artists and designers on the project, rather than offering the point of view of the artists and designers themselves. This means that in Calvert and Schyfter's paper (2017) we do not hear directly from the art and design practitioners sharing their own new knowledge of operating within a collaboration, but rather from researchers in another field applying their own principles and methods to collaborative art and design projects. While accounts written from the perspective of disciplines outside of design are valuable to the expansion of knowledge into interdisciplinary ways of working across the sciences, social sciences and arts, I argue that accounts written by and for practitioners allow a first-hand perspective through practice-based and practice-led specific and own disciplinary methods.

More recently, Szymanski et al. (2020) offer a useful study into interdisciplinary collaboration between artists, social scientists and biologists. The paper discusses the project *Crossing*

[15] In the chapter *Living among living* things, Carey et al. offer the closest explanation of the design and science process taken during their collaborative approach and a discussion on the roles design can play during interdisciplinary interactions with scientists (Carey etl al., 2014:169–180). The designers share the IDEO design process and discuss its similarity with scientific processes of creativity, experimentation and research (Carey et al., 2014:172; 178–179). While the chapter is useful for discussing these roles and processes, the designers involved, Will Carey and Adam Reineck, were both industrial designers from IDEO (Carey etl al., 2014:169). The gap remains for similar accounts, written from a first-hand fashion design perspective, of collaboration with scientists.

Kingdoms – an experiment between the actors, each bringing different questions and aims from their own disciplines. Of key importance here is the employment of artist-led methods and an acknowledgement of the scarcity of such projects: 'guided by artistic research interests, rather than by goals to promote scientific research' (Szymanski et al., 2020:2). The artists, Catts, Zurr and Bates,[16] articulate their own specific research questions and the paper suggests the roles taken on by each actor were 'identified through working together' (ibid.). The inclusion of the artists' voices is further highlighted as they are co-authors of the paper. The authors state that their study diverges from many examples of art-science collaborations through chiefly being guided by artistic research drivers (ibid.). In this sense it highlights the scarcity of artist-led projects in art-science and offers a space from which my own study builds, in a fashion-led research context.

In terms of the role of art, *Crossing Kingdoms* suggests how artist-led ways of working invited each actor to become more critically reflective, and to pose questions rather than offer solutions to problems (Szymanski et al., 2020:5–6). Specific roles of art are presented by artists Catts and Zurr including that of 'meaning makers', 'disruptor', and challenging and exploring subjects in terms of ontology, epistemology, politics and ethics (2018:40–42). They state that artists' roles can 'involve aesthetics, reimagining, making strange, social fact gathering, humour, irony, satire [...] Art gets its power from its perceived frivolity and non-utility in terms of its material outcomes' (Catts & Zurr, 2018:42). They highlight how this perception of frivolity offered them a space for criticality and reflexivity, which demonstrates that the role of the artist is more than a vehicle for the promotion of science within art-science interactions (ibid.). This also indicates how collaboration allowed for reflection on own disciplinary roles and practices (Szymanski et al., 2020:5). Although this example highlights the roles that art, rather than fashion, can assume – it shows the importance of the inclusion of artists' perspectives, and in this study fashion's perspectives, in opening up different conversations and reflections in interdisciplinary interactions.

[16] Oron Catts, Ionat Zurr and Tarsh Bates are three influential biological artists operating from SymbioticA, University of Western Australia (UWA). In 1996, artists Oron Catts and Ionat Zurr formed the internationally renowned Tissue Culture & Art Project which led to the establishment of SymbioticA - their artist-led laboratory in the University of Western Australia, in 2000; Catts operates as the Co-Founder and Director of SymbioticA: the Centre of Excellence in Biological Arts, School of Human Sciences (University of Western Australia, 2020b). Dr Ionat Zurr is a researcher and lecturer at the School of Design (UWA) and SymbioticA's academic co-ordinator (University of Western Australia, 2020a). Catts, Zurr and Bates each undertake artistic practices working with living systems such as tissue culture, which blur between biotechnology, ethics and art (University of Western Australia, 2020a; 2020b; 2020c).

Specifically in the context of fashion[17] in collaboration with science and technology, *Re-FREAM's Art Tech* Toolbox (Montagnino et al., 2020) offers an overview of co-creative methods and ways of working between art, fashion and science. The report principally details the work of fashion practitioners who have operated as part of *Re-FREAM's* fashion and science collaborations (Montagnino et al., 2020:40–59). The project descriptions suggest some of the distinctive aspects of fashion, as a form of 'aesthetic research', 'an interface', expressive and interactive, and an area that 'explores emotional and technological relationships' where the body is a key focus (Montagnino et al., 2020:43–58). The role of fashion is discussed as aesthetic, emotional and body centred. What is missing are the specificities of the types of roles which fashion practitioners brought to such collaborations and, while offering overviews of collaborative practices through design research theory and diagrams, specific examples of the relationships between the interdisciplinary actors in such collaborations. Again, this shows a gap for my study in presenting understandings gained from first-hand fashion-led collaborations into roles and relationships between fashion-led research and biology.

Claudia Schnugg's *Creating Artscience Collaboration* (2019) offers insights into collaborative projects featuring fashion and textiles: with the inclusion of fashion designer Annouk Wiprecht's *Agent Unicorn* project, material researcher Natsai Audrey Chieza and *Gingko Creative Residencies* and examples by artists exploring biology such as Anna Dumitriu, Oron Catts and Ionat Zurr. Schnugg describes how collaboration brought about shifts in ways of working – with Wiprecht moving to create a product which was both fashionable as well as functional (Schnugg, 2019:57–61) and Chieza highlighting the importance of networking and relationality (Schnugg, 2019:75–76). These suggest key aspects which may be particular to fashion and material research in collaboration, on which my research builds. Schnugg's inclusion of multiple perspectives (scientists and artists or designers) and her focus on roles and relations within these forms of collaboration also pave the way for this study in which I offer a first-hand perspective from fashion-led research and biology collaborations.

A key example of a design researcher exploring the roles of product designers, when working in interdisciplinary teams with scientific researchers, is designer, researcher and Senior Lecturer in Design at the University of Brighton – Dr Carlos Peralta. Peralta (2013) offers a

[17] Fashion in the *Re-FREAM's Art Tech* Toolbox report is discussed as part of a broader umbrella of the arts and arts research (Montagnino et al., 2020).

valuable study of interdisciplinary collaboration between product designers and scientific researchers. Peralta's study is key in offering a focus on the role of designers within collaborations; however, his focus is on identifying the roles and ways in which designers can contribute to scientific research,[18] rather than to design or design research itself. Understanding that Peralta's study is useful in promoting the value of collaboration for scientists, and how this can contribute to the inclusion of more designers from the outset of scientific research, ensures his study is meaningful to the disciplines of both product design and science. The gap remains in studies looking at interdisciplinary collaboration between designers and scientists to contribute to design research itself.

In his doctoral thesis Peralta summarises designers' and scientists' contributions and roles within collaborative projects, identified through key papers[19] in his literature review (Peralta, 2013:36). He brings together these authors' summaries of the key contributions of designers to scientific research (Peralta, 2013:36), including:

- Having an ability to unlock 'tacit' knowledge
- Acting as connectors between the science and the general public
- Providing modes of experimentation and reflection
- Encouraging novel ideas for research directions
- New or different contexts for scientific findings
- Divergence of thinking
- Constructing models to simulate and represent
- Designing artefacts for testing and experimenting
- Ideating scenarios
- The ability to find applications for scientific research outcomes
- Visualising scientific ideas

Peralta also summarises the findings of Pearce et al. (2003) in understanding the ways in which artists and scientists collaborate and the differing roles of artists (Peralta, 2013:36). These include:

[18] Peralta's thesis focuses on the natural sciences rather than social sciences (Peralta, 2013).
[19] These include the papers of Rust (2004, 2007), Gault and Kogan (2010), Persson and Warell (2003), and Dawson (2002).

- Own disciplinary knowledge
- Communication and design skills
- Project management skills
- Lateral ways of thinking about science
- Consideration of the social and human dimensions of technologies
- Challenging the dominant structures in this process
- Engaging in invention

Peralta's summaries of designer and artist contributions act as a framework to compare, develop and extend the roles of a fashion-led researcher, which I have identified through my research (see Data Discussion chapter).

Key roles identified in Peralta's literature review of authors' summaries are the designer's role as a connector and as offering a divergence of thinking from a scientific research perspective (Peralta, 2013:36). Carole Collet, Professor of Design for Sustainable Futures at Central Saint Martins (University of the Arts London, 2019b), investigates synthetic biology, specifically through textile and material design research and practice. From a design perspective within design-science interactions, Collet emphasises the importance of working from the inception of projects (Collet, 2012a:7). Both Suzanne Lee[20] and Christina Agapakis[21] highlight the benefits for designers in early engagement and collaborative work (Agapakis & Lee, 2019). Some of the values that Lee, Agapakis and Collet attribute to designers are their roles as connectors between technology, scientific advancements and concepts to a wider public (ibid.). Benony and Maudet also argue for the importance of integrating designers at an early stage, to 'address societal concerns' (Benony & Maudet, 2020:2–3). This is possible when the designer questions, critiques and applies wider contextual implications from the outset, rather than joining at a later stage for the purposes of production of applications or aesthetics. Accordingly, collaboration from the outset could be key to designers engaging with scientists

[20] Suzanne Lee is a pioneer in the integration of biology and design. She instigated and leads *Biofabricate* – a yearly conference bringing together companies, researchers, designers and scientists working at the intersections of biology and design. Her background and training are in fashion design, and she studied at Central Saint Martins. She worked in the fashion industry during the 1990s, before moving into academia as Senior Research Fellow at Central Saint Martins, University of the Arts London. Lee was Chief Creative Officer at Modern Meadow, a biofabrication company in New York, until 2019. She authored the book *Fashioning the Future: Tomorrow's Wardrobe* (2005).

[21] Dr Christina Agapakis is Creative Director at Gingko Bioworks, a synthetic biology company working to engineer micro-organisms for use in industry (Fast Company, 2019). She is a synthetic biologist with a PhD from Harvard University and was one of the collaborators on the 2009 *Synthetic Aesthetics* project (Ginsberg et al., 2014), where she collaborated with Sissel Tolaas to create cheese from microbes collected from human bodies (Agapakis & Tolaas, 2014:271–282).

(Collet, 2012a:7; Agapakis & Lee, 2019). I tested this approach in my enquiry by focusing on interdisciplinary collaborations whereby the fashion practitioner has initiated, worked from the outset or contributed significantly to the projects, to understand the role a fashion practitioner can have as a key agential actor operating from start to end of a collaboration.

Peralta[22] proposes three forms of collaboration: design supplier, design consultant and team researcher (Peralta, 2013:368). The team researcher is most relevant to this study, described as the most intense form of collaboration, where the designer is a fully integrated team member from an early stage of the process, helping to define and develop the project until resolution (Peralta, 2013:368).

Peralta's identification of the team researcher links to Lindy Richardson's[23] definition of 'true collaboration'[24] (Richardson, 2013:44). Richardson (2013) argues for a distinction between collaboration and cooperation in the context of textile design, particularly in relation to textile projects in education. Richardson's definition of collaboration includes 'all participants fully integrated and sharing together in the development of the project towards the shared goal' (Richardson, 2013:43), which most closely links to Peralta's team researcher mode. Richardson specifically sets this apart from cooperation (most closely linked to Peralta's design supplier), which she argues comprises distinctive practitioners working as individuals on specific constituents within shared projects, beside but separate from one another (ibid.).

Richardson's notion of collaboration offers an interconnected approach between participants from the outset, highlighting a common objective as a key component for collaboration (Richardson, 2013:43–44). However, I would argue that each collaboration is very nuanced. Setting up a pure or 'true' version of collaboration, and placing forms of collaboration into a hierarchy that advocates a 'true' way, may not account for the range of methods and new technologies afforded to collaborative practitioners as clearly as Peralta's definitions do. Differences in settings and disciplinary backgrounds, funding routes, drivers, goals and

[22] The roles of the designer can be categorised in different ways, and Peralta uses three modes: according to level of integration, entry point at which the designer is brought into the process and the focus of their roles and tasks. Culminating his doctoral study, Peralta proposed a framework showing the findings of his research into the roles designers can play during collaborative projects (Peralta, 2013:381). Peralta's design supplier is distinguished as a less intensive form of collaboration, where the designer remains external to the scientific research team and is brought into the project at a later stage, with a focus on resolving 'design issues related to scientific research resources' (Peralta, 2013:367–368). Peralta's design consultant has an intermediate level of engagement, while remaining external to the scientific research team; this form is marked out through having early participation in the defining and development stages (Peralta, 2013:367–368).

[23] Lindy Richardson is Programme Director of Textiles at Edinburgh College of Art (The University of Edinburgh, 2018).

[24] I am using the word 'true' specifically in terms of the form of collaboration, not in relation to the outcomes.

expectations for each participating actor can all affect the form of collaboration. Therefore, 'true' collaboration may not always be possible. In this project, my discussion looks at the assemblages of collaborations in relation to Richardson's notion of a 'true' collaboration and how close or looser configurations impacted agency and relationships within the collaborations (see Data Discussion chapter).

Peralta proposes four distinctive roles that designers undertake in interdisciplinary collaborations with product designers. These range from collaborators, who work from the start and identify the design need and methods to engage with it; to experts, who enter partially through the collaboration when the scientists have defined the project and some early ideas on what is required; and technicians, whereby scientists have defined the project, it is a late stage and the designer is working in service to the scientists to carry out their idea (Peralta, 2013:369). Peralta also sets out specific roles that designers undertake in scientific research: supporter, explorer, integrator, contributor and visualiser and communicator; in particular, he notes how the social and commercial dimensions of scientific research can be most affected by designers (2013:370–376). While all of these roles are useful in understanding how designers collaborate, and the roles they operate in as part of interdisciplinary teams with scientists, they are based on bringing designers into a scientific research team. This is in contrast to projects driven or initiated by fashion designers and practitioners from the outset. Acknowledging this gap, I have sought out such examples, including the *Primitive Streak* collection and Maison Martin Margiela *9/4/1615* exhibition as case studies in this research, as well as conducting six collaborative projects initiated by myself as a fashion-led researcher.

Benony and Maudet (2020) conducted a study proposing distinctive roles identified in collaborative practices between designers and biologists, after observing and studying engagement between the disciplines. Both authors hold a design background and operated as design researchers during the study. Like Peralta's work, this is a rare yet important paper in the literature because of its focus on roles in the context of design and biology collaborations: 'little work has been carried out in relation to how designers and scientists collaborate in scientific research' (Peralta & Moultie, 2010:1643). Benony and Maudet (2020) propose the following roles which were not fixed roles and evolved over the course of the projects[25] (Benony & Maudet, 2020:8):

[25] These roles are in conjunction with the phases of a design process as described in the Double Diamond (Design Council, 2019) – a common model used to outline a design process.

Discovery Phase

- Designers as guests
- Biologist as guides

Defining

- Biologists as influencers
- Designers as ‘elastic minds’ (Antonelli & Aldersey-Williams, 2008)
- Biologists as ‘bridges between ideas and reality’

Developing

- Practice: designers as apprentice
- Practice: biologists as supervisors
- Theory: designers as amateurs
- Theory: biologists as librarian

Delivering

- Designers as lone makers and biologists’ exclusion
- Designers and biologists as collaborators

These roles are useful but not universal, specific to the projects and arguably to the level of the designers as students, and the scientists as supervisors (Benony & Maudet, 2020:19). The authors acknowledge this limitation of their study, stating that: ‘in such collaborations, differences of seniority and expertise can strongly influence the collaboration patterns’ (Benony & Maudet, 2020:19). For example, although the authors discuss the roles as ‘asymmetrical’ and ‘complementary’ with designers leading on process and biologists on content (Benony & Maudet, 2020:17–19), they designate the biologists with roles that suggest they yielded more control and dominance in the projects: guides, influencers, supervisors and librarians (ibid.). Benony and Maudet’s proposed terms for defining the biologists’ roles suggest the balance of power is greater for the scientists than the designers in these collaborations. Only in the delivery phase are biologists and designers viewed as equal collaborative peers, in the presentation and final display of the projects (Benony & Maudet, 2020:19).

How far the issue of an imbalance of power in Benony and Maudet's study, in selecting students (as designers) and tutors (as biologists), affected the collaborations is unclear. This does, however, present a gap that my study fills. First, I investigated collaboration from an active practitioner-researcher (fashion-led) perspective rather than via the role of observer and researcher; second, I focused on collaboration in an academic doctoral research setting, which arguably shifted the collaborators to operating as colleagues. For example, my collaborators and I could be argued to be on a similar academic level – three of the six collaborative projects were conducted where all three actors were doctoral candidates, and one collaboration was conducted with previous collaborators. Acknowledging my position as a researcher and my previous experiences in scientific collaborations may have meant I was perceived as holding prior knowledge of working with scientists, as opposed to the relationships observed by Benony and Maudet (2020).

Although both Peralta (2013) and Benony and Maudet's (2020) studies are useful as a framework for understanding identified roles taken on by designers when working in interdisciplinary collaboration with scientists, both studies focus on designers from product or industrial design disciplines. Additionally, Peralta looks at how designers can benefit and contribute to scientific research, and Benony and Maudet look at how designers have worked in projects where the scientists may have been operating at a different level to the designers in terms of academic superiority (as student and tutor). My study looked at collaborations where fashion practitioners and biologists are operating, conscious of relative equity, and was conducted for its contributions to the discipline of fashion design research, rather than seeking new knowledge for scientific research.

Fashion-Led Research as Distinctive

Having set out a framework of the types of roles taken on by designers more generally, in this section I discuss the importance of a nuanced fashion-led research approach. It is important to define fashion-led research, here, to understand what it can bring when in collaboration with biology.

I extend Elaine Igoe's[26] argument acknowledging a specific textile design research approach, to account for the differences between textiles and traditional subjects that design research has been built upon (Igoe, 2010:8). I develop Igoe's argument to signal the need for a specific fashion-led research that crosses over with practice design research and fashion design; however, I locate fashion-led research as specific and distinct in and of itself. This is because applying the umbrella term 'design research' or 'practice-led' to fashion means it cannot account for the multiplicities, specificities and nuances of fashion-led research. The predominance in the literature of 'the historically "*chattier disciplines*"' (Igoe, 2010:9) shows that design research discourse has not emerged from or through fashion practice. Design research has been developed from, and is therefore grounded in, so-called 'harder' design disciplines, such as: industrial design, architecture and design engineering (Igoe, 2013:25). Therefore, I argue here that design research speaks more broadly for the discipline of fashion but has not been designed or developed through it.

Additionally, diverging from Igoe's call for a specific textile design research approach means taking into account key differences between textiles and fashion. For example, Igoe discusses how, typically, commercial textiles need to interact with other design disciplines to be made into applications and presented to wider society (Igoe, 2010:5). Where textiles typically require another actor in order to interface with the social, fashion directly interfaces with society and bodies and therefore holds additional performative, socio-cultural and socio-political meanings. To delineate fashion thinking specifically, Dr Claire Pajaczkowska's[27] proposal of six aspects understood as fashion thinking, are useful for drawing out specificities related to fashion (2016:79–94). These include:

- A neophilic compulsion, driven by a search for the new, for innovation and change (Pajaczkowska, 2016:90)
- Hyper-sociality (ibid.)
- 'Heightened reciprocity of its culture: highly collaborative and interactive, the fashion participant is offered agency as a subject "in relation to" her others' (Pajaczkowska, 2016:90–91)

[26] Elaine Igoe is Senior Lecturer in Fashion and Textiles at the University of Portsmouth and Visiting Research Tutor in Textiles, School of Design, at the Royal College of Art (Royal College of Art, 2020; University of Portsmouth, 2020).
[27] Dr Claire Pajaczkowska was Senior Research Tutor in Fashion and Textiles at the Royal College of Art. She proposed nine facets of textile thinking, and an additional six aspects directly related to fashion thinking, in her chapter 'Making known: the textiles toolbox – psychoanalysis of nine types of textile thinking' in *The Handbook of Textile Culture* (Pajaczkowska, 2016:79–94).

- Being self-expressive and customisable, valuing individual difference within the collective, and an 'affinity to bespoke, personalised and customised fitting' (Pajaczkowska, 2016:91)
- Adaptive pliability – a heightened awareness and response to global, economic, societal and political aspects such as gender, race and identity (ibid.)
- Being 'parodic, self-parodic, knowing, funny and fun' (ibid.)

As Pajaczkowska argues, fashion and its thinking are hyper-social (2016:90), as garments are the most commonly produced applications of a fashion design process (Burke, 2011:14–17). Within textiles, the cloth acts as the active agent; yet, within fashion I argue that it is this heightened reciprocity (Pajaczkowska, 2016:90–91) and agential relationship between the body and cloth (and bacteria, in this study) that provides the active agency. Garments typically sit on the human body, acting as a direct interface between skin and society. The roles of body and cloth may fluctuate within fashion, but they both act and interact agentially. Clothing, then, is viewed as a medium of communication and transmission, where fashion is seen as 'a process, a "way", rather than garments themselves' (Pajaczkowska, 2016:91). It is fashion's process, as well as aspects of bodily related, materially directed and typically three-dimensional form, that set it apart from other design disciplines.

Fashion-led research is understood in my study as a research space combining fashion design practices with practice-led design research methods. It incorporates a preoccupation with materiality, the second skin and the notion of a body[28] (whether human or nonhuman, in this study). This extends Ninela Ivanova's[29] definition of fashion-led in terms of wearability and user-centred experience, in direct relation to the body to include nonhumans[30] (Ivanova, 2015:14).

Fashion-led research, here, uses fashion practices to understand fashion practice as a collaborative model. 'Fashion-led' refers to Candy and Edmonds' definition of practice-led (described in the Introduction of this chapter), where new understandings and contributions are found in the process of practice, leading to new contributions for the practice itself (Candy &

[28] The term 'bodily' is an expanded understanding of bodies, accounting for human and nonhuman bodies, such as bacterial bodies, as understood in the context of new materialisms (see Theoretical Context).
[29] Ninela Ivanova is a Post-Doctoral Research Fellow (Royal College of Art, 2019).
[30] My enquiry builds directly upon Ivanova's definition of 'fashion-led', but questions the necessity for a garment to be wearable, and to be understood purely in relation to the human, through the inclusion of bacteria, in examining agency within the human and nonhuman assemblages.

Edmonds, 2018:64). In this way, my fashion-led research approach was a fluid, flexible way of thinking, understanding that the outcome is only a small part of a whole system, and it is the processes, shifts and changes before and after the final outcomes that this approach focuses on. A fashion-led research approach differs, as it concentrates on the relations between actors and the roles of these agents within the collaborative process. My approach drew on stages 1 to 6 of Burke's[31] fashion design process, to integrate specific fashion design practices, including: concept, fabric research, draping on the stand, draping and shape research, two-dimensional design visualisation, model fitting, pattern and garment production, photographing, promotion and exhibition (Burke, 2011:57). My fashion-led research approach also held to generalised aspects of practice-led design research, including:

- Subjectivity, specifically an emphasis on qualitative design research methods (Archer, 1995:11–13)[32]
- Researching through the process of making (Frayling, 1993:5; Archer, 1995:8–11)
- Understanding that new knowledge can be uncovered through the process itself (Candy & Edmonds, 2018:64)
- Arguing away from research in a science tradition[33] (Gray, 1996:3)

This fashion-led research approach was disseminated through points of reflection, analysis, discussion and sharing of new knowledge gleaned from its earlier stages, distinguishing the approach from a fashion design process, such as Burke's (2011:15),[34] which is typically resolved through commercially viable fashion products and collections. Although fashion practice recognises its industry anchors, my project argues for a broader understanding of fashion practice set in an academic context that diverges from the commercial fashion system. This locates my enquiry specifically as a fashion-led research approach in collaboration, set

[31] The fashion design process is further detailed in sources such as the *Basic Fashion Design* series of books (notably: Renfrew & Renfrew, 2016; Seivewright & Sorger, 2019), *The Fundamentals of Fashion Design* (Sorger & Udale, 2017) and *Fashion Design* (Jones, 2011). In this study, I chose to draw on Burke's process, as it offers a clear descriptor of a fashion design process from design brief to commercial fashion business.

[32] A pioneer in the emerging field of design research in the early 1960s, Bruce Archer emphasised the importance of subjectivity and a need to be 'situation-specific' in his view of practice research (Archer, 1995:11–13). Archer advocated for qualitative methods and subjectivity, as opposed to quantitative methods in a science tradition. He argued that practitioner accounts can only be considered research when they are transparent, share knowledge, and are clear and 'systematically conducted' (Archer, 1995:13).

[33] In this case, a 'scientific method' of research into art or design is understood to mean research conducted by non-practitioners such as historians, theoreticians or those from external disciplines, looking at the visual arts from an external, detached and objective perspective: 'where the researchable is objectified' (Gray, 1996:3).

[34] Burke describes the roles of a fashion designer (Burke, 2011:14–17) but not in collaboration with biologists and differing from the roles of a fashion-led researcher. The fashion design process is aimed towards commercial viability, whereas a fashion-led research approach does not hold the same commercial objectives and can therefore be more experimental and ask questions from a separate space.

within fashion design research, with overlaps in practice-led design research approaches. Contextualising this research in academia has offered the space and time to focus on experimental forms of practice, rather than working towards applications, specific industry goals and commercially focused projects. In this way, fashion-led research can enable the formation of complex, emergent and innovative philosophy, ideas and new methodologies (Haseman & Mafe, 2009:213).

Fashion and Biology

I have discussed the roles of designers in design and science in interdisciplinary collaboration and set out the necessity for and definitions of a specific fashion-led research approach. In this third section I focus on the emerging space of biology and fashion and how fashion designers are working and disseminating their work in this space. I argue that there is a gap in the literature for sharing the roles, relationships and agential shifts of the fashion practitioners and their collaborators during such interdisciplinary projects. The focus of these interdisciplinary collaborations, from a dissemination perspective, was on the visual presentation of final outcomes rather than sharing processes and inter-relations.

The area of 'science fashion' (Tillotson, 1997:i; Smelik, 2018b) or biofashion – a practice understood in this study as combining biology with fashion design – is gaining traction within the fields of biodesign and on the periphery of fashion design (Benony & Maudet, 2020:2). Designers and research and development branches of larger fashion companies are beginning to pivot resources towards looking at the potential for innovation and applications to market, with drivers such as sustainability and the development and industrialisation of new biomaterials. They follow in the footsteps of their contemporaries: interdisciplinary designers and artists who have traversed fashion, art, design, biology and synthetic biology practices from the 1990s to today, including Helen Storey, Suzanne Lee and Maison Martin Margiela, and those working from the late 2000s onwards, such as Donna Franklin, Amy Congdon, and Sputniko! In a commercial context, investors are financing emerging biotechnology companies such as Spiber, Bolt Threads and Modern Meadow, who are producing new laboratory-grown

materials such as Mylo[35] and Zoa, and working with fashion companies such as Stella McCartney.

A new generation of fashion designers are today working in interdisciplinary ways, exploring biomaterials and working with algae, bacteria and perspiration in their practice. Examples of this new generation of biofashion practitioners include Alice Potts[36] and Piero D'Angelo[37] (Show Studio, 2018; Davis, 2020; LVMH Prize, 2020). Although the drivers and foci for fashion designers working with biology may differ, fashion designers bring a maker's perspective as active practitioners. Depending on the career stage of the fashion designer, whether they are independent or part of a company and their role within the fashion, biodesign or biotechnology industries, some of a fashion designer's chief motivations might typically include: the craft of design and making itself; brand promotion and publicity; material innovation and development; research and development; and commercial, financial and business aspects (Agapakis & Lee, 2019). These fashion practitioners are using fashion design modes of dissemination, which positions them as public and industry-facing: for example, Potts and D'Angelo share their practice using social media platforms, in panel discussions, in digital and published media and magazines, in interviews, articles and using catwalk and gallery exhibitions (Show Studio, 2018; LVMH Prize, 2020).

There are existing structures available for fashion and biology practitioners to engage in collaborative, cross-disciplinary or interdisciplinary approaches. Some examples I have identified can be divided into the following categories of approaches, typical of fashion and science interactions:

[35] In 2020 Bolt Threads received major investment from fashion industry partners, Adidas, The Kering Group, Lulu Lemon and Stella McCartney, in order to continue the development of their mushroom-based mycelium fibre biomaterial, Mylo, as part of the Mylo Consortium (Bolt Threads, 2020).

[36] The materials researcher and biodesigner Alice Potts has approached working with biology in different ways. Potts works individually and as part of biotechnology and design company Modern Synthesis to grow and develop bioplastics and biomaterial samples. In 2017 Potts took part in the Royal College of Art Biodesign Challenge team, engaging in collaborations with the Bioengineering department at Imperial College London. She undertook a residency fellowship programme at the Onassis Foundation to explore her research into sweat, working with athletes to produce a body of work called *Perspire*. These modes of engagement have led Potts to research how bodies secrete sodium and to use this secretion from human perspiration to develop methods of growing sweat crystals on materials, such as the production of a pair of ballet shoes coated in crystals grown from perspiration excreted by a ballet dancer (Show Studio, 2018).

[37] In his 'Wetware Couture' project, biofashion designer Piero D'Angelo made use of *Physarum Polycephalum* (slime mould) to produce garments, in collaboration with soft robotics engineers, using 3D printing and rapid prototyping. Rather than working from a fashion design studio, D'Angelo locates his studio within OpenCell London, a biotechnology community. He was selected as a semi-finalist for the prestigious LVMH Prize in 2020 and describes how his work is an exploration of how biotechnology will influence the future of fashion (LVMH Prize, 2020).

- Fashion designers collaborating with scientists (one-to-one) – these can be on a scale varying from those led by fashion, or science, or a 'true collaboration' (Richardson, 2013:43–44) approach
- Fashion designer or artist-in-residence, within a laboratory, start-up or company (for example: Gingko Bioworks or Bolt Threads residencies)
- Interdisciplinary teams featuring a fashion designer, or a garment as a final outcome (team)
- Fashion and textile designers researching for applications and towards solutions (for example: materials research)
- Speculative or critical fashion and textile work, referencing science
- Fashion designers emerging from and through fashion and into companies and interdisciplinary teams
- Interdisciplinary design and science competitions (for example: Biodesign Challenge)

Table 1 (in Volume 2: Tables) is populated with projects focusing on fashion, garments or materials in conjunction with biology, whether working with bacteria, mammalian cells or tissue culture. The projects link to the fashion and science approaches above, and many of the practitioners utilise biological or scientific collaboration. The nature of design and its tendency to operate on a project basis means that each practitioner can fluctuate between one or more of these approaches, producing a wide-ranging body of work, some of which may fall simultaneously into more than one of these categories, even on a single project.

The examples in Table 1[38] show the preference of fashion practitioners for sharing images of the final outcomes from collaborative research, rather than the roles and relationships of the actors within the projects. Many practitioners concentrate on the final outcomes of collaborations, yet how they achieved them remains unclear in the literature. This is in terms of the roles, processes, methods and interactions between scientific collaborator and fashion practitioner. Moreover, the currently available opportunities do not always enable the

[38] Table 1 (see Volume 2: Tables) offers an overview in terms of current options available to practitioners. Other opportunities include: enrolling on university courses focusing on biodesign, for example, the Master's in Biodesign at Central Saint Martins; and working in hackspaces such as London Biohackspace or Genspace, New York. Furthermore, operating within commercial fashion companies exploring biotechnology or biological design in research and development, such as Bolt Threads in collaboration with Stella McCartney. Additionally, new, emerging and future territories that have not yet been created or explored.

activation of a fashion practitioner from the outset – for example, the *MIT BioLogic* project, where designers were brought in during the latter, application stages, rather than integrated from the start (Yao et al., 2015).

These examples show that, although there is growth in the visibility of biofashion practice, accounts and studies into the processes of interdisciplinary ways of working between fashion and biology are less prevalent in academic literature or forms of communication. The focus of the media and fashion designers is on their final outcomes: the biological garments produced. What have remained hidden are the fashion designers' collaborative processes, either in conjunction with biologists or with the biological media itself, and the roles that these fashion designers play within these interdisciplinary collaborations with biology.

This offers a space for research into the interdisciplinary collaborative processes that some of these fashion designers are engaging in. This includes, in particular relation to my own study: how the relationships between fashion designers working with biology can operate, and the roles that fashion practitioners who choose to collaborate are assuming in these partnerships and interdisciplinary collaborations. It offers an opportunity for the extension and divergence of the role of a fashion-led researcher – to focus on the aspects of practice and making, before diverging to share new knowledge and disseminate research and findings in an academic context. Without foundational research into the processes and roles of fashion within interdisciplinary teams, it is harder to understand the value of collaborations between fashion and biology for fashion design research.

Practice-Based and Practice-Led Dissemination of Collaboration

In this last section of the Contextual Review chapter, I show how existing literature and practice has primarily centred on practice-based dissemination, offering a gap for practice-led research approaches such as this study.

There is a preference among curators and editors for a practice-based[39] approach to disseminating interdisciplinary work, projects and collaborations between (fashion) design and science. Seminal publications and exhibitions have typically centred on descriptions, or

[39] By practice-based, I mean an approach focusing on the final object produced rather than the process of its production (Candy and Edmonds, 2018:64).

theorised accounts, drawing on final visual outcomes of projects. This manifests as a page in a book or a description in a gallery showing the installed work or photographs of the final outcome, and a project description outlining the concept and parameters of the project (for example, see: Myers & Antonelli, 2012; Evans, 2003; Myers, 2015; Tibbits (ed), 2017). Exhibitions featuring these types of design and science projects have also followed a practice-based approach (see: Open Cell, 2019; Atzmon, 2019).

These methods of dissemination give the appearance of stability and order in their propagation of perfected, finalised outcomes rather than engaging with and opening up the realities of a shared design and science process. Information is omitted regarding: collaborator roles; any emergent interdisciplinary methods; first-hand practitioner perspectives and reflections; and transparency via sharing knowledge of process failures, as well as perceived successes.

Practice-led and practice-based fashion design researchers challenge typical fashion design dissemination conventions by contributing accounts of making and collaborating to the field of art and design research (for example: Lee, 2012; Ivanova, 2015; Bugg, 2006; Sgro, 2018). In terms of doctoral theses, my study shares commonalities with Ivanova's research and work with scientists (Ivanova, 2015), Tillotson's PhD thesis merging fashion and science on the theme of scent (Tillotson, 1997) and accounts from the area of biological art and design concerned with materiality and the garment, such as that of Franklin (2014). Furthermore, there is research into biological design from a textiles rather than fashion perspective by practitioners such as Natsai Audrey Chieza, Carole Collet and Amy Congdon (Chieza & Ward, 2015:2–17; Collet, 2012a; Congdon, 2020).

However, what is missing from the existing literature on practice-led and practice-based accounts of collaboration are accounts merging the three gaps identified: first, accounts of interdisciplinary collaboration between fashion design and biologists; second, first-hand fashion-led researcher accounts and studies of processes of collaboration; and, third, studies focusing on the roles a fashion-led researcher can play in interdisciplinary collaborations with biologists. My study fills this space by combining these gaps, which formed my research questions.

Summary

This section reviewed the key literature highlighting that there is a space for, and therefore value in, unfolding collaborative processes between fashion and biology, and in examining the potential of the roles played by a fashion-led researcher in interdisciplinary teams.

Although there are numerous examples of designers from the discipline of fashion collaborating with biologists, there is a preference for sharing, discussing, displaying, exhibiting and making public the final outcomes of these projects. What is missing in the academic literature are first-hand accounts of the relationships between fashion-led research and biology in collaboration and the roles of a fashion-led researcher within interdisciplinary teams.

This study builds upon existing literature by Peralta, Benony and Maudet to reveal and make explicit my roles as a fashion-led researcher and the potential of collaborative relationships between fashion and biology practices. It fills a gap for accounts detailing the role of fashion during interdisciplinary collaborations with biology, contributing to understandings of the relationship between the two disciplines.

THEORETICAL CONTEXT

Introduction

This chapter presents the theoretical context underpinning my thesis. This context is used as a lens through which to discuss and view nonhuman bacteria as a co-actor with agency, in the collaborations. Key theorists and philosophers that I discuss here are: Gilles Deleuze and Félix Guattari (1987), Karen Barad (2007), Jane Bennett (2010) and Anneke Smelik (2018a). I have located this study in the context of fashion-led research in collaboration with microbiology and from a Western European white lesbian feminist perspective. I have chosen to employ three key concepts: materiality, agency and assemblage. My understanding of these three concepts is drawn from new materialisms and actor-network theory (hereafter ANT). Considered together, materiality, agency and assemblage present ways of thinking from the viewpoint that humans, objects and organisms operate relationally and can hold agency.

There are significant overlaps between new materialisms and ANT, which make these specific areas important to my study. Both theories elevate the importance and experience of the nonhuman – questioning the anthropocentric[40] dominion and considering nonhuman agency and affect. In this sense, these theories are flat ontologies – attempting to flatten hierarchies in experiences of humans and nonhumans by viewing them as co-actors operating as part of a networked whole. This is important to my enquiry because, having worked with and been affected by the activation of bacterial agency within my collaborations, I argue that the inclusion of nonhuman agency is necessary to acknowledge its part in shaping my final project outcomes and ultimately in uncovering my own shifting roles as a fashion-led researcher.

New materialisms and ANT are material-semiotic approaches – recognising that the materiality of matter and objects are as significant as language and signs. In this way, the new materialisms build upon post-structuralist thought, which prioritised linguistic and socially constructed theories and modes of analyses, viewing constructions of the social world through language, discourses, histories and thought systems. Socially constructed theories have primarily been

[40] I am cautious in adopting an anthropomorphic approach, as ultimately this is still an anthropocentric technique. Instead of viewing myself as the bacteria or trying to understand how the bacteria feels, I am including bacterial agency in acknowledgment that it affected how I designed and operated, and working with how the bacteria shaped my role. I am therefore looking at the bacteria as part of the collaborative assemblages in order to understand the phenomenon of study – my roles as a fashion-led researcher.

approached from an anthropocentric, collective human perspective – and therefore have not focused on the active nature of matter (Fox & Alldred, 2017:21–23).

This recognition of the importance of materiality is relevant to fashion design, as it is assumed to be primarily a material and bodily practice. Thus, taking the notion of materiality from primarily theoretical, philosophical approaches and applying it directly to the context of fashion-led research and the body, this project asserts the importance of practically applying theoretical concepts to fashion as a visual and material culture, and to the analysis of my collaborations in examining material, bodies (body as human but also more-than-human bodies) and how they engage with each other. In acknowledging human and nonhuman agency, materiality becomes a signifier but also an active and key agential part of my collaborations.

ANT draws heavily upon Gilles Deleuze and Félix Guattari's notion of the rhizome (1987) in its understandings of a network, comprising human and nonhuman elements and its focus on the inter-relations or, as Karen Barad terms them, intra-actions (Barad, 2003:828) of its relational ties. Understanding that inter-relations are affective to self – although anthropocentric[41] – offers a way of questioning human dominion, and an attempt to flatten binaries between elements such as nature-culture, human-nonhuman and matter-meaning (de Freitas, 2017; Barrett & Bolt, 2012:3). This theoretical lens has led to understandings of a discursive fashion-led research approach developed through the analysis of relational ontologies and flattened hierarchies within my collaborative projects (Barad, 2003:814; Fox & Alldred, 2017:7). This is in acknowledgment that the 'intra-active becoming' (Barad, 2003:828) of my role is through my entangled collaborative assemblages with biologists and bacteria.

In my fashion-led research approach, I argue that using materiality, agency and assemblage as analytical categories enabled a tighter focus on the relationships, processes and roles acted out within collaborations. It also allowed for the inclusion of nonhuman agency which I found affected my roles and the outcomes. In order to understand the assemblage as a whole, it is useful to look at these three elements separately.

[41] As a human, I acknowledge that I operate, and can only ever operate, from an anthropocentric viewpoint and thereby propose that including bacterial agency in the analysis of my projects contributes to an understanding of the role of the fashion-led researcher. My study does not claim to decentre the human – particularly in relation to its aims and rationale. This project instead aims to question the human–nonhuman binary through the inclusion of multiple perspectives and bacterial agency, without claiming a total decentring of human experience.

Within this thesis, materiality is understood in terms of the active nature of all matter: objects, living organisms and humans. Matter is taken in Bennett's terms as vibrant and active, always in the process of becoming, rather than inert or finalised objects. This activity is located within the bond between elements, right down to molecular level. This becomes particularly relevant in relation to bacteria, which are simple, single-cell organisms that grow and generate into whole systems. This allows us to view bacteria as a co-agent rather than an inert substance. Bacteria is affected by its environmental context and stimuli and is therefore agential in the production of designs. This is particularly relevant to my work with bacteria, as it was living and actively interacting with the fabrics that we grew it on. I argue that working with bacteria affected how both I and the scientists worked and the final designs we produced.

Although the generally understood concept of agency relates to independence and free choice, this is defined from a human-centric and anthropocentric perspective. Therefore, part of what I am doing here is viewing agency from a non-anthropocentric perspective. Agency is taken to mean an action or intervention producing a particular effect; it is understood as both a human and nonhuman phenomenon. It is conceived of as the actions of each actant and how these affect, shift and change other actants' behaviours and outcomes. For example, the bioluminescent bacteria in *Lo Lamento*, *Azazel* and *Living Light Dress* (see Volume 1: Collaborative Projects) demonstrated this notion of agency clearly, in that it would only glow when all of the conditions were met, and even then when they appeared to have been met, it was not always predictable that it would glow with the same brightness. The agency of the bacteria is imposed on me as a fashion-led researcher because, unless the conditions are right in my designs, it will not glow.

Agency here is used in terms of the way in which the different actants can dictate the design at different points of the process. Where the bioluminescent bacteria required very particular conditions in which to grow, it shifted how I designed, the materials I used and methods of working. The understanding of the importance of bacterial agency led to a shift in my roles – towards recognising the multiple roles I played as a fashion-led researcher. Therefore, working with the bacteria and biologists led to my roles as a fashion-led researcher.

Assemblage is understood as a co-functioning, interrelated system. In this thesis I use the term assemblage to look specifically at the relationships between the following actants, recognising

that there were more elements at play: fabric and garments, bacteria, myself as a fashion-led researcher, and biologists. This became a lens for thinking through, to understand the roles of the fashion-led researcher.

In the rest of this chapter I will set out the three key concepts – materiality, agency and assemblage – in further detail, in relation to my rationale for this enquiry. Drawing my understandings of these concepts of assemblage, agency and materiality from new materialisms and ANT has enabled the inclusion of nonhuman bacterial agency. I argue that the inclusion of microbes into the social – which in my study is fashion-led research in collaboration – has led to new understandings of the distinctive roles of the fashion-led researcher. This, I argue, is because it is a role that has developed and evolved through negotiation and is relational within the entangled and interconnected processes of collaboration with human and nonhuman entities. These three concepts provide the analytical categories used as a lens through which to frame the Data Discussion chapter.

Materiality

In this study I take the new materialist understanding of the term materiality to mean the active nature of all matter. Materiality refers to all things: human bodies, living and non-living organisms, forces, objects and abstract concepts (Fox & Alldred, 2017:2). Matter – including all objects, organisms, humans, forces, phenomena – is viewed as alive, active and in flux. In this study, seeing each actor as agential, affecting and effecting one another, meant conceiving of myself as a fashion-led researcher, the biologists, the material and garment and the bacteria – all in terms of materiality – as key agential parts of the collaborations. Employing materiality as a concept has allowed a closer understanding not only of the relational and agential interactions between each actor but also of what a fashion-led researcher might be.

Karen Barad[42] is a key theorist whose work is often viewed within a new materialisms context. This approach draws on theoretical particle physics, quantum physics, feminist theory and the work of physicist Niels Bohr. Barad uses these influences to build the theory of 'agential realism' and, in particular, poses the term 'intra-actions' to describe the ways in which matter forms through its specific interactions and apparatuses (Barad, 2003:815; 2007:151). Barad

[42] Karen Barad is currently Professor of Feminist Studies, Philosophy and History of Consciousness at the University of California.

contends that viewing matter as an 'end product rather than an active factor in further materializations, is to cheat matter out of the fullness of its capacity' (Barad, 2003:810). Indeed, through its emphasis on agential relations during process rather than knowledge obtained via object-based final outcomes, fashion-led research holds significant crossovers and opportunities with Barad's notion of intra-actions within the assemblage.

Barad's notion of materiality refers to all human and nonhuman actors and the conditions of their production, which they view as realised through a series of intra-actions in their becoming (Barad, 2007:151–152). This means that the matter produced is politicised, through the lenses and capabilities of the human and nonhuman inter-relations leading to their process of becoming. This has ethical consequences, dependent upon the types of objects and matter produced; it also means that all participation in (for example) scientific experiments has implications. To Barad, then, materiality is a process of intra-actions, and it is these specific parameters, apparatus and lenses, and the ways in which humans and nonhumans interact, understanding that these can also be political and exclusionary, that produces materialities.

Jane Bennett is also viewed as a leading theorist in new materialisms. Bennett's form of 'vital materiality' (Bennett, 2010:112) is developed from the fields of political ecology, Marxist philosophy and phenomenology. Bennett argues for an elevation of the importance, agency, affect and experience of the nonhuman – questioning human dominion, particularly within politics and the ecological domain. Bennett extends this argument further, to the human body, viewing it as a symbiosis of human and nonhuman elements, which decentres the notion of a wholly 'human' body (Bennett, 2010:112). Bennett's vital materialism accounts for the vitality of bacteria, and Bennett views the body as material: an ecosystem of human and nonhuman elements.

Vital materialism offers one form of critique of a human-centred approach, centring on the interrelations between human and nonhuman matter (Bennett, 2018:448). I argue that, by acknowledging and showing the importance of nonhuman and human agency in my own collaborative approaches, I am centring on the active materiality within my fashion-led research collaborations. This means a centring of the nonhuman actors – bacteria and the cloth, as well as the human actors – the fashion-led researcher and the microbiologists. In my approach, nonhuman elements are viewed as active participants, and my focus is on the inter-relations and roles within my fashion-led research collaborative assemblages.

Both of these theorists of the material turn argue for the importance of matter. This is in reaction to a series of 'turns' in the humanities and social sciences focusing on language and representation, such as the linguistic and semiotic turns. The material turn is then a development of social constructivist approaches focusing on language to build realities. For new materialist theorists, this shift is represented by expanding upon descriptive and linguistic forms of representation for the construction of knowledge, towards 'practices/doings/actions' (Barad, 2003:802).

This pivotal transference of focus onto practice in process, or, as Barad describes, its doings and actions (ibid.), signals the point at which new materialisms become highly relevant to practice-led research and my fashion-led research approach. This is because new materialisms take the notion of matter as material objects-in-becoming. When applied in the context of fashion-led research, this represents a shift from asking what fashion represents and signifies to asking what fashion practices can do. This marks a development from humanist approaches to fashion: for example, those that consider fashion as signs and signifiers through its material, visual and cultural outcomes; embodied human experiences of craft and making or phenomenological studies into wearing garments; and studies exploring fashion's role in the creation, performance and fluidity of human wearers and their identities.

In my study I considered the role of a new materialist understanding of materiality, in the context of fashion-led research in collaboration with microbiologists, when working with bacteria. I extended semiotic and linguistic approaches as the fashion garments became part of the fashion collaboration and acted, not only in the role of signs,[43] signifiers and objects, but also as co-actors and agential parts of the collaborations.

As discussed in the introduction to this chapter, fashion studies scholars such as Smelik, Bruggeman and Toussaint have taken new materialist arguments into a fashion setting, contending the need for a renewed materialist approach that considers technological innovations utilised by fashion designers (Bruggeman, 2014:16–17; Smelik, 2018a:42–45; Toussaint, 2018:46–50). I draw on Smelik's definition of new materialism in understanding

[43] The fashion garments are the only actant to have the sign and signifier element. The bacteria and scientists do not hold these roles as signs or signifiers in this context, but the fashion garments change the nature of the relationship between all of the partners – it is now not just a piece of fabric, it is a piece of fabric turned into a fashion garment, even if it cannot actually be worn, because it can be worn conceptually.

that ‘human bodies, fibres, fabrics, garments and technologies are inextricably entangled’ (Smelik, 2018a:34).

Smelik argues that, in particular, contemporary fashion and technological innovations collapse dualisms such as material-immaterial, animate-inanimate and human-nonhuman – citing the work of Iris Van Herpen as a key example (Smelik, 2018a:35). Smelik’s proposal of a new materialist framework for fashion studies intensifies the poststructuralist challenge to reconsider historic binary divides, such as nature-culture. Smelik cites both the decentring of the human as subject and the elevation of nonhuman agency as components of a new materialist approach that is relevant to fashion, inclusive of new materials and technologies that enable new forms of connection between the body, materials, garments and society (Smelik, 2018a:33–34). This viewpoint echoes the key tenets of new materialist perspectives such as Barad and Bennett, but shifts this philosophical argument into the forum of fashion and wearable technology.

My study builds on Smelik’s argument for the usefulness of materiality in a fashion-led research setting. Understanding fashion in collaboration as an assemblage between human and nonhuman entities enables a clearer understanding of the potential and roles of fashion-led research in interdisciplinary collaborations. Taking new materialist concepts into the context of fashion allows us to question how we view all entities as assemblages of multiple nonhuman bacterial, biological, chemical and physical participants in constant ‘becoming’ (Barad, 2003:803). This is particularly valuable in broadening perspectives when operating in the field of biological design and working with living systems. This turn towards materiality has enabled an opportunity and space for focusing on the inter-relations, processes and roles in collaborations, to develop new knowledge through social productions and processes.

Agency

In this thesis agency is understood as interactions and ‘intra-actions’ (Barad, 2003:828) between actors. Agency is viewed as the fluctuating, relational, affecting and effecting ways in which energy and forces are exerted from actor to actor. I have looked at the agency of both human and nonhuman actors and use the term agency to describe how an actor modifies or exerts a certain force or action, which affects other actors.

I have drawn on definitions of actor and actant from ANT and new materialisms. Bruno Latour is one of the central theorists in the development of ANT. Within ANT, Latour's definition of the term 'actor' or 'actant' is drawn from semiotic approaches. Latour describes how entities become actors or actants as soon as one entity modifies another entity in a trial (Latour, 2004:237). Latour's understanding of the term 'actors' is applicable to both humans and nonhumans (Latour, 1996:369). To Latour, actors become actors through acting, performing and affecting one another.

Latour's agency is not held specifically by humans or nonhumans but viewed as the associations and social ties between actors' interactions. Latour is clear that an ANT form of agency does not attribute intentionality to nonhumans: 'not to impose a priori some spurious asymmetry among human intentional action and a material world of causal relations' (Latour, 2005:76). Taking Latour's definition of actors in my thesis, I have focused on the interplay and inter-relations between human and nonhuman actors in terms of their actions and roles.

Similarly, Bennett refers to actors or actants when describing human and nonhuman entities. Bennett poses a similar definition of actant to Latour. She posits an actant as a relational entity: 'An actant never really acts alone. Its efficacy or agency always depends on the collaboration, cooperation, or interactive interference of many bodies and forces' (Bennett, 2010:21).

Again, Smelik is useful in the way she shifts agency into a fashion context. She considers material agency part of her new materialist framework for fashion studies (Smelik, 2018a:45). Smelik discusses the potential of material agency as a way of expanding on existing analysis methods in object-based fashion studies, within the context of museum and archival research (Smelik, 2018a:45). She contends that it is necessary to rethink conventional modes of object analysis in the light of technological innovations, which she argues render traditional methods no longer applicable (ibid.). Material agency, for Smelik, is not in the anthropomorphisation of objects but viewed as a process encompassing agential fluctuations, connections and transformations that occur within human and nonhuman material interactions (ibid.).

In this study I have shifted Smelik's argument – located from a theoretical position in fashion studies – to my context of fashion-led research. This means that rather than adopting a theory-based approach like Smelik's, I was working from a first-person, practice-led fashion research perspective. This required locating myself as both researcher and active agent within my

collaborations. In this way, my study offers new perspectives on fashion-led research and biology collaborations as I operate from within them.

Material agency in this study is important, as I was working with bacteria that are alive and affective. Arguably, working with living systems and 'vibrant matter' (Bennett, 2010:112) spotlights the liveliness of matter in producing and forming bacterial-materials (Igoe, 2018:1788-1789; Tonuk & Fisher, 2018:1706–1716). As a maker and practitioner-researcher, my role as a fashion-led researcher was affected by the inclusion of living systems as co-actors – the bacteria as active, vibrant and affecting relations, roles and agency. In this sense, it is agential – bacterial requirements and considerations affecting how the biologist and I operated, ultimately the final outcome in and through its natural, bacterial properties and processes.

It is this emphasis on becoming in process (Smelik, 2018a:44) that is important to my fashion-led approach to research and making. First, the bacterial growth and properties such as bioluminescence in *Lo Lamento*, *Azazel* and *Living Light Dress* (see Volume 1: Collaborative Projects) emphasise the concept of becoming that is shown via the growth and activation, division and multiplication of living and active cells. Second, the roles of the fashion-led researcher fluctuated, developed, shifted and came into being, during and because of these collaborations working with biologists and bacteria as active participants. Third, I argue that the -led aspect of fashion-led research itself places the emphasis on process, and becoming, rather than finality of outcomes. Process and becoming – notions drawn from new materialisms – are therefore integral to these three key arguments of the study.

Assemblage

Assemblage, in this study, is used to describe the actor relations between three mediators – myself as fashion-led researcher, biologists and bacteria. I argue that viewing my collaborations as human-nonhuman assemblages, between these three key mediators and their interactions, shaped distinctive roles for the fashion-led researcher in interdisciplinary teams, within my research enquiry.

The concept of assemblage was introduced by Deleuze and Guattari (1987) to describe the relations between objects and subjects as flowing, inclusive of humans and nonhumans, and accounting for complex connections stemming to and from semiotic, material and social

interactions within a system (Deleuze & Guattari, 1987:22–23). Their notion of assemblage links objects and subjects via their entangled relational threads, rather like the network in ANT (Callon & Latour, 1981; Latour, 2005). Deleuze and Guattari's assemblage – originally *agencement* (Delanda, 2016:I) – refers to a system of arrangements and rearrangements constantly in flux. They use the notion of territorialisation to describe the drawing out of a space described as an assemblage, with the understanding that these territories are continually shifting and changing, thereby necessitating the concepts of deterritorialisation and reterritorialisation (Deleuze & Guattari, 1987:376–380).

Bennett and Latour both discuss an 'assemblage' (Latour 2004:52; Bennett 2010:21) that includes organic and inorganic substances holding efficacy and agency within processes, particularly in relation to social, economic, political and ecological systems. Bennett's notion of assemblage acts as a collective group, or web, which is alive, coexistent and energetic: a network with threads linking actors via actions (Bennett, 2005:445). Bennett's assemblage is non-hierarchical – or not centrally governed – and includes human and nonhuman, cultural, technological and natural actors (Bennett, 2005:445).

Taking my collaborations as agentic assemblages highlights the challenge of where to draw the lines or territories (Deleuze & Guattari, 1987:376–380) in terms of selecting which objects to focus on and at what level of assemblage. In this study, I have highlighted the associations between the mediators as fashion-led researcher, biologists, bacteria and fabric. New materialist theorists may argue the need to account for many more actors, to describe the infinite potential configurations and reconfigurations, the multiplicities and assemblages of assemblages at an atomic level or beyond, of these actors. However, I contained the assemblages in this study, as this is a level at which the roles of each actor were identifiable within the collaborations. This allowed a deep focus on the roles and relations between these actors, which in turn enabled understandings of the roles of a fashion-led researcher as in-becoming and fluctuating, within interdisciplinary collaborations.

Bennett examines the philosophical and political implications of understanding assemblages as arrangements of human and nonhuman actants (Bennett, 2018:447). Bennett uses examples of complex assemblages such as a North American blackout (Bennett, 2005:448–452) and stem cells (Bennett, 2010:82–93) to argue for the collapsing of binaries, particularly between

humans and nonhumans (Bennett, 2005:446). She notes, in particular, the inadequacy of human-centred agency.

Bennett's notion of assemblage is most relevant to this study: I use this concept to understand my collaborations as agential co-creations and highlight the relations between the actors within them. The assemblage, here, offers a theoretical lens through which to view the entangled, agential associations between humans and nonhumans: between myself as a fashion-led researcher, the biologists, bacteria and fabric. This lens means that each actor becomes understood through its associations and interactions with the other actors, which serves as a tool to highlight the processes, associations and understandings of the 'in-becoming' of roles and outcomes. In particular, this lens demarcated my roles as a fashion-led researcher that occurred through these collaborative processes and in collisions between human and nonhuman actors within these co-agential networks.

In understanding an assemblage in the context of fashion, Smelik argues that we view fashion designs as 'hybrid assemblages of fibres, materials, skin and body that are always in the process of becoming' (Smelik, 2018a:44). In contrast, instead of concentrating on the act of wearing fashion and garments, which might have necessitated a phenomenological lens, I used the notion of assemblage within the context of fashion-led research as a tool with which to think through and understand the position, role and potential that fashion can bring. Therefore, employing new materialisms as a basis for my theoretical lens enabled a deeper focus on the agential, relational and process-led understandings of the metamorphosis of my roles as fashion-led researcher, through collaborative biological and bacterial assemblages.

Fashion as an Assemblage

Most appropriate to this study is the work of a group of contemporary fashion and textiles scholars who applied the concepts of materiality, agency and assemblage as part of a framework to analyse fashion and wearable technology, viewing every element, organic or inorganic, as holding agency.

Joanne Entwistle[44] (2016) argues for the relevance of ANT to fashion. She contends that although ANT has predominantly been applied within sociological and economic contexts, because of its origins in these disciplines, the importance and usefulness of the performativity of actions by actors in assemblages can be applied to the fashion system. This could enable an understanding of each stage in the production of a garment or material object, inclusive of all actors (Entwistle & Slater, 2014:161; Entwistle, 2016:272). This is in relation to understanding the complexity of issues of consumption within fashion, and viewing the network as part of a whole systems approach.

Entwistle approaches this from a theoretical and economic fashion research angle, from a position of observer and researcher (Entwistle, 2016:272–273). In comparison, I took the notion of the assemblage to my fashion-led approach to working in collaborations, which were micro-level projects at a local level. I used these assemblages as a way to examine inter-relations between actors in my collaborations, focusing on the fashion-led researcher, scientist, bacteria and fabric. In this way, I focused on these actors to understand how these mediators affect one another, and the final design, and how this enables understandings of the role of fashion-led research within interdisciplinary collaborations.

Fashion scholars Daniëlle Bruggemen, Anneke Smelik and Lianne Toussaint have all brought ideas drawn from new materialisms into the context of fashion studies by proposing methodological frameworks of analysis drawing on new materialist principles, and applying them to examples of fashion garments – principally with active or animate qualities, such as wearable technology. Arguably, these technological garments pose a challenge to conventional methods of object-based analysis used in fashion studies. For example, in her doctoral thesis, Bruggeman (2014) argues that applying new materialisms to fashion allows us to move beyond the representation, signs and semiotic approaches that are so prevalent in post-structuralist analyses of fashion towards the foregrounding of materiality, fluidity, performativity and body and identity-related approaches for fashion (Bruggeman, 2014:17). This means taking the theoretical ideas of new materialisms and applying them to the practices and analysis of fashion.

[44] Dr Joanne Entwistle is Senior Lecturer at King's College London, specialising in fashion, gender and dress (Entwistle & Slater, 2014:176–177).

Bruggeman uses the new materialisms to speak about human-centred experiences of fashion and identity. She proposes a new materialist approach inspired by Gilles Deleuze and Félix Guattari (1987), and their work on aesthetics and art, arguing that materiality and ideas cannot be viewed separately (Bruggeman, 2014:17). Bruggeman applies these concepts to her proposed methodology for analysis, set within the context of fashion studies, also drawing on the concept of embodiment in performance studies, and phenomenology (Bruggeman, 2014:13). In this way, Bruggeman's approach accounts for the experiential, performative and bodily aspects of fashion – the matter of materiality. Specifically, she uses a new materialist approach to develop understandings of performing identity, the body and the self (Bruggeman, 2014:16).

Smelik also draws on new materialisms within the context of fashion studies. She proposes a framework for fashion analysis focusing on new materialist understandings of materiality and material agency, arguing for the importance of materiality and understandings of fashion, garments and textiles as active rather than images or representations (Smelik, 2018a:49). Where fashion studies have previously focused on object-based methods of analysis, Smelik argues that taking a new materialist approach enables us to change our focus from a fashion garment as a singular entity to seeing it as an assemblage of actors, their shifting relationships and processes (Smelik, 2018a:50). Smelik primarily discusses wearable technology, using examples of the work of fashion designer Iris Van Herpen to highlight the active nature of technological materials.

Where Smelik proposes a framework for the area of fashion studies and focuses on materiality and material agency, I apply new materialist thinking by engaging directly with the matter itself. Therefore, although Smelik takes a new materialist approach, she draws away from the actual materiality – the formation, processes and inter-relationships, roles and objects – as continuously in-becoming.

Technological materials draw attention to this vibrant nature of matter because of the things they can do, such as glow, sense and move with soft robotics and the incorporation of electrical currents. Fashion scholar Lianne Toussaint builds upon the arguments of Bruggeman and Smelik, proposing that, because of their active and agential nature, the materials within techno-fashion require new methods of analysis (Toussaint, 2018:24). Lianne Toussaint focuses on the 'smart, interactive, self-organizing and responsive' (Toussaint, 2018:24) nature

of techno-materials and users' experiences of wearing them. To do so, Toussaint's framework combines new materialist aspects, accounting for the agency of techno-fashion garments in transforming shape or appearance, and post-phenomenology theory, in its relation to technology and to the human experience of wearing such garments.

Drawing away from these three scholars, the first significant difference in my project is that I operated from a practitioner-researcher perspective using the theoretical ideas to really think into this material engagement. This study diverges from the fashion studies approaches of Smelik (2018a), Bruggeman (2014) and Toussaint (2018), which have drawn upon concepts from new materialisms to provide theoretical frameworks to analyse final outcomes produced by fashion designers. The first significant difference is that this study operates from a practitioner-researcher perspective, rather than a purely theoretical fashion position.

The second divergence is that I employed a practice-led – and specifically fashion-led – approach focusing on analysing the roles and inter-relations of the process of collaboration rather than a practice-based approach focusing principally on analysis of final outcomes, to draw out new knowledge. The third difference is that I have argued for the inclusion of bacteria as a key agential force and biological living system.[45]

In my study the focus has not been on the experiential aspects of wearing garments, or notions of performativity or identity. Additionally, I did not operate in the context of techno-fashion or wearable technology, which is technologically anchored and principally human-designed and generated. Instead, I have argued that the relevance of new materialisms, which Smelik, Bruggeman and Toussaint variously draw on in different ways to develop their methodological frameworks for analysis, can be extended and developed for the purposes of my own fashion-led approach. In particular, I have developed Smelik's arguments regarding materiality and agency, contending that new materialist concepts can also be usefully applied to biologically active materials – and to my own examples working with bacteria.

These definitions of materiality and agency draw on my fashion design background and understandings of the importance of material sensitivity. I understand a form of negotiation

[45] Bacteria replicates, grows and has its own morphologies that are not created by a human. If provided with the requisite conditions, bacteria will grow. In comparison, it is more difficult to see the vibrant nature of fabrics such as woven or knitted materials – cloth that has been designed and created by human agency.

occurs when working with materials and, in particular, when draping with fabrics. This is because specific qualities of fabrics can guide a fashion designer in how to work with the material, and forcing materials to perform in a certain way, or imposing design agency, does not consider inherent material properties. Being sensitive to materials means working with fabric and its agency, allowing its own properties to translate into the final garment. In my approach, using bacteria that already exists, I demonstrated this sensitivity and agency of materials. The bioluminescent bacteria is particularly interesting because it is highly sensitive and showed this in a very particular way. For example, when working with bioluminescent bacteria for the *Azazel* project, bacterial agency was shown when it did not glow on the lower half of the garment (see Volume 1: Collaborative Projects). Although this could have been for a number of reasons, the final outcome was not wholly dictated by myself, biologists, or the fabric, but in part through the agency of the bacteria.

Summary

This investigation offers a fashion-led researcher's perspective, within collaborative mechanisms, to document praxes between fashion-led research and biology. Drawing upon themes within ANT and new materialisms, I focused on the assemblage, materiality and agency inclusive of humans and nonhumans within this study. The assemblage is understood in my thesis to consist of myself as a fashion-led researcher, scientists, bacteria and fabric. I used this underlying theoretical context to understand, analyse and interpret the interactions of the actors within my case studies and collaborative projects in the Data Discussion chapter. Employing this theoretical lens enabled me to examine my projects inclusive of human-nonhuman relations. I argue that the concepts of assemblage, agency and materiality are relevant in contributing understandings of the potential relationship between fashion-led research and biology through viewing them as assemblages, and to shaping the distinctive roles of fashion-led research in interdisciplinary teams, within this study.

METHODS

Research Design and Methods

In this section I outline the development of the research methodology employed for this investigation. This is a fashion-led research PhD undertaken through practice, utilising qualitative research methods. A multi-method approach (Gray & Malins, 2004:72) was selected to study the mechanisms of collaborative approaches between me, as a fashion-led researcher, and biologists. My qualitative multi-method approach was designed considering the concepts of agency, materiality and assemblage, drawn from new materialisms and actor-network theory (ANT). This theoretical context acted as a lens through which to view collaborative interactions throughout the study. These concepts informed the choices of qualitative research methods employed, as I selected methods that allowed for plural agential perspectives. As discussed in the Theoretical Context chapter, the new materialisms encourage a flattening of hierarchies and the inclusion of both human and nonhuman agential relations (Barad, 2003:814; Fox & Alldred, 2017:7; Cruickshank & Trivedi, 2017:569–570). Nonhuman agency was addressed in this study through the inclusion of bacterial agency within the collaborative projects.[46]

This context further feeds into the methods via the acquisition of plural perspectives rather than a singular top-down researcher perspective. Plural viewpoints were collated using semi-structured interviews (Savin-Baden & Major, 2013:359) with three key actors within the collaborations: fashion practitioners, their scientific collaborators, and a curatorial or producer perspective. The semi-structured interviews formed the basis for two key case studies: the *Primitive Streak* collection and the *9/4/1615* exhibition. The case studies used methods of interdisciplinary collaboration across fashion and biology to produce outcomes for educational and cultural sectors, chiefly for public engagement and promotional purposes. These cases were selected as two significant examples of projects where fashion practitioners have instigated and led collaborations with biologists: major fashion house Maison Martin Margiela in conjunction with Dr Ad van Egeraat; and Helen and Kate Storey. I have found these

[46] This position did not reduce the bioethical issues arising when working with living systems of any kind, encompassing areas of human dominion, control and the complicated relations between humans and nonhumans (Catts & Zurr, 2013:73–74; Tonuk & Fisher, 2018:1714). However, I contend that employing this theoretical context was an attempt to question such hierarchies when working with living systems and collaborating within a fashion context.

particular projects important in their establishment of pioneering interdisciplinary fashion and biology approaches in a context when this was relatively uncharted territory – Europe during the 1990s.[47] These interdisciplinary projects have signalled potential pathways for successive fashion and biology collaborations and are important to contemporary fields, such as biodesign and biofabrication.

Including plural perspectives showed the value of these interdisciplinary collaborations – to the fashion practitioner and their collaborators – and exposed the different effects and impacts of the collaboration on each actor. I gathered plural perspectives by conducting three sets of interviews per project. I included these voices in the resultant case studies to interrogate understandings of the potential relationship between fashion-led research and biology, from the perspectives of the fashion practitioner, scientist and producer or curator. This led to knowledge of the importance of collaborative practices from fashion and biology perspectives, and therefore this project and its findings may be applicable to both disciplines. Asking practitioners and collaborators to reflect on their experiences, and in turn myself reflecting on these interviews – during the interview itself, through transcribing, checking each participant was happy with the transcript, and sitting with and re-reading the transcripts – facilitated a discursive and reflexive approach. Including plural perspectives, rather than considering the research question purely from a fashion-led research viewpoint, led to a fuller understanding of the roles of a fashion-led researcher from both disciplines.

Following Rose (2001:203), and Gray and Malins (2004:72), my multi-method approach enabled the formation of a research methodology accounting for the pluralistic nature of an artistic enquiry. I used both case study and collaboration as method, expanding upon both in detail in Phase 2 of this chapter. Employing case study as method enabled new understandings from multiple agential perspectives from two key projects between fashion and biology. This is because existing art-science or design-science accounts have primarily been written from the

[47] During the 1990s and 2000s, arguably the sciences sought to draw on the popularity of the arts. The context of the 1990s is important, as during that time in the United Kingdom, the sciences were undergoing a negative reception from the public because of issues such as the AIDs crisis, BSE and debates over genetically modified crops (Bauer, 2009:225; The Royal Society, 1985; Born & Barry, 2010:107; Bauer et al., 2007: 82). This negative public attitude towards science was directly addressed in The Royal Society's report entitled *The Public Understanding of Science* (1985), which, among other recommendations, suggested the potential of museums as a means to foster greater public understanding of science. This notion of public understanding of science was a precursor to what is now widely known by scientists as public engagement, when engaging in arts projects or those outside the scientific agenda. It was in the context of the 1990s, when public engagement schemes such as the Wellcome Trust's Sciart Programme were introduced, from which the *Primitive Streak* collection was an outcome. Therefore, looking back at these projects from the 1990s offers insights into a time when science looked to the arts to gain popularity, which can help to identify the value scientists were seeking from artists.

artist's perspective, and the scientists' voices within such collaborations rarely heard. My enquiry therefore included these voices to understand the roles, value and impact of such collaborations from both fashion and biology perspectives. Collaboration as method was used to reveal my own disciplinary traits, to chart a fashion-led research approach in this enquiry. Data collection methods were tailored to account for the individual nature of each collaborative project. This multi-method approach allowed responsive data collection to react to the complex collaborative and interdisciplinary nature of the 'artistic' (Gray & Malins, 2004:71–72) research question.

The research was conducted in four phases: early data collection; targeted data collection, comprising two key case studies, a series of six collaborative projects and workshops; scientific collaborator interviews, results and analysis; and findings, discussion and conclusions. The four phases account for the various stages undertaken during my research process, my shifting modes of operation during these phases and the bespoke methods employed at each point of the enquiry. As the study progressed, the phases became more targeted, in response to my research questions. This primarily enabled me to understand mechanisms of collaboration both from a fashion-led research standpoint and by gathering plural perspectives.

I use the following Methods chapter to discuss the methods employed through Phases 1 to 4 of my research investigation. First, I give an overview of the phases of research, before focusing on the key methods within each phase: interviews, case study as method, collaboration as method, workshops using a fashion-led research toolkit developed through the research, and the data analysis tools employed. I conclude this chapter by summarising the methods used within this study and how they answer the research questions identified, and the rationale for the research approach taken.

Phases of Research

During Phase 1, I observed and embedded myself in the fields of study in order to investigate the collaborative approaches undertaken by other fashion and science practitioners. This phase was conducted from the position of embedded practitioner – immersing myself by navigating a place within the fields of artists and designers practising and working with biological elements. Working as an embedded practitioner entailed engaging in an immersive survey of practice and the research field: attending and running events, talks and workshops and

informally interviewing biological artists, designers and scientists. I discuss this position in more detail in Phase 1 of this chapter.

In Phase 2, following the contextual review, in which I mapped practitioners in the field of research, I focused on two key case studies. The case studies were selected as two key examples of fashion leading in fashion and biology collaborations. They were developed by conducting semi-structured interviews with three actors from two collaborations between fashion and biology. Overall, the case studies were necessary to gain an understanding of the typologies of fashion and biology approaches from the collaborations that foregrounded this research.

I then turned the lens onto myself as a fashion-led researcher and my fluctuating role within collaborative projects as the phenomenon of study. The position of practitioner-researcher (Gray, 1996:13; Gray & Malins, 2004:19) is adopted to understand and map, from a first-hand perspective, how my role as a fashion-led researcher shifted and fluctuated in a series of six collaborative projects. Adopting a practitioner-researcher role sets this project apart from other studies that have explored fashion and biology collaborations purely from a social science or theoretical fashion perspective (see: Entwistle & Slater 2014; Entwistle 2016; Bruggeman, 2014; Smelik, 2016; Smelik, 2018a; Toussaint, 2018; Granata, 2017). Here, I operated as an active participant in the collaborations to understand collaborative practices from within the process. I used workshops using the fashion-led research toolkit that I developed during the process of this research, as a tool to test and gain new understandings of the types of roles fashion-led researchers can play during collaborative projects. I will discuss the workshops and use of the toolkit in detail in Phase 2 of this chapter.

For Phase 3 I used a variety of early data analysis methods to filter for applicability to the research question. Final data analysis methods included reflexivity, process diagrams and transcription of collaborator interviews. My use of qualitative methods of data collection and analysis means the validity of findings is open to subjectivity, and therefore I incorporated interviews and supporting literature. These included interviews from collaborator perspectives (which form the case studies) and the use of reflective interviews following my collaborative projects (scientific collaborator reflections).

Lastly, in Phase 4 I drew out key findings, contributions and conclusions using soft coding to group findings into aspects relating to assemblage, agency and materiality (concepts discussed

in the Theoretical Context). During this phase, I presented and interrogated the data findings from the case studies, collaborative projects, workshops and use of the fashion-led research toolkit, and reflective interviews. Two key contributions are posited from this enquiry. The research has led to new understandings of both:

1. the potential relationship between fashion-led research and biology, *in particular*; and

2. the potential of fashion-led research to play a distinctive role in interdisciplinary teams, *in general*.

Presenting, analysing and synthesising the data findings allowed this study to be viewed in a wider context of practice research, and to understand how fashion-led research in collaboration can contribute to fashion design research.

These phases allowed for understandings of the shifting roles of a fashion-led researcher within interdisciplinary teams. Methodological innovation entails documenting the process and procedures of collaborative fashion design research and biology practices. The research tools, in conjunction with my theoretical context, enabled exploration of the significance and agency of the fashion-led researcher in formulating, leading or working from the onset and curating these interdisciplinary interactions. Undertaking these phases of the research led to the development of understandings of the potential roles of a fashion-led researcher in interdisciplinary teams.

In the following section I draw out the key research methods and my rationale for employing them in relation to my research questions and enquiry, through Phases 1 to 4 of my study.

PHASE 1

Phase 1 was conducted from the position of an embedded practitioner navigating a place within the field of artists and designers practising and working with biological elements. Immersing myself in the research field meant taking my work outside the fashion discipline and embedding myself as a fashion practitioner and fashion-led researcher in the contexts of

synthetic biology, microbiology, biotechnology, biological design, biological art and fashion design. I aimed to observe and actively contribute by working first-hand with scientists, designers and artists, exploring the interactions within these areas by participating, meeting, networking, attending workshops, curating events, panel sessions and debates. I looked at how synthetic biologists, microbiologists, artists and designers were working together, between and beyond the frictions, tensions and differences in their points of view to collaborate, debate, exchange, facilitate and operate.

Operating as an embedded practitioner meant I was working and immersing myself alongside practitioners in the research field, rather than employing a top-down approach to research, in which a researcher studying an object or phenomenon from a position away from the phenomenon might operate. The immersive nature of this embedded role emphasised an understanding of myself as part of an interconnected network, linking to the notion of assemblage discussed in my theoretical context. Smelik discusses fashion as 'materially embedded in a network of human and nonhuman actors' (Smelik, 2018a:34). I wanted to extend this notion from fashion to fashion-led research and my context of looking outwards to biology, which I explored by embedding myself in interdisciplinary spaces. Embedding led to new insights and the development of empathy (in particular to nonhuman actors), meaning I evaluated the agency of the human and nonhuman actors, such as bacteria, viewing them as actors in a flattening of hierarchies rather than objects.

Early Interviews

This phase of the research used a combination of ethnographic and autoethnographic approaches to data collection. I conducted early, informal interviews (Savin-Baden & Major, 2013:360) with key practitioners about their work in biological art and design. Interview participants included biological designers and artists such as Anna Dumitriu, Suzanne Lee and Sputniko! and prominent scientists within the field of synthetic biology, such as George Church.

These informal interviews were semi-structured and I used open-ended questions to enable responsive questions, answers and fluidity in these early discussions (Savin-Baden & Major, 2013:360). They differed from the more targeted and focused interviews discussed in Phase 2,

as the informal interviews contained early research questions regarding what it meant to work with living systems.

This early immersion and the informal interviews enabled me to embed myself in the research field of study in order to engage with key practitioners and the leading debates in the fields of synthetic biology, biological art and design and fashion research. It led to opportunities for collaboration and discussion and helped me to narrow down my research questions, which meant I could conduct targeted, semi-structured interviews during Phase 2. The early interviews developed my initial understandings of key stakeholder positions, enabling me to enter the fields of study as an embedded practitioner – a fashion-led researcher. As the phases progressed, interviews became targeted to gather specific information from selected practitioners relating directly to the research questions.

PHASE 2

Phase 2 forms the main body of data collection: two key case studies employing case study as method; a series of six collaborative projects working with bacteria and biologists, using interdisciplinary collaboration as method; and workshops using a toolkit. Here, I detail the rationale for the selection of these methods in relation to my research questions.

Case Study as Method

After conducting a contextual review and mapping out the field of study, I found that existing literature and practitioner accounts tended to focus on final outcomes rather than discussing the roles, relations and agency within collaborative projects. There was a gap in understanding in these areas, both from a fashion practitioner perspective and from the viewpoints of biologists, curators and producers. The case studies (see Appendix 1: Case Studies) were therefore a necessary step in examining the ways in which fashion and biology collaborations have operated. I selected four case studies and conducted interviews with the fashion practitioners from each of these studies. The practitioners were selected either for their background in fashion design or because they had worked with a fashion designer or fashion house, and key projects were selected as examples of collaborations with microbiology driven, initiated or led by fashion.

I narrowed these down to two key case studies, which better demonstrated the shift in my research questions towards understanding the mechanisms of collaborative practices, rather than the shifting trajectory of fashion designers into the area of biological design. The case studies refer to individual projects working in collaboration with scientists, rather than business or commercial approaches. This is because I conducted this enquiry from a position in academia, looking at the potential for fashion within the early research and development phases of a fashion design process, rather than from a commercial setting.

To produce the case studies, I researched the collaborations – locating and contacting the curators, fashion house and scientists involved. I selected the *Primitive Streak* collection because of my interest in Helen Storey and her shift from commercial fashion into collaborative fashion and science praxes in an academic setting. I chose the *9/4/1615* exhibition because I wanted to understand why Maison Martin Margiela, as a high-end commercial fashion house, wished to use bacteria and collaborate with a microbiologist. I formed targeted interview questions and conducted interviews, by telephone, video-conferencing or in person, with Helen Storey, Kate Storey and Caroline Coates (Case Study 1: *Primitive Streak* collection) and Ad van Egeraat, Thimo te Duits and Patrick Scallon (Case Study 2: *9/4/1615* exhibition). The interviews were semi-structured, and the case study analysis is supported using existing literature, such as reports, interviews, Internet resources, diaries from participants and theoretical writing, which centred on the collaborations. Semi-structured interviews allowed a fuller understanding of the mechanics of the project and what the individuals gained from it – in their own words. Therefore, interviews were selected as a more useful, qualitative method than quantitative methods, such as questionnaires[48] containing closed-ended questions, which could not elicit such open responses (Archer, 1995:13).

[48] Questionnaires were employed as an early form of data analysis following the collaborative projects. I formulated and distributed the questionnaire to a sample group consisting of practitioners in biological art and design, in synthetic biology and microbiology, and other collaborators and members of the public. In this way, it was intended as a form of data validation that was collaborative in nature, and inclusive of a fashion-science participant sample. The questionnaire included images of my project outcomes of making and was distributed in a gallery setting, asking participants their views on the value of displaying and probing science via fashion-led research practice. The questionnaire was useful when looking at the final outcomes as a visual data set; however, my shift in focus to the collaborative process itself meant that this questionnaire was no longer relevant to my study. The questionnaire did not allow for the open-ended flow of dialogue that emerged when questioning participants using semi-structured interviews, and therefore I found interviews more useful in obtaining much more in-depth answers about the personal perspectives and understandings of participants' experiences of collaborative projects.

My aim with the interview questions and the selection of these particular projects was to gain and share new insights into the collaborative processes undertaken in these fashion and biology approaches and to understand the roles of each actor. I chose projects that had occurred during the late 1990s instead of more contemporary projects, as I wanted to look at a time when the sciences were perceived negatively by the public and were seeking to draw on the popularity of the arts (Bauer, 2009:225; The Royal Society, 1985; Born & Barry, 2010:107; Bauer et al., 2007:82). These choices could be critiqued in terms of understanding collaboration as a result of the close existing relationship between the Storeys as sisters and the relevance of these projects for contemporary practitioners, due to occurring in the 1990s. I argue that the infrequency of these types of collaborations means that the insights gained through the case studies are still useful for providing information about fashion and biology's relationship when working together in interdisciplinary collaborations. Each collaborative project contains elements such as chance, expedience and availability – for example, because of fitting into funding rounds, or design cycles. The case studies still stand as important examples in the field in which to analyse and provide insights into the value of scientists and fashion practitioners seeking to engage collaboratively.

In understanding and reflecting on these early, precursive projects, I highlight and elicit further the focus of this project's rationale as the value and roles that a fashion-led researcher can play, and the ways in which these roles can be valuable to collaborations and interdisciplinary teams. In addition, interviewing the actors and reflecting upon these projects from the 1990s allowed a significant period of time for the actors to have reflected on the work and to see how these projects shaped their trajectories – in particular, the roles of the fashion practitioners. This enabled me to understand the relationships and longer-term impact of the projects on each of the actors involved in the fashion and biology collaborations.

The interviews were responsive, allowing the integration of key questions along with the freedom to discuss topics arising during the conversation. I adapted the questions to the flow of answers, using questions as prompts rather than more rigid, closed questions. The questions centred on examining the key drivers, development and shifts in roles, modes of collaboration and co-authorship, and the impact of fashion and science practitioners within these cases. The form of questioning followed Donald Schön's 'reflection-in-action' (Schön, 1983:49) approach, in which the practitioner-researcher considers their actions and the process and develops their actions (in this case, the interview questions) based upon reflection (Schön,

1983:56). This approach meant that not all questions were identical, and interviews were learnt from and written up prior to conducting further interviews.

Ultimately, the case studies allowed me to understand how fashion, design and art practitioners worked and collaborated with biologists, and their views on design-science collaborations. Employing these qualitative research methods allowed flexibility and an understanding that subjectivity and specificity are strengths in design research practices, rather than quantitative methods in a science tradition (Archer, 1995:11–13). The interviews and case studies generated plural perspectives on how the collaborations were formed, how they operated, how the fashion practitioners worked with the scientists, the roles of each actor, and the impact of the collaboration between fashion and biology. These methods therefore allowed a space for gathering subjective insights into two examples of interdisciplinary collaboration, allowing for new understandings of the potential relationships between fashion-led research and biology.

Interdisciplinary Collaboration as Method

One of the core methods of data collection was the formation and production of a series of six collaborative projects (see Volume 1: Collaborative Projects), which were designed in collaboration with biologists. They were either initiated and organised by me or included myself working as a fashion-led researcher from the project's inception. Using interdisciplinary collaboration as a method allowed a way of working as a fashion-led practitioner-researcher in my own collaborative projects, to obtain and share insights into the collaborative process at first hand. This differs from studies that have either focused on analyses of final outcomes from collaborative praxes or have not been written from a practitioner's perspective (for example, see: Bruggeman, 2014; Smelik, 2016; Smelik, 2018a; Toussaint, 2018; Evans, 1998; Evans, 2003; Lee, 2005; Granata, 2017). It was necessary to share the roles and relationships of fashion-led research in collaboration, as these were not discussed in the existing literature. My aim was to gain and share specific first-hand knowledge as a practitioner – by immersing myself within collaborative praxes to examine the roles of fashion-led research in interdisciplinary teams.

In this way, the agential roles of the scientist and bacteria were important within my collaborative approach, as points of comparison to lead to new understandings of the distinctive role a fashion-led researcher can play in interdisciplinary teams. This study uses collaboration

as a method to show my own role and value as a fashion-led researcher within interdisciplinary collaborations. I worked as a practitioner-researcher, analysing and reflecting upon my role as a fashion-led researcher. I worked with synthetic biologists Anton Kan and Bernardo Pollak at the University of Cambridge to develop bioluminescent garments imbued with glowing *Photobacterium kishitanni*; and with Dr Simon Park from Surrey University to develop cyanobacterial-material hybrids, conceptually exploring the self-repairing property of the bacteria. I also collaborated with synthetic biologists at Puraffinity to develop a proof-of-concept garment using functionalised bacterial cellulose grown in the laboratory. Making, growing, experimenting with and displaying bacteria informed the mediation and collaborations between assemblages inclusive of myself as fashion-led researcher, biologists and bacteria as co-actors.

The key driver for each collaborative project was to explore the possibilities of bacteria and its natural properties and to produce bacterial-material installations for gallery settings. The practice of exhibiting our outcomes provided a shared goal and mutual focus between me as a fashion-led researcher and the biologists. The collaborative projects enabled me to understand how I operated, the formation of my role within an interdisciplinary team, and the agency of the co-actors in such processes. This led to the development of a fashion-led research toolkit which I used to draw out data during a series of workshops. The workshops will be discussed in further detail in the Workshops section of Phase 3 in this chapter.

Collaborations are used to understand how and why incorporating a fashion-led research approach, and thus interdisciplinary thinking at the point of idea generation, when working with scientists or collaborators, can help to explore new areas and forms of design. The form of collaboration within this thesis was the synthesis of specialised, expert practitioners principally undertaking their own disciplinary roles (Darbellay, 2015:165–166). This enabled collaborations that brought me as a fashion-led researcher together with biologists, with the requisite disciplinary knowledge to produce bacterial-material outcomes. Leading, initiating and working from the start of a collaborative project was integral to this enquiry (Collet, 2012a:7; Toomey & Kapsali, 2014:12) to understand and share how collaborations between fashion-led research and biology are formed and operate from their inception. This is in line with Carole Collet, Suzanne Lee and Christina Agapakis, who emphasise the value and importance of engaging with designers from the outset of collaborative projects (Collet, 2012a:7; Agapakis & Lee, 2019). I used my collaborative projects to test this approach.

Darbellay asserts that within interdisciplinary collaborations, stakeholders bring specific knowledge and thinking as experts from their own fields and disciplines, producing an integrative approach that works towards a shared purpose (Darbellay, 2015:165–166). My study works with disciplinary experts and takes Darbellay's definition of interdisciplinarity – or the combination and interaction of at least two disciplines – to enable understandings and analysis of a complex phenomena (Darbellay, 2015:165–166). Alternatively, Davies and Devlin describe a nuanced continuum of interdisciplinarity citing hugely complex examples of mutual foci, such as climate change and the AIDS pandemic (Davies & Devlin, 2010:11–19). It is Darbellay's (2015:165–166) definition of interdisciplinarity that I drew on, as Davies and Devlin's mode does not reflect the scale of the bespoke one-to-one methods of the form of interdisciplinary collaboration employed within this enquiry.

An interdisciplinary approach helps to reveal individual disciplinary methods (Igoe, 2010:8). Employing interdisciplinary collaboration was intended to outline disciplinary boundaries, as my collaborators were disciplinary experts. The collaborative projects allowed me to understand and document the key points of my own fashion-led research in collaboration process, undertaken with biologists. These projects also allowed me to outline the shifting roles of the three key actors: fashion-led researcher, bacteria and biologists. This allowed the emphasis of the study to highlight the relationship between fashion-led research in collaboration with biology. The projects provided a space for experimentation and led to understandings of the distinctive nature of the role of fashion-led researchers within interdisciplinary teams, highlighting the value of fashion-led research to an emerging collaborative landscape.

Collaborative Projects and Scientific Collaborator Interviews

Interdisciplinary collaborations with biologists were undertaken as an integral method throughout my research project and were reflected upon using collaborator reflections and autoethnographic reflexivity. I conducted a series of six collaborative projects to examine the role and potential impact of a fashion-led researcher working within collaborative fashion and biology projects. I conducted three collaborations with Anton Kan and Bernardo Pollak, [49]

[49] Anton Kan and Bernardo Pollak were scientific collaborators for *Lo Lamento*, *Azazel* and *Living Light Dress*. At the time, Kan and Pollak were PhD candidates at the Haseloff Laboratory, Department of Plant Sciences, University of Cambridge.

which form Set 1 – *Lo Lamento*, *Azazel* and *Living Light Dress*. I worked with Simon Park[50] to produce *Living Lace* and *Oscillatoria Sutured*. *Aequorea* differs, as the only example of a science-led project, in collaboration with Ben Reeve,[51] who was working at the time as Chief Technical Officer of the company Puraffinity. The collaborative projects form Volume 1: Collaborative Projects.

I worked from the outset of each project as an active practitioner-researcher – a fashion-led researcher. The intention of employing this practice-led way of working was to examine how a collaborative fashion-led approach with biologists operated, what the shifting roles were, and to understand the potential impact of a fashion-led researcher working within each interdisciplinary assemblage. Undertaking the collaborative projects allowed me to obtain and develop first-hand insights, by immersing myself within collaborative, practice-led projects, which could not be ascertained through the contextual review, practitioner interviews and case studies alone.

Due to the bacterial nature of the projects, health and safety aspects were key concerns. Risks mainly entailed the biohazards associated with working with live bacteria. Therefore, aspects of scientific collaborations using bacteria and living materials were carried out in the laboratory of the collaborator or under the supervision of the scientists. I followed existing laboratory health and safety procedures and frameworks, for example wearing gloves, goggles and a laboratory coat and washing my hands using antibacterial soap when entering and leaving the laboratory. Where the collaborative projects were carried out in galleries or studios, the scientist inoculated the garment with the live bacteria wearing gloves and ensuring safety and best practice at all times. Autoclaving and antibacterial sprays were used to clean potentially affected areas after the removal of the pieces, such as from vitrines and galleries, and masks, gloves and laboratory coats worn in these instances.

[50] Simon Park was a scientific collaborator for *Living Lace and Oscillatoria Sutured*. At the time, Park was Senior Lecturer in Molecular Biology at the University of Surrey, while also running the Exploring the Invisible website to share his experiments with bacteria and biological living systems with the wider public. Park's own practice included teaching microbiology at the University of Surrey, yet he also produces a series of experiments drawing on elements of scientific and artistic practices and has a history of collaboration with artists and designers (Exploring The Invisible, 2012).

[51] Ben Reeve was a scientific collaborator for *Aequorea* and worked as Chief Technical Officer of Puraffinity (formerly CustoMEM). Reeve is a bioengineer and materials expert, and holds a PhD in Bioengineering and Synthetic Biology from Imperial College London. Reeve is currently Co-Founder and Chief Technical Officer of Modern Synthesis, a biomaterial innovation company in the UK.

Although some of my collaborators are from the field of synthetic biology, and I have undertaken workshops and attended conferences in this field, my collaborative projects did not actively employ synthetic biology. Therefore all of my projects can be described as working with microbiology.

The work produced did not deal with livestock or humans, and thus did not require specific ethical considerations, and the study was conducted in accordance with the Ethics Committee at the Royal College of Art. I felt a personal responsibility to define my own ethical parameters, and thus I only utilised bacterial matter (rather than animal or plant tissue), and produced bespoke and one-off pieces to manage and minimise my impact upon the environment and the organisms. As biological design is still an emerging area, I am aware of the responsibilities in producing work which could be used to question, probe and shape the types of future applications we as humans and users want and need to produce, and the overall look and visual design aesthetic. Therefore, although this work deals with living bacterial systems, rather than humans or animals, there are human management responsibilities which arose in the work and debates have been generated amongst artists and designers working with biological and living matter, encompassing bioethical issues.

Human ethical considerations were a key requirement, and a completed ethics course and certificate were undertaken and approved by the Ethics Committee at the Royal College of Art (for Ethics Certificate, see Appendix 2). Ethics concerned the use of images and documentation arising from collaborative works, interviews, debates, videos and film-making and photographs, and the use of transcriptions and video recordings within the thesis. Consent forms and information sheets were sought from all collaborators, interviewees and participants to cover human ethical considerations and meet relevant ethical standards. Participants signed permission forms allowing me to use information and data gathered within the thesis.

Following my collaborative projects, reflective interviews with collaborators were conducted to understand my scientific collaborators' perspectives on the process and collaborative outcomes. Interviews were carried out via telephone or video-conferencing, or in person. These interviews were recorded on audio or video and transcribed. This approach brought together dual reflections to better understand the perspectives and mechanisms of the relations between the fashion-led researcher and biologists. The interviews enabled new insights and a more in-

depth understanding of collaborations between fashion-led research and biology, from the biologists' perspectives.

I interviewed Kan, Park and Reeve – three of my scientific collaborators. The interviews were semi-structured, and I asked the microbiologist (Park) and synthetic biologists (Kan and Reeve) to reflect upon their perspectives as scientists during the interdisciplinary collaborations. The collaborative projects were conducted during 2016 and 2017, and the interviews were carried out in 2019, allowing time for the scientists to reflect on and consider the impact of our projects. I questioned the scientists about their roles during the work and their understanding of my roles; the purpose of the collaborations; how their research developed after the projects; reflections on final outcomes and their viewpoints on fashion-led research and science collaborations. This was done to obtain their understanding of the shifting roles and potential impact of myself as a fashion-led researcher during collaborative projects – all of which I initiated, led or worked from the outset as a fashion practitioner.

Workshops

To understand the potential value and roles of fashion-led research, I needed to understand how fashion-led research is viewed by those working within fashion and textiles. I conducted a series of six workshops using my fashion-led research toolkit. This was to ask what fashion-led research is, from the perspective of specialist practitioners operating in fashion and interdisciplinary fashion and biology spaces. My definition of fashion-led research is detailed in the Contextual Review chapter and is aligned with a focus on the process rather than final outcomes, and an understanding that new knowledge can emerge through the process itself. The process of exploration here is fashion-led research in collaboration with biologists. Conducting the workshops was key for gathering insights from others as part of my research approach – which is relational, questions hierarchies and examines other perspectives.

The workshops were conducted in person and virtually (using video-conferencing and digital software). I selected workshop participants from within the discipline of fashion, with primarily fashion or textile practitioner backgrounds. The participants were selected to represent fashion practitioners operating in interdisciplinary ways with collaborators or teams, including scientists. By selecting these specialist participants, I intended to obtain further understanding of the nuances of fashion and how it is viewed from the perspective of those operating within

the discipline. This was to understand what those working within the fashion discipline viewed as distinctive to fashion, rather than to any other design discipline. I also wanted to examine whether the types of roles reported by these participants could be applied or applicable to wider understandings of my role as a fashion-led researcher in my collaborative projects. I found that although each participant viewed fashion in their own way, there were some overarching key aspects and roles offered by the participants. I lay these facets out in the Data Discussion: Part 2.

Initially, I ran four workshops with four practitioners who had each worked or were working with biology and living systems, and collaborating in interdisciplinary teams with scientists, operating in the United Kingdom, Italy and Denmark. I ran a further workshop with the Textiles and Material Design Research Group at the Royal College of Art, London. Lastly, I ran a workshop with participants from Focus Textil in São Paulo, Brazil. I tailored the workshops to ask specific questions of the participants: to reflect upon participants' understandings of fashion, how fashion operates during collaborations, how fashion is distinct from other design disciplines, participants' ways of working and the types of roles they have taken on in interdisciplinary teams.

In the workshops, I drew, in particular, on the 'in-action' element of Schön's practitioner 'reflection-in-action' (Schön, 1983:49) approach. This form of reflection centres on 'outcomes of action, the action itself, and the intuitive knowing implicit in the action' (Schön, 1983:56). I used the workshops to gather feedback from fashion practitioners, to expose new understandings of the potential of fashion-led research and how fashion-led researchers demarcate distinctive roles in interdisciplinary teams. I reflected upon the findings and discussions within each workshop and mapped out emerging themes, which I reflected upon, honed and added to, after conducting subsequent workshops. Reflections centred on key questions regarding participants' thoughts and understandings of the following questions: What is fashion? Why do fashion practitioners collaborate with scientists? What are the distinctive roles of fashion-led practitioners within these interactions? This method of workshopping using a toolkit led to further insights into the potential role of a fashion-led researcher.

In this way, the workshop findings enabled new understandings of the potential of fashion-led research to play distinctive roles in interdisciplinary teams.

PHASE 3

Phase 3 comprises the data analysis and results. Many early data analysis methods were employed and then filtered for applicability, to ensure their direct relation to the research question and sub-questions.

Data Analysis Tools

I used a variety of early data analysis methods, including an overall data analysis chart to search for patterns in the data; linguistic analysis using a digital analytical tool; coded thematic classification of keywords; ethnographic material interviews; reflective interviews with scientific collaborators; a questionnaire, and mapping the collaborations using Venn and assemblage diagrams. I then filtered these data analysis methods to select relevant tools, in accordance with the three key aspects of the study: fashion-led research, fashion-led research and biology in collaboration, and the contribution to fashion design research. This was to respond directly to the main research questions and contributions of the study. The final data analysis tools used in the study were:

Fashion-Led Research

- Reflective analysis from workshops and collaborative projects
- Mapping collaborations (diagrams)
- Transcriptions

Fashion-Led Research and Biology in Collaboration

- Diagramming (assemblage diagrams and Venn diagrams)
- Reflective interview analysis from interviews with scientific collaborators
- Transcriptions

Contribution to Fashion Design Research

- Reflexivity

Reflexivity

After trialling alternative early data analysis methods[52] for suitability, reflexivity was selected as most appropriate for this enquiry. Reflexivity is more suitable for answering the research question and sub-questions than earlier data analysis methods, as it enables an emphasis on reflections on actions and process, which are key to a practice-led rather than practice-based approach. Donald Schön (1983) describes 'reflection-in-action' (Schön, 1983:49) as a form of considered action: a process of doing, reflecting on practice and developing as reflections, which integrates with tacit knowing and occurs during the process of making (Schön, 1983:50–56). Schön's notion of reflexivity as a rigorous form of reflection was employed in this study in terms of gathering plural reflections for the case studies, collaborative projects and iterations of workshops undertaken, as well as in the reflexive approach employed throughout the data analysis stages of the investigation.

I drew on Sgro's use of reflexivity in the context of fashion within this enquiry, in its employment as a tool to explicitly reveal and share knowledge of my process as a fashion-led researcher in collaborative practice. Schön discusses how practitioners reflect on their actions by actively identifying processes and key features and setting or recognising criteria by which these judgments are formed (Schön, 1983:50). In her doctoral research enquiry, Donna Sgro[53] contends that, particularly within fashion design, practitioners are not making explicit or disseminating tacit knowledge of their fashion design processes (Sgro, 2018:7). Sgro uses reflexivity in combination with fashion design practice to externalise knowledge and critically reflect on her processes (Sgro, 2018:50–51).

Reflexivity was key to my data analysis and was used to reflect upon data collection, such as interviews and their transcripts, using the following criteria (key questions): the key drivers, roles and impact (reception and participant reflection) within the case studies. Following Schön's recognition of analytical criteria, within the collaborative projects, I specifically reflected upon my own role using mapping and diagramming, as methods of reflexivity, to show how this shifted throughout the projects. I employed reflexivity in interview analysis by

[52] Early data analysis methods included a data analysis chart mapping patterns across the collaborative projects, the use of a textual analysis tool, data coding via linguistic themes identified by the textual analysis tool, early ethnographic material interviews, reflexive analysis of a debate which I organised and ran, including key practitioners working between biology, art and design, a questionnaire and analysis and diagrams as mapping tools.
[53] Donna Sgro is a Design Lecturer at the University of Technology, Sydney (University of Technology Sydney, 2019).

including the voices of my collaborators and those of the collaborators within the case studies in the main body of the thesis. Reflexivity was employed in my consideration of the perspectives of my collaborators, and of the scientific collaborator and curator or producer voices to form the case studies. I took an approach that reflected upon these projects from multiple angles, as a conscious decision to highlight the importance of considering these alternative viewpoints and their voices in order to understand what these forms of collaboration and ways of working mean to each actor. This allowed me to ask and understand how the collaborations, my role and the value of the fashion-led researcher were perceived by my collaborators, to reveal the biologists' understandings of the value of fashion-led researchers within interdisciplinary teams. Understanding their perception of my role in these collaborations enabled me to understand the perception of fashion-led research from a less personal and biased standpoint (my own) and to critically evaluate its value outside my own discipline.

Transcriptions

Following the interviews undertaken during the case studies and following the collaborative projects, I transcribed each conversation manually, acknowledging transcription as a subjective method (Bucholtz, 1998:1446). I used the process of transcribing to sit with the data and reflect upon the conversations, answers and accounts from the interviews I had conducted. I recorded each interview, for which I had gained prior consent from each interviewee, and I listened to each recording and transcribed the speech verbatim – including repetitions of words and breaks in speech – to stay as true as possible to the reality of the speech during the interviews and our conversations. This was because I wanted to represent the process and conversation as it had unfolded, rather than presenting an edited version, as I contend that sharing the whole process is important to a fashion-led approach. This is achieved by communicating the realities of the speech and accepting that this forms part of the process, rather than focusing on editing or summarising interviews to present them as final outcomes.

After transcribing the interviews, I sent each script to the relevant participant for them to check the transcription, clarify any words I had not understood or heard correctly, and to ensure that they were satisfied with the transcript in representing the conversation accurately. I took this reflexive approach in considering the participants I interviewed and the process of interviewing, transcribing and interfacing with my participants as a reflexive stage in its own

right. The process entailed: obtaining consent forms from each of the interviewees, transcribing all interviews myself and sending back each of the transcriptions to the participants to obtain their consent and check they were happy with the content. Out of concern for representation and ethics, I offered each participant the opportunity to redact any part of the interview for example, if they felt unhappy about a particular part being included in my research or felt that I had misrepresented the conversation. I viewed my transcription process both as part of the flattening of hierarchies in representation, drawn from the new materialisms, within my enquiry, and as a key part of forming a discursive, shared and oscillating process between myself as interviewer and the participants being interviewed.

Diagramming

Following the collaborative projects, I mapped and tracked my tasks, roles and processes as a fashion-led researcher throughout the projects, which I compared as a collection of data. I used mapping, spreadsheets and production of Venn diagrams and assemblage diagrams as methods to disseminate my projects. This allowed me to track my role as a fashion-led researcher focusing on the processes taken in order to find common tasks, steps and stages to understand my overall process as a fashion-led researcher. The Venn diagrams are included as Appendix 3 and map the overlapping tasks of the biologists, myself as fashion-led researcher and the responses of the bacteria, to show human and nonhuman agential roles in the assemblages.

I also used mapping as a form of sorting data collated from the workshops into participants' understandings of fashion, its role during collaborations and the types of roles taken on in interdisciplinary teams. This led me to reflect back on the steps taken and the shifting assemblage configurations and types of roles I took on as a fashion-led researcher at each specific point of the collaborations. I used mapping and diagrams as the basis to reflect upon and draw up overall data findings, as it enabled me to visually outline the types of roles that fashion practitioners undertook in interdisciplinary teams.

PHASE 4

In Phase 4, I discuss and interpret the data findings drawn from the case studies, collaborative projects, scientific collaborator interviews and workshops, and offer implications and

conclusions to the enquiry. The discussion and conclusions centre on the relationship between fashion-led research in conjunction with biology, and I outline the contributions of the study to understanding the distinctive roles a fashion-led researcher can play in interdisciplinary teams.

Summary

The methodology selected for this study was a qualititative multi-method approach, as is characteristic of studies in art and design research, to account for the distinctive nature of such approaches (Gray & Malins, 2004:71–72). I contend that a multi-method approach was most appropriate for this study, as it enabled the data collection and analysis via bespoke methods. This allowed me to gather tailored and relevant data accounting for the various aspects of the research question, aims and experiences of each collaborative project. This approach to data collection was designed to test the key aspects of the research question – to understand what a fashion-led, collaborative research approach working with biologists can contribute to fashion design research.

Qualitative research methods were used for data collection, using a multi-method approach and tools drawn from primarily autoethnographic and ethnographic methods, including interviews, key case studies, collaborations and workshops. The research was conducted from the perspective of a fashion-led researcher and through the lens of a practitioner-researcher. Validation methods such as interviews and questionnaires were used to test data findings. Early data analysis methods were filtered as the study progressed, with the most relevant included in the enquiry: mapping and diagrams, reflexivity and transcriptions. Qualitative research methods of data collection and analysis note subjectivity as a strength in producing a focused and thus more widely appropriate and useful insight into the field, from the perspective of a practitioner-researcher (Archer, 1995:13).

This investigation looked at collaborations, from my perspective as a fashion-led researcher, using the methodology set out in this chapter to expose new knowledge at the intersections of fashion-led research and biology. My research design and methods interrogated the hypothesis through the development of new understandings of the ways in which collaborative approaches between fashion-led research and biology can operate, and outlined the distinctive role of a fashion-led researcher in interdisciplinary teams.

DATA DISCUSSION: PART 1

Introduction

In this chapter I discuss, analyse and synthesise my key data findings across the thesis in relation to my two contributions:

> Contribution 1: This thesis contributes to understanding the potential relationship between fashion-led research and biology, *in particular*.
>
> Contribution 2: This thesis contributes to understanding the potential of fashion-led research to play a distinctive role in interdisciplinary teams, *in general*.

In the first part of this chapter I examine two major case studies (see Appendix 1: Case Studies) and draw out findings to contribute to understanding the potential relationship between fashion-led research and biology during collaboration, in particular. The case studies signalled that the context and positionality of projects, and the role of intermediaries, are important in activating fashion and biology assemblages. They show that agency and relational ties could lead to hybrid methods, or fluctuations in individual agency. Fashion and biology assemblages could lead to shifting roles, chiefly for fashion actors, towards new terrains for fashion design and fashion-led research. The active nature of bacteria, particularly in the MMM collaboration, highlighted transient and temporal aspects of biological fashion, and showed how nonhumans shifted human agential roles towards those of care and cultivation, as well as destruction.

I use the second part of this chapter to discuss how the scientific collaborator interviews, workshops and collaborative projects led to both understandings of the potential relationship between fashion-led research and biology and how fashion-led research can play distinctive roles in interdisciplinary teams, in general. This study proposes the following sets of roles of a fashion-led researcher, understanding them to be multiple and in-becoming within the constant shifting of the agencies and materialities of the assemblage configurations: intuitive and sensory, curious, translator, facilitator, provocateur and risk-taker, seducer and societal or public-facing communicator.

Each section of the Discussion chapter is divided into three analytic categories – assemblage, agency and materiality – which are discussed in detail in the Theoretical Context chapter. These three concepts, drawn from the new materialisms, allowed the relationships between fashion and biology to be examined as assemblages, as agential and in terms of active materiality. Drawing on these new materialist concepts enabled collaborations to be viewed as assemblages inclusive of nonhumans and humans. This has, in turn, led to new understandings for fashion design research, into the workings of collaborative assemblages, agential mechanisms and inter-relations, the drivers of the key agents and active materialities when fashion-led research co-creates with bacteria, fabric and garments, and biologists.

Case Studies

The case studies were undertaken in order to obtain insights into these collaborative fashion and biology approaches. The rationale for selecting case study as method is presented in the Methods chapter and the Case Studies form Appendix 1. I undertook two case studies:

- Case Study 1: *Primitive Streak* collection (interviews with Helen Storey, Kate Storey, Caroline Coates)
- Case Study 2: Maison Martin Margiela (MMM) *9/4/1615* exhibition (interviews with Dr Ad van Egeraat, Thimo te Duits, Patrick Scallon)

I focused on the human actants within the assemblages: the *Primitive Streak* collection comprises Helen Storey, Kate Storey and Caroline Coates; and the *9/4/1615* exhibition Dr Ad van Egeraat, Thimo te Duits and Patrick Scallon. Each one includes a fashion practitioner, a biologist and a curator or producer.

I start this section by outlining the relationships between fashion and biology as assemblages. I next look at agency and agential fluctuations in the context of the case studies. Last, in the Materiality section, I chiefly examine the relationship with living systems, particularly in relation to the Maison Martin Margiela[54] (hereafter MMM) *9/4/1615* exhibition study in which the microbiologist and fashion house worked directly with living bacteria and moulds.

[54] Discussing nonhuman actors (specifically bacteria) was not relevant in the *Primitive Streak* collection, where Helen and Kate Storey did not directly apply living biological systems to the cloth.

Assemblages: Context and Positionality

The case studies highlight the potential for the relationship between fashion and biology to explore new terrains and contexts for fashion design in collaboration – specifically within museum and gallery settings. They show that the context and positioning of these assemblages are key when considering shared fashion and biology approaches. The location of each collaborative fashion and biology project, for example, whether conducted in the cultural sector, an industry setting, an educational or academic context, or in research and development, brings about different sets of drivers and considerations.

Positioning the projects in a museum or gallery-funded context signalled a point of departure from traditional fashion design business motivations. For Helen Storey, obtaining Wellcome Trust funding meant that the development of commercial applications was optional rather than necessary. Storey reported feeling that the project was allowed more freedom to be exploratory and creative, because there were fewer perceived commercial constraints or financial risks (Storey, 2018). The location of the case studies, within a collaborative science fashion space and in a gallery and museum context, meant that they did not have to adhere to profitable marketability but could operate in a manner closer to artistic patronage. What this tells us about the potential of relationships between fashion and biology is that although these forms of assemblages were not understood or positioned in a fashion design context, this allowed self-expressive and experimental modes of working to be opened up. Shifting the context away from the fashion industry eliminated issues around wearability, uncertainty about projected sales and issues in mass-producing garments. It also led to opportunities to occupy less typical spaces for fashion design, such as museums and galleries. However, while this repositioning outside industry allowed more freedom and experimentation, it created new risks in terms of reputation.

The case studies indicate that positioning these types of projects outside the conventions of the fashion design or biology disciplines may pose more of a risk to the actors' professional reputations. For example, at the time of the collaboration, Helen Storey's work was questioned by fashion designers and educators with regard to its validity as fashion (Storey, 2018). It could be argued that by employing scientific methods and collaborations as a point of genesis, Storey

was taking a significant turn away from the commercial fashion industry. Rather than economic risks, the risks were to Helen Storey's reputation because of the public showcasing of the project, as well as a perceived risk to Kate Storey's career as a biologist in not being taken seriously as a scientist as a result of collaborating with fashion and the arts[55] (Storey, 2018).

The case studies suggest there is a perceived risk for fashion in experimenting in the unknown, and an inquisitiveness about stepping outside traditional disciplinary boundaries. As well as brand promotion, curiosity and potential for the unexpected were key factors for MMM in wanting to collaborate with microbiology. Patrick Scallon, Art and Communications Director of MMM at the time, explained that 'we also wished for a terrain that could bring us unforeseen aspects and surprises [...] and in this it didn't disappoint' (Scallon, 2019b). For MMM, this collaboration with biology held significance as a point of difference, novelty and originality, to showcase the company and its artistic expression (Scallon, 2019a). There is an aspect of bravery and risk-taking to the actors in both of these assemblages, in stepping out into the relatively uncharted territory of fashion and biology assemblages at the time. In forging these early fashion and biology assemblages, the examples in the case studies arguably paved the way for today's fashion terrain, in which areas such as biodesign and biofabrication have emerged. This is useful for understanding how and why fashion in collaboration with biology has and can continue to reach out into alternative contexts, terrains and spaces outside fashion design. In this way, the relationship between fashion and biology has allowed us to see that fashion design and fashion-led research are much broader than their understanding in a commercially driven context.

Assemblages: Intermediaries

In order to occupy and position fashion and biology collaborations within contexts such as museum and gallery settings, the case studies highlighted the importance of the role of an intermediary[56] or bridge-builder (Schnugg, 2019:217–218). In both case studies the importance

[55] Helen Storey reported feeling initially concerned about the impact for Kate Storey as a female scientist beginning her career, and how Kate Storey may have been perceived and taken seriously, or otherwise, in scientific circles because the project involved collaborating on a fashion collection (Storey, 2018). Although Kate Storey explained that she was also concerned about this, and that this did occur, she stated that in the long term, the collaboration was 'a very positive thing for my career' (Storey, 2019a).

[56] In her text *Creating Artscience Collaboration*, Claudia Schnugg discusses the importance of the role of intermediaries or bridge-builders in art-science collaborations as 'a cultural producer, curator, mediator, translator between the fields, and facilitator who guides the project and helps to communicate the project to the microcosmos of the organization in which it is embedded [...] This person has to be able to grasp the artistic and scientific value and impacts of the work, and to contextualize it within the organization and the disciplinary fields' (Schnugg, 2019:217–218).

of the role of an intermediary was key to assembling the assemblages. As exhibition curator at the Museum Boijmans Van Beuningen, Te Duits' role as an intermediary was important to the MMM assemblage in bringing together the actors, providing access to the space (museum) and therefore creating the opportunity and sourcing funding for the project. In *Primitive Streak* the intermediaries were both the Wellcome Trust and producer Caroline Coates. The Wellcome Trust was pivotal at the time in fostering a number of art-science projects through the Sciart programme. Additionally, Helen Storey's business partner and producer, Caroline Coates, was instrumental in seeing the potential in Storey taking part in the project; thus, both intermediaries were agentially key in the configuration of this assemblage.

On a wider scale the importance of intermediaries to these types of interdisciplinary collaboration is important in fostering and establishing relations between fashion and biology practitioners. The case studies suggest that these types of fashion and biology projects would not have occurred without the intermediaries who carved out the configurations and reconfigurations or shifting territories of the assemblage (Deleuze & Guattari, 1987:376–380), and they show the importance of cultural institutions and funding bodies in fostering interdisciplinary projects. The intermediary can be an important role in fashion in terms of organisation and logistics, particularly as it frees up the fashion practitioner and biologist to concentrate on other areas such as the collaborative, creative and experimental aspects of the project.

Agency: Agential Fluctuations and Hybrid Methods

The case studies suggest that fluctuating agential relations between actors affected fashion and biology assemblages at specific points. They highlight that different forms of collaboration can lead to new ways of working and to new outputs, particularly where relational ties are tighter or looser in the assemblages. This indicated that it is not always positive to have a closer agential relationship or negative to have relational ties between actors that operate further apart, showing that they enabled different things. The case studies show that a close collaborative relationship can lead to shared and hybrid methods, whereas an assemblage in which actors remain quite separate and work predominantly in their expected disciplinary roles can lead to more individual agency, responsibility and freedom. Where relational ties are less strong, this can allow actors to have more individual agential freedom. In terms of contributing to fashion design research, this finding opens up the potential for a spectrum of possible collaborative

approaches, whether tighter or looser, in understanding that there is value in collaboration in offering different agential opportunities to actors in each case.

Where the actors within the MMM collaboration operated as separate practitioners, in contrast, the collaborative approach between Helen and Kate Storey was far more shared and interactive (Storey, 2019b). In working directly with each other through laboratory visits, in continual dialogue during the design process and in disseminating the final collection, Helen and Kate Storey operated closer to 'true' (Richardson, 2013:44) collaborative practitioners, while the MMM assemblage could be argued to be closer to a cooperation than collaboration, with actors operating as individual practitioners (Richardson, 2013:43).

The closer relational ties between actors in the Storey collaboration suggest that tighter fashion and biology assemblages can lead to shared, hybrid disciplinary methods. The actors began a process in which Helen Storey would fax drawings to Kate Storey, who would draw on and annotate them, exchanging information on factual details for visualising the scientific elements (The Helen Storey Foundation, 2003:10–11). This back and forth process occurred between meetings, as a way of communicating through paper and using drawing as a method. Through their collaboration, Helen and Kate Storey created experimental interdisciplinary methods, including the development of a new language, [57] using amalgamated science and art terms during the collaboration as a form of communication between the actors. These hybrid forms of drawing, translation and communication helped to describe what Helen Storey had viewed through the microscope to those in the studio who had not seen the embryonic processes at first hand. Further shared methods included biologist Kate Storey working with fabric, suggesting suitable materials to best convey properties of the embryonic tissues, and performing a form of draping by rolling fabrics into forms evoking the tissue shapes (The Helen Storey Foundation, 2003:11).

It is difficult to ascertain how far the established agential bonds in the existing relationship between fashion designer Helen Storey and biologist Kate Storey – as sisters – contributed to their close working agential relationship. Thus, shared methods may have emerged during the Storeys' *Primitive Streak* collection collaboration because of how closely the human actors

[57] Helen Storey begun to use a form of Tai Chi hand signalling to convey biological forms and processes to members of the design studio (The Helen Storey Foundation, 2003:9; Kohn, 2011). Hand gestures were used by Helen Storey to demonstrate shapes of the embryonic development to the design studio team, who had not viewed the processes through the microscope (The Helen Storey Foundation, 2003:9; Kohn, 2011).

were thinking, sharing and collaborating. Either way, this case suggests that establishing a constant and close agential relationship allowed new methods to emerge that have the potential to be useful as ways of thinking and working for fashion design research. These examples of hybrid design methods show that there is potential for the production of new methods and ways of working during interdisciplinary fashion and biology collaborations.

Agency: Asserting Individual Agencies

In contrast, looser relational ties in the MMM collaborative assemblage arguably allowed greater individual agency to be exerted. Although this did not lead to shared methods, it allowed more freedom for the actors to exert greater agency over their own parts of the project, which led to unexpected findings for the final outcomes. The microbiologist, van Egeraat, exerted greater agency in managing his part of the project and therefore was given more freedom and involved in less of a dialogic relationship with the fashion house. This looser agential relationship between actors meant that, although the fashion house originally wanted the garments to be coloured with green mould, van Egeraat asserted his own agency during the early testing and experimentation stages of the project and produced a range of colours that MMM could then select from (te Duits, 2018; Scallon, 2019a). Van Egeraat reported a sense of satisfaction, agency and purpose within the collaboration, arguably due to the looser nature of the collaboration facilitating greater individual agential influence (van Egeraat, 2018a).

This indicates that agential fluctuations occurred at specific points and that assemblages where agential relations were less tightly linked led to greater personal agency, allowing actors to put their stamp on their part of the project. In MMM, at an early testing and experimenting stage of the collaboration, this exertion of the biologist's agency was important but the hierarchies within this assemblage indicate that the biologist was working in service to the fashion house. Working for MMM, Scallon described the importance of allowing the scientist this agency, especially as Martin Margiela and Jenny Meirens had wanted to retain the original idea and just use the green mould (Scallon, 2019a). Scallon intervened and fought for the use of the bacterial colours that van Egeraat had cultured, stating: 'If this has now been discovered, we have to actually run with it' (ibid.). Therefore, although the collaboration was led by the fashion house, the scientist exercised agency via the cultivation of coloured bacteria. This meant that MMM had to allow and enable the biologist this freedom, and, on a local actor scale, it showed Scallon exerting a pivotal agential force in influencing the direction of the collaboration at this

point. This suggests that fashion and biology assemblages require the navigation of these shifting agencies, and therefore outcomes are a negotiation rather than a singular design vision. For fashion design research, then, stepping back and negotiating agencies can shift project direction and affect final outcomes.

Agency: Shifting Roles

The case studies show that within fashion and biology collaborations, expected disciplinary objectives and agencies can shift. For example, during *Primitive Streak*, fashion designer Helen Storey was keen to retain scientific accuracy, while scientist Kate Storey wanted to ensure that the balance of beauty and aesthetics were upheld: these intentions show a reversal of typical conventions in their practices (Storey, 2019a), displaying how expected roles can shift, upturn or blur during fashion and biology collaborations. It also suggests how working or coming into contact with another discipline can mean elevating the other discipline and undervaluing one's own. Here, then, Helen and Kate Storey were keen to achieve a high level in the opposing discipline – in terms of scientific accuracy or creativity of design. Working with other disciplines can also show the value and boundaries of one's own discipline: Helen and Kate Storey reminded each other of the value, through appreciation, of each other's discipline, harnessed through the collaboration. This substantiates the importance of this research in highlighting the value and roles of fashion-led research and contributing this directly to fashion design research, rather than asking how fashion can bring value to scientific research.

Fashion and biology collaborations can bring into question the attribution of agency within collaborative assemblages, which may provoke misconceptions on aspects such as the provenance and origins of fashion ideas and concepts. The collaborative nature of the fashion house, agency and authorship were key themes in the MMM collaboration. It was revealed in the film documentary *We Margiela* (2017) that the idea for coating the garments in mould and bacteria came from Jenny Meirens and Patrick Scallon, rather than the head designer of the fashion house – Martin Margiela. During my interview with him Scallon expanded upon this, sharing previously undiscussed and new insights into the concept of choosing to work with bacteria and therefore undertaking a collaboration with microbiology. Scallon described the origins of the idea to use mould and bacteria on garments. Scallon had been discussing with Meirens about how his mother in Ireland would create an effect on flowerpots by mixing live yoghurt with moss, which she would use to paint the pot to produce a fast-growing effect

(Scallon, 2019a). This was to give the impression of ageing, because new or artificially coloured pots were considered less attractive at that time (ibid.). Scallon and Meirens talked about the idea of Ancient Roman statues and how 'nature could change the dress or the statue or its aspect' (ibid.), which led to the idea of the clothing being shown outside and coated in green mould. Consequently, Scallon and Meirens developed this concept, leading to the collaboration between the fashion house and a microbiologist for the exhibition (ibid.).

Even though the microbiology concept was revealed to have originated from Scallon and Meirens, working under the umbrella of MMM[58] (*We Margiela*, 2017; Scallon 2019a), there was a perceived hierarchy of ideas. This was shown when Scallon expressed concerns that the *9/4/1615* exhibition curator Thimo te Duits would not 'work on it as hard' (Scallon, 2019a), knowing the idea had not come from Martin Margiela directly. This points to the phenomenon of the utilisation of the identity of the modern-day individual designer as part of an attempt to imbue exclusivity and monetary value to materials (Clark, 2016:18). The importance of the perception of a head designer from the perspective of an outsider, such as exhibition curator Thimo te Duits, is shown by the concern Scallon had in unmasking the idea as his and Meirens', rather than Martin's, therefore perpetuating the myth of the head designer being the sole person to attribute concepts and ideas. This highlights the importance and value given to fashion design by other disciplines, even if there is a misconception that each idea originates from the head designer. This is useful to fashion-led research in collaboration, as it emphasises the importance of discursive and shared ways of working, and of incorporating plural perspectives that, in the case of MMM, can lead to different and novel routes and ways of thinking.

Fashion and biology assemblages have the potential to lead to shifts in the career trajectories of the fashion actors, following collaborations. The case studies indicate this: in particular, when agential relations are tighter within the assemblage. Helen Storey gained and developed scientific and hybrid knowledge and methods through a close working relationship and assemblage, which arguably led to a change in her career trajectory. It may be argued that the tighter arrangement of the Storeys' working relationship and collaboration, in comparison to the looser assemblages between the actors in MMM, enabled Helen Storey to gain a deep knowledge of scientific processes. This was achieved through working directly and closely with Kate Storey. When Helen Storey begun working with Kate Storey, she described herself

[58] This refers to the fashion house collectively rather than the designer himself, which Scallon explained was to initially encompass artistic projects produced under the name of but not directly by Martin Margiela (Scallon 2019a).

as a novice in terms of skills and knowledge in a scientific setting. However, Helen Storey enjoyed, and was driven by curiosity, in a discipline she had little prior knowledge of (Storey, 2018). The *Primitive Streak* collection was Helen Storey's first collaboration with biology, and the depth of research and tight working relationships within the assemblage helped her to develop new scientific knowledge and skills. This collaboration gave her enough knowledge and curiosity in working in fashion and biology assemblages to continue working on collaborative projects with other scientists throughout her career. This signalled a significant shift away from a commercial fashion design pathway and shows the potential of fashion and biology in collaboration in leading to new routes and roles for fashion practitioners.

Following *Primitive Streak,* Helen Storey conducted further scientific collaborative projects, and her career trajectory moved towards academia. The fashion and biology collaboration shifted Helen Storey from the context of fashion design into collaborative ways of working, which she has continued to conduct. Helen and Kate Storey have continued to work together collaboratively, showing that the close nature of their collaborative assemblage was effective and something that both actors wanted to re-engage in. They applied for additional funding[59] ten years after their original 1997 *Primitive Streak* collection, creating new garments and expanding the project's reach through producing a website and disseminating through the use of data evaluation methods (Coates, 2019; The Storey Laboratory, 2007; REF 2014, 2014:2–3). Helen Storey has spearheaded an approach operating in collaboration showing how this can afford a shift in career trajectories for fashion practitioners towards new, unexpected and unexplored directions.

In contrast, looser relational ties between actors in the MMM fashion and biology assemblage did not lead to further interdisciplinary collaborations. The MMM actors remained embedded in their disciplines following the collaboration – they reported no major shifts in their career trajectories thereafter. The three MMM actors worked relatively separately during their collaboration and closer to their own disciplinary roles, describing *9/4/1615* as a 'one-time adventure' (van Egeraat, 2018b). For each of the MMM actors, the project was a sideline.[60]

[59] Both the REF case study and Kate Storey's laboratory website evidence *Primitive Streak's* impact by detailing additional funding awarded by the Wellcome Trust in 2010-11 (The Storey Laboratory, 2007; REF 2014, 2014:2–3).

[60] The project was supplementary for the fashion house, which, as well as working on the retrospective exhibition, was simultaneously producing womenswear collections and launching its menswear line, and Margiela had recently become Creative Director of Hermes in 1997 (Grant, 2009:153; te Duits, 2018). The microbiologist, Ad van Egeraat, was simultaneously working as Assistant Professor at the Wageningen Agricultural University and conducted the project in his free time (van Egeraat, 2018a).

Although the actors engaged with *9/4/1615* at the time, and each expressed the view that the work had a personal value to them, it was a unique endeavour. They did not work together again, and MMM did not re-engage with microbiology following the exhibition. Arguably, the looser relational ties of this fashion and biology assemblage meant that the actors did not feel so tightly connected, or think that it could ultimately change their careers. They each remained embedded in their own disciplines. This further supports the finding that the tighter engagement and closer agential relations in Helen Storey's project were contributory factors in a career shift for the fashion designer.

Agency: New Terrains

There is potential in relationships between fashion and biology to open up new terrains and contexts for fashion design research. Fashion and biology collaborations show the potential value of research into interdisciplinary fashion approaches, offering it a space to be positioned in the context of academic research, which encourages the sharing of knowledge not always possible within an industrial fashion design setting. When reconsidering the Storeys' project now, I contend that it represents an early form of fashion-led and fashion-based design research. The process of Helen Storey's learning is imbued in the garments, communicating the shared learning and elements of fashion and biological knowledge. I argue that this case study exemplifies an early example of a practice-led and practice-based project, as knowledge is bound into both the processes of collaboration and in the craft and scientific translation practices embedded within the garments. Helen Storey's bridging of the two approaches – science fashion and fashion research, in working in academia – acts as an important precursor to the pathways that fashion-led researchers can take. It combines practical making and collaborative practice with modes of dissemination.

To understand how this body of work can now be understood as fashion-led and fashion-based research, I evidence its inclusion as a case study in the University of the Arts London (UAL) 2014 Research Excellence Framework[61] (REF) report (REF 2014, 2014). Inclusion of the project so long after its inception (1997) is a result of the acknowledgement of non-academic research in the 2014 REF report. The significance of this shift in highlighting non-academic research is that it creates a space for practice (whether -based, -led, or combinatory) to be

[61] The UK Research Excellence Framework (REF) in 2014 was the first UK national survey to evaluate the quality and impact of both academic and non-academic research in higher education institutions (Walker & Winter, 2018:1–3).

evaluated for impact alongside traditional modes of research dissemination, thus expanding the space for the location of fashion-led research projects (and fashion-based or combinatory approaches) in the future. This provides further opportunities and acknowledges the importance of future fashion-led researchers within an academic context to create public-facing, impactful outcomes.

Materiality: Transient and Temporal

Collaborative fashion and biology approaches highlight the temporal nature of biological fashion and materials, particularly when created using bacteria. By bringing fashion into contact with biology, its relationship to garments becomes even more transient. For the *9/4/1615* exhibition, the garments made by MMM and coated in bacteria and moulds by van Egeraat were produced specifically for the exhibitions. It was agreed that the garments would be destroyed following each exhibition because of the use of bacteria on the clothing (van Egeraat, 2018b; Scallon, 2019a). This highlights that the destruction of biological garments may be required for bioart and biodesign projects when working with living cells and bacteria. This moves away from fashion garments built to last and be reworn and used, recontextualising the garments produced in this fashion and biology collaboration as contaminated biological objects to be destroyed. This expands our understandings of fashion and garments, emphasising the delicate and temporal nature of these works as ecologies, and suggests how an interconnected, new materialist approach can be applied – in incorporating nonhumans as a key part of fashion practices and materialities. This is important for fashion thinking, as, although we cannot escape an anthropocentric viewpoint, the MMM case questions wholly human-centred design practices, here through the incorporation of living matter, which can lead us to question theoretical, conceptual and ethical implications – important for a future in which companies are looking to industrialise living systems through the production of biodesigned objects. Fashion-led research and its thinking can operate here to critique, question, discuss and propose implications, rather than merely proposing the application of biotechnologies.

It was important for MMM to document the garments via recordings and photographs because of the temporal nature of living fashion and biology practice made with bacteria. The images of the dresses shown by MMM at *9/4/1615* now remain in photographic and video form. While film is used within fashion design and by practitioners such as Helen Storey to enhance and

engage audiences through storytelling and narrative surrounding body-garments, there is an added importance to recording and documenting pieces when working with living systems, as the garments are ephemeral. Images and films of the pieces allow these works to be regenerated digitally and relived far beyond the expiry or regeneration of the living matter itself, forming a new kind of aliveness – immortalised digitally. This is resonant of modes of fashion design in which photographic methods capture the transience of garments produced solely for the catwalk; yet there is an added urgency due to bacterial growth and decay.

Fashion and biology approaches can lead to expanding and shifting roles and agential relations during and because of assemblages configured with human and nonhuman actors. For example, van Egeraat's role as a microbiologist is seen as shifting through coming into contact with bacteria and fashion. Arguably, his role as a microbiologist shifted away from the privileging of scientific drivers, which may involve classifying the bacterial samples, towards valuing aesthetic drivers within art and design disciplines. Van Egeraat stated, 'I don't know – still not – the names of all these bacteria and moulds' (van Egeraat, 2018a). He was not interested in the types of bacterial and yeast cultures collected, and thus his research aim was singular: he was purely 'interested in fast growing organisms on this medium and then of course the colours of the bacteria' (ibid.). This shows a shift in the microbiologist's typical way of working, away from classification and towards aesthetic and also temporal drivers – the speed of fashion required him to look for and cultivate faster-growing strains. Van Egeraat's way of working was less influenced by the other actors and more by encountering fashion, and this shift – towards thinking about the aesthetics, colours and how bacteria could grow on materials – was different from his usual considerations when working within his own discipline.

Materiality: Care, Utility and Couture

Materiality is particularly relevant to the MMM case study, because of the way the garments are imbued with living and decaying bacteria and mould. Working with living organisms brought the actors in the MMM assemblage different sets of considerations than are typical of a fashion design approach. These included aspects of care and cultivation, as well as temporality and destruction, power and violence (Catts & Zurr, 2018:47–49) and the expansion and shifting roles of actors due to the introduction and shifting agencies of nonhuman bacterial actors within the assemblage. These types of considerations are not usually foregrounded in

fashion design approaches but are important as fashion expands into the areas of biological design and biofabrication.

As stated above, MMM's employment of living, and then decaying, moulds and bacteria on the garments for the *9/4/1615* exhibition highlights principles of care and cultivation in interdisciplinary fashion and biology approaches when working with living systems (Margiela et al., 1997:153–156). This shifted the materials of the MMM fashion garments into hybrids of living and growing bacterial-materials, away from the wearable, commercial aspects of fashion and towards an environment requiring cultivation. This can be linked to care labels and the care we give to our garments in terms of mending, washing and pressing, but also expands this further into a realm where clothing coated with living materials requires specific conditions to regenerate and grow, similar to growing and sustaining plants. Although MMM does not pose the pieces as wearable garment solutions, using bacteria in this context raises questions about the care of garments and their application. This suggests that active materialities open up new forms of care and responsibilities for fashion design research, when operating in assemblages with living systems.

Working with living systems can mean relinquishing design control within interdisciplinary fashion and biology projects. Indeed, the unpredictable nature of working with living organisms arguably demonstrates that the agency of the outcome is also determined by bacterial, living actors. Van Egeraat described how the bacteria reacted to the garments during the final exhibitions, stating that some of the final garments contained defects and spots due to airborne infections (van Egeraat, 2018b). This altered the aesthetic of the bacterial colours he had inoculated the materials with (ibid.). As all the processes were conducted by the human hand, including selection of the type of bacteria, working with biological elements that were living and became contaminated altered the final designs. This shows a nonhuman form of agency, in reaction to other agents, that was distinct from the designs intended by the humans.

Additionally, within the *9/4/1615* exhibition catalogue, van Egeraat includes information about the collaboration, stating that 'for the exhibition *Martin Margiela (9/4/1615)* bacteria and fungi are used in an unprecedented way – to enhance garments with colours produced by microorganisms' (Margiela et al., 1997:153). This also points to the balance of design control when working with living organisms, in which organisms produce colour and therefore arguably partially dictate the aesthetic of the outcome (ibid.). This acknowledgement of

bacterial agency, or at least other factors not determined by the humans, corresponds with new materialist and ANT understandings of the assemblage, discussed in the Theoretical Context chapter of this thesis. A combination of conditions, including the replication and growth of the bacteria, conflate here to determine the overall outcome, which can be said to be a co-creation between human and nonhuman actors. This case highlights how fashion design research practices with living systems are co-agential, negotiated and responsive to nonhuman materialities.

The boundaries between fashion designer and biologist and their roles can blur during fashion and biology collaborations. In the MMM collaboration, in discussing the method for the spraying and placement of the bacteria during inoculation, van Egeraat explains that this was carried out by him 'not in a real pattern, but what I did was [spray] on some places more than on the other places so you get a variety of growth and density' (van Egeraat, 2018a). The microbiologist may be viewed here as participating in the design of the fabric through his choice of where to spray the bacteria and thus colour the materials. When interviewed, van Egeraat did not view this as participation in the design, although he stated that he felt the choice about bacterial placement was his (van Egeraat, 2018b). However, the scientist effectively decided where to spray the growth medium, determining the pattern of bacterial growth. Therefore, I argue that he was able to assert a form of agency over the design, due to collaborating with fashion, at a level similar to that of (for example) a person responsible for the embellishment of a haute couture item of clothing. This demonstrates how the individual agency of co-actors can affect outputs of collaborative assemblages between fashion and biology.

Summary

The case studies signalled that the context and positionality of interdisciplinary fashion and biology assemblages can lead to outcomes that differ from those expected from the fashion design and biology approaches alone, bringing into focus different sets of drivers and considerations. In addition to fashion practitioners and biologists, the role of intermediaries was found to be key to these fashion and biology assemblages.

The case studies highlight how agential fluctuations and tighter or looser relational ties affected the collaborations in different ways. It was found that establishing tighter relations between

fashion and biology led to the development of innovative methods and hybrid processes, and looser assemblages enabled greater assertion of individual agencies, leading to unexpected outcomes. They suggest that these forms of collaborative assemblages can lead to shifts in roles and career trajectories for fashion practitioners, and there is potential for these relationships in opening up new terrains and contexts for fashion design. Last, working in assemblages incorporating fashion, biology and bacteria brought into focus issues surrounding the transient and temporal nature of these garments, requiring specific methods of documentation and shifting actors' own disciplinary ways of working. Contrasting aspects such as care and destruction were prominent in these assemblages, and outcomes were negotiations between human actors and nonhuman agencies and active materialities.

More broadly, the case studies show that there is value in researching fashion and biology in collaborative assemblages and that operating in an academic research context can create opportunities for sharing knowledge gained in such collaborations, which may not be possible to share in a fashion industry context. This shows the potential for these types of collaborations to be valuable forms of research, generating data findings and new knowledge.

In the next part of this Discussion chapter I discuss six explorative collaborative projects, scientific collaborator interviews and a series of workshops, to examine new understandings of the distinctive roles a fashion-led researcher can play through my own collaborative practices.

DATA DISCUSSION: PART 2

Introduction

In this part of the Discussion chapter, I discuss key data findings from the six collaborative projects (see Volume 1: Collaborative Projects), three scientific collaborator interviews and a series of workshops. These findings relate to both contributions of my thesis:

> Contribution 1: This thesis contributes to understanding the potential relationship between fashion-led research and biology, *in particular*.
>
> Contribution 2: This thesis contributes to understanding the potential of fashion-led research to play a distinctive role in interdisciplinary teams, *in general*.

Collaborative Projects, Scientific Collaborator Interviews and Workshops

The collaborative projects, scientific collaborator interviews and workshops were conducted to gain first-hand insights into collaborations between fashion-led research and biology, to gather plural perspectives on the relationships between these areas and to identify the roles that fashion-led research can take on in interdisciplinary teams. The collaborative projects are outlined in Volume 1: Collaborative Projects and the rationale for each method is discussed in the Methods chapter.

Overall, the findings highlighted the requirement for a deeper understanding and sharing of knowledge into the types of roles, value and impact that a fashion-led researcher can bring to interdisciplinary teams with biologists. The scientific collaborator interviews showed that these aspects were not fully understood by those outside the fashion discipline. The workshop findings offered propositions for types of roles, and their multiplicities, that fashion practitioners can play in collaborative projects. They gave insights into what fashion means to its practitioners and how the discipline is distinct from other design disciplines – primarily gathered from specialist fashion participants working in interdisciplinary spaces with biology. The six collaborative projects showed how different assemblage configurations gave rise to different roles and agencies, and at which points these roles occurred – opening up the types of

roles fashion-led research can play in interdisciplinary collaborations with microbiologists and bacteria.

In the following section, I first outline the role of fashion-led research from the viewpoint of my scientific collaborators in relation to scientific understandings of public communication and the logics of interdisciplinarity (Barry et al., 2008; Born & Barry, 2010). I next set out the roles of a fashion-led researcher drawn from the workshops and collaborative projects. I discuss how the shifting assemblage configurations acted as the catalyst for negotiating agencies and roles. I look at agency and agential fluctuations, hybrid methods and new terrains, chiefly in the context of the collaborative projects. Last, I examine the roles encountered through working with living systems and materials.

Assemblages: Fashion-Led Research Roles

The scientific collaborator interview findings suggested that, although key aspects of the roles of a fashion-led researcher were understood by the biologists during our collaborations, the nuances and multiplicities were not. The social, aesthetic and material aspects of fashion-led research were well defined: for example, collaborator Reeve suggested that fashion is 'unavoidable to people [...] visual and also tactile' (Reeve, 2019). Kan discussed how he saw an aspect of my role as the 'design and conceptualisation of the piece' (Kan, 2019). The value of fashion, as perceived by the scientists, lay in its ability to enable biology to connect and interface with society, both aesthetically and as an embodied discipline. While these aspects are important, the workshop data findings and collaborative projects indicate there is more to the role of fashion-led research. The scientific collaborator interviews highlighted the gap for this thesis, in sharing understandings of the potential value of fashion-led research in interdisciplinary teams.

Operating as an agential part of collaborative assemblages alongside biologists highlighted the differences between our disciplines and enabled closer understandings of the role of fashion-led research. Kan described interdisciplinary collaborations as important because of social engagement: 'The more varied the collaborations are, the more the science gets out there, and the more it engages society at large, which is a good thing' (Kan, 2019). Similarly, for Reeve, our collaborative project was viewed as part of the company's 'outreach and engagement side', as well as through the potential of the collaboration to explore possible material applications

for a fashion context (Reeve, 2019). To the biologists, collaborating with fashion-led research was viewed as a catalyst for outreach and public engagement, yet this can be a problem because it only validates design in terms of its usefulness to science.[62] This understanding links to Peralta's research on the ways in which designers add value to scientific research and the roles designers can assume – design supplier, design consultant and team researcher – as these roles are supplementary to scientific aims (Peralta, 2013:368–369). This further supports the importance of sharing the roles of fashion-led research in order to understand its value in interdisciplinary collaboration specifically for fashion design research.

The collaborative projects may be viewed as outreach and communication (ibid.) from the scientists' perspective, as a result of a history of public engagement, as highlighted by Born and Barry (2010:108).[63] The notion of art-science as a bridge for public communication of science originally developed from scientists identifying a need for developing affective encounters to re-engage the public in scientific debate. There was a recognition of the cultural, social and public-facing aspects of art and design, and they perceived the role of art and design to be valuable. Where this can become problematic is the perception that art and fashion are purely a way to illustrate science or where the artist, designer or design researcher is operating unequally to collaborators within an interdisciplinary team. Here, Born and Barry's proposed logics of interdisciplinarity (Barry et al., 2008; Born & Barry, 2010) are useful in understanding the different and intersecting drivers at play for actors in these collaborative assemblages.

These forms of interdisciplinary fashion-led research and biology assemblages show that the outcomes and collaborations can be viewed differently, according to the differing perspectives and agencies of their collaborators. Although fashion-led research can operate in accordance with Born and Barry's logic of innovation, for example, to satisfy business or economic aspects

[62] Projects related to the arts come under the umbrella of public engagement or science communication, as described by Reeve, when engaging with culturally and materially valuable disciplines, such as art and design. For example, scientific funding bodies, such as the Wellcome Trust, position funding associated with the arts as 'public engagement and creative industries' (Wellcome, 2020). The notion of 'outreach and engagement' (Reeve, 2019) is the most common way that science can interface with art in terms of scientific funding. Social scientists Born and Barry's paper 'Art-Science' (2010) offers an overview of the emergence of scientists fostering a relationship with the arts as a form of public engagement. This shows how the arts initially came to be viewed in this way by scientists. They cite examples deriving from C.P. Snow's 'two cultures' debate (Snow, 1998) through to the Wellcome Trust's Sciart initiative (further detailed in Appendix 1 – Case Study 1: *Primitive Streak*).

[63] The authors discuss how the emergence of 'public engagement' superseded the notion of the public understanding of science during the mid-1990s (Born & Barry, 2010:108). In terms of interdisciplinary exchanges, where the latter had concentrated on the logic of innovation (bridging communication between arts and science principally for economic purposes), public engagement incorporated the logics of both innovation and accountability (accountability to the public and to funders), and was used by funding bodies to help to assemble a public audience for art-science (Born & Barry, 2010:109). From a funding perspective, the aim was that art-science would enable engagement with the public so that scientists would be accountable for their research, whilst re-engaging the public in scientific debate through the development of affective encounters with science to draw on the cultural, social and public-facing aspects of art and design.

(Barry et al., 2008:22), and accountability – to be held accountable to wider audiences such as funding bodies or the public (Born & Barry, 2010:109) – the collaborative projects enabled me to operate chiefly in a manner closest to the 'logic of ontology'[64] (Born & Barry, 2010:105). This logic attempts to 'place artists and scientists on level footing so that ways of thinking from art can come into science and vice-versa' (Szymanski et al., 2020:2). This accounts for the agency and perspective of the artist or designer as far more than a vehicle to communicate or find solutions for science, enabling contributions to fashion design research.

The collaborative projects demonstrated that fashion can operate not just as an interface between science and the public but as a 'loaded' interface that brings its own agency, narrative, meaning and critical perspective, closer to the logic of ontology. When working with Park on *Living Lace,* an email exchange between us demonstrates the poetic narrative I brought to the microbiological experiments we were undertaking:

> I would like to slowly suspend and spin the […] garment into the flask, and then to see how the Helion works to expand and contract with the piece […] In this way, the piece is both real and living and yet simultaneously ethereal (Geaney, 2016a).

In creating works with living systems, I was asking poetic, critical and bioethical questions about notions of human and nonhuman relations. This demonstrates how fashion-led research has the potential to question, and set a social context; it can be performative, and give form and new meanings to two-dimensional materials. As discussed in the Contextual Review chapter, some of the key facets of fashion thinking, as posed by Pajaczkowska, are communicative, including its hyper-sociality, 'highly collaborative', 'self-expressive' and 'heightened reciprocity of its culture' (Pajaczkowska, 2016:90–91). This suggests fashion as a political, ethical, social and self-expressive discipline. The example above shows that the role of a fashion-led researcher is closer, here, to a reflexive and self-expressive practice, questioning implications rather than producing applications or solutions. This shows how fashion can explore biology and how this can be useful for fashion design research as a way of thinking through practice, rather than being primarily driven by scientific goals, research or drivers.

[64] Born and Barry identify a logic of ontology, which differs from creating innovation or being held accountable: an orientation in interdisciplinary practice towards effecting ontological change in both the object(s) of research, and the relations between research subjects and objects (Born & Barry, 2010:105).

To further evidence the roles of a fashion-led researcher operating in interdisciplinary teams, the workshop insights are significant in sharing and reporting new knowledge and identifying what fashion practitioners view as their value within collaborations. The findings are drawn from practitioners operating in fashion, biofashion and textiles research and practice. I found that the proposed roles were multifarious. Table 2 (see Volume 2: Tables) summarises the data findings on the specificities and key roles of fashion (in the left-hand column). The key roles, qualities and characteristics identified were: intuitive and sensory; curious; translator; able to zoom in and out to see minute details and the overall picture; facilitator; provocateur and risk-taker; creating desire and user-centred; and seducer and societal or outward-facing communicator and storyteller. The findings indicated that fashion involvement can bring the following specific aspects to interdisciplinary teams: emotional and related to feelings and behaviours; social and direct; fantastical, a dream space; communicative, poetic, with the aim of storytelling; and functional and material.

The workshop findings expand on Pajaczkowska's facets of fashion thinking, as well as research conducted by Peralta (2013), and Benony and Maudet (2020), by proposing the varying roles of a fashion practitioner. While Peralta (2013:36) and Benony and Maudet (2020) draw together useful aspects and roles that designers can assume in collaboration, their findings are drawn largely from designers operating in industrial and product design. Additionally, the designer roles proposed by Benony and Maudet (2020) are more limited, as they position the biologists as teachers and leaders within the collaborations, and the designers as students or guests. My research builds upon the work of Peralta (2013:36), and Benony and Maudet (2020), as I am arguing that there are nuances of a fashion approach that make it distinct from other design disciplines and therefore worth investigating and understanding in more detail. In comparison to Peralta, Benony and Maudet, my data findings are specific to fashion and science in collaboration, and to understanding the value of fashion and its potential in interdisciplinary teams.

Additional workshop findings suggested that fashion-led research is a research lens, related to fashion design practices, which can lead to new methods and alternative routes for fashion-led research. From my own examples, I found that key to the role of fashion-led research in collaboration was the designation of fashion design practices. The Venn diagrams (see Appendix 3) show that I employed specific fashion design methods within the collaborative projects. These fashion-led elements emphasise a preoccupation with bodies (human and

nonhuman) and the employment of fabric and materials – further emphasising a focus on the body as central to a fashion approach. Therefore, during the collaborative projects, specific tasks conducted by the fashion-led researcher included: draping materials, fitting and reworking toiles and patterns, the production of garments, sourcing of fabrics and mannequins, and fabric selection – activities that are specific to fashion design. These fashion design practices help to mark out the role of a fashion-led researcher as distinctive from other design research disciplines through its specified methods.

The fashion-led researcher roles also encompassed aspects of the methods and roles of practice-led design research at specific points of the overall fashion-led research collaborative process – including subjectivity (Archer, 1995:11–13), research and uncovering new knowledge through process (Frayling, 1993:5; Archer, 1995:8–11; Candy & Edmonds, 2018:64) and arguing away from research in the tradition of science (Gray, 1996:3), as discussed in the Contextual Review chapter. The assemblage configurations in relation to roles and collaborative project breakdowns are shown in Table 3 (see Volume 2: Tables). Specifically, the collaborative projects highlighted how, operating individually within the assemblage, I assumed different sets of roles which could be understood as closer to fashion design research roles, namely, design researcher, data analyst, transcriber and interpreter. There were also poetic, intuitive, self-expressive and responsive roles. This blending of the sensory and fashion-design-related aspects, alongside the fashion design research roles, further supports the workshop data findings towards fashion-led research, specifically the proposed finding that it is related to fashion design practices and therefore to bodily and sensory aspects.

The collaborative projects highlight the importance of the role of the fashion-led researcher as an initiator of interdisciplinary collaborations. The Venn diagrams (see Appendix 3) and Table 3 (see Volume 2: Tables) show that one of the main tasks I took on as a fashion-led researcher was to initiate the collaborations. This occurred in all collaborative projects except for *Aequorea*, where I was approached by a previous collaborator to work on their project. As discussed in the Contextual Review chapter, this contrasts with research conducted by Benony and Maudet (2020), who positioned the biologists as teachers and leaders within the collaborations, and the designers as students or guests. Through my collaborative projects, case studies and the workshop participants selected for this thesis, I have highlighted examples in which fashion practitioners have operated in more equitable or prominent positions within collaborations from their inception, the importance of which was discussed in relation to Collet,

Lee and Agapakis in the Contextual Review chapter (Collet, 2012a:7; Agapakis & Lee, 2019). Retaining a conscious equity of hierarchies within the collaborations therefore highlighted the value of fashion and a fuller understanding of the potential roles that fashion practitioners can play when acting in an agential mode from the outset and operating in closer hierarchical levels within interdisciplinary teams.

Assemblages: Shifting and Negotiating Assemblage Configurations

Table 3 (see Volume 2: Tables) demonstrates how the shifting arrangements and configurations of the assemblages highlighted different aspects of the roles and agencies of the fashion-led researcher, at specific points of my fashion-led research process. The roles were constantly in flux, multiple and in-becoming. For example, although the workshop and scientific collaborator interview findings highlighted the social and outward-facing aspects of fashion as a mode of communication, the collaborative projects showed how, even within a collaborative space, the fashion-led researcher retained a certain level of individual reflection and responsiveness (to data). This suggested the need to be reflective and responsive to data, materials and potential audiences while retaining individual ways of working within the assemblages. Agility and responsiveness to shifting assemblages were therefore important to fashion-led research in collaboration.

The roles of a fashion-led researcher were seen to fluctuate: shifting between individual, reflective and outward-facing social roles at different points in order to gather, reflect on, respond to, disseminate and share knowledge. For example, assemblages consisting of me as a fashion-led researcher, biologists, bacteria, material and, additionally, the public, required specific roles relating to communication and interfacing: translator, connector and intermediary. These types of roles were taken on more during public-facing aspects of the project, in addition to performer (when in public-facing mode), storyteller and communicator, relational and networker. Roles encompassed reflexivity when assemblages were configured as the fashion-led researcher alone but shifted as the assemblage fluctuated to include additional actors, such as biologists and the public. This revealed the roles of networker, storyteller and communicator, specifically at the final stages of the fashion-led research process in collaboration.

The roles of a fashion-led researcher can fluctuate between modes at any one time and can be poetic and ideational while simultaneously operating towards functional and workable solutions. The collaborative projects, when the assemblages consisted of me as a fashion-led researcher and the biologists, brought into becoming the roles of collaborator, as well as inter-relational, playful and poetic roles. Moreover, during the collaborative projects, and particularly the different making processes, when the assemblages were made up of one or more of fashion-led researcher, biologists, material and bacteria, my roles shifted to include organiser and solution-finder. Collaborative tasks included: shared concepts (discussions about the concept), early ideas, emailing about different ideas and trying to make sense of the project. These collaborative methods highlight aspects of the fashion-led researcher's roles as modes of ideation and poetics, as well as the devising of functional, workable solutions. This also shows how the stages of the fashion-led research approach moved from ideation and a dream or imaginative space to logistical and organisational phases, to bring projects to fruition.

The collaborative projects suggest that the roles of the fashion-led researcher were not fixed but negotiated, configured, reconfigured and multiple. Roles were often in flux, and different roles emerged within different assemblage formations. Rather than taking on one role at a time, Table 3 (see Volume 2: Tables) shows that my roles as fashion-led researcher were plural during many of the tasks, phases and stages of my overall fashion-led research and collaboration process. Working within these forms of collaborative assemblage meant that my role as fashion-led researcher was 'in-becoming' and shifted through the different configurations and arrangements of assemblages. Where the assemblage configurations differed, new roles arose or could arise. As discussed in Part 1 of this chapter, my projects also suggested that working with bacteria opened up new ways of thinking than may not be typical of a fashion practitioner, involving responsibility, care and cultivation, as well as forms of violence[65] (Catts & Zurr, 2018:47–49).

The collaborative projects demonstrated that when assemblages consisted of myself as fashion-led researcher and bacteria, sets of roles shifted to those less expected of a fashion practitioner. Assemblages comprising bacteria shifted my ways of working towards relinquishing total

[65] Violence is understood here in terms of Catts and Zurr's understanding of the ethical implications and the forms of inherent violent actions when working with living systems (Catts & Zurr, 2018:47). Catts and Zurr argue that forms of violence are 'involved in humans relations with life and with the human enterprise of engineering life' (ibid.). This is a contested viewpoint, but here it accounts for the acts of cultivating and growing life (here, bacteria) but also aspects of autoclaving and killing bacteria (both laboratory-grown and pre-existing 'wild' forms on fabrics, mannequins and display cases).

design control to allow for a negotiation of agencies from the human and nonhuman actors. This led to roles that highlight the reciprocity of the fashion-led researcher, such as: provocateur, co-creator, observer, care-giver, nurturer and interpreter, as well as destroyer. While working with the biologists and bacteria, I was operating as observer and facilitator, as well as collaborator, organiser, responsive and relational fashion-led researcher. Working in these different configurations of collaborative assemblages helped me to understand the development of my role as a fashion-led researcher, sharing the importance of observation and provocation as well as co-creation, and the shifting roles assumed in these examples of interdisciplinary human and nonhuman assemblages.

The Venn diagrams (see Appendix 3) further substantiate that the collaborative projects can be viewed as co-creations between the assemblages of these three actors: fashion-led researcher, biologists and bacteria. All three actors intersect to affect the final outcome. This collaborative approach to the final outcome requires that the fashion-led researcher relinquishes elements of agency, not only to the living material but also to its cultivator – in these cases, the biologist or biologists. These collaborative assemblages that include bacterial agency highlight the shift of my role as one with complete agency to one of shared agency – as a fashion-led researcher in collaboration with biologists and working with living systems. By allowing for more fluidity of agency within the collaborations, my role shifted away from one closer to a fashion designer exerting full agency and towards one of a fashion-led researcher enabling fluctuations in agential relations, as co-creator, observer and provocateur.

Many of the roles adopted during the collaborative projects included relational aspects, so many of them required inter- and intra-relational ways of working within my own discipline (for example, with other fashion and textile researchers or in the fashion design studio), or working across disciplines, with biologists and bacteria. When the assemblage included me as fashion-led researcher and the material, this highlighted the fashion, contextual and social aspects of the role. In addition to working in a relational, operational, adaptive and responsive way, working with just the material encompassed roles of co-creating through draping with material, working intuitively, manipulating (material and garment) and producing an outcome. This suggests that fashion practitioners already hold a sensitivity and responsiveness to working with fabric and material, which is emphasised when operating in interdisciplinary teams.

Agency: Agential Fluctuations and Hybrid Methods

The collaborative projects indicate that a looser collaborative working approach can also lead to and produce hybrid working methods. As discussed in Part 1 of this chapter, the case studies suggested that the agential fluctuations in terms of closer relational ties between actors led to hybrid and innovative methods and processes, where looser relational ties allowed for greater individual agency and unexpected findings. The collaborative approaches in this thesis range from the close, direct and true collaborative model taken by Helen and Kate Storey to a looser, individual form of collaboration, closer to cooperation, in MMM. My own approach, as set out in the collaborative projects, may be described as somewhere between these models. The collaborations were interactions between the biologists, bacteria, garments and me as a fashion-led researcher; however, many of the exchanges were primarily conducted using digital methods of communication. Distance and time constraints were factors in the number of visits I paid to the science laboratories, and the biologists did not visit the fashion and textile research studio. This form of collaboration cannot be described as 'true' (Richardson, 2013:44), because distance and other work commitments prevented full integration. By using digital methods of communication, my projects still led to interdisciplinary working methods and a continual shared dialogic relationship with my collaborators.

Fashion-led research working with biology in collaborative assemblages led to shared ideas and discussions between the interdisciplinary actors, which impacted key decisions and enabled experiments to be shared and new knowledge gained – for example, understanding the materials and technical aspects of growth for the bacteria, and sharing ideas about the project's aesthetics and concept (Park, 2019). During our interdisciplinary collaborations, it was the value of our shared discussions and the constant discourse between the human actors as collaborators that moved the projects forward. For example, Kan stated that the concept for the work evolved from our group discussions (Kan, 2019). In our interview reflecting upon the collaborative projects, Park stated that it was the differences between our areas of expertise that led to the combination of fabrics and bacteria, an idea he would not have considered himself, as prior to this he was using the bacteria purely to try to grow biotextiles (Park, 2019).

> I think it's the combination of expertise that allows it to happen. And I think it is ok for scientists to start generating biomaterials in a vat in a lab but the scientist will have no concept of what

> to do with them and the processes involved that would need to convert that lab grown biomaterial into a finished article (Park, 2019).

Key to this collaborative approach are hybrid or shared methods conducted by the fashion-led researcher and biologists. Contemporary modes of communication were employed within the collaborative projects, which meant that hybrid or shared ways of working could be conducted virtually by email and using online video-conferencing methods. These digital communication methods enabled the biologists and I to share information and images and to hold discussions about logistical details, organisation and the production of our installations and promotional aspects. This shifted the agential roles of a fashion-led researcher into collaborative ways of working, showing how hybrid methods may be more typical when operating as part of an interdisciplinary team.

By working in collaboration with biologists, I also shifted my practice location, working in the fashion design studio and the laboratory. Interdisciplinary collaboration enabled me to take on aspects of scientific methods in my approach. For example, in *Living Lace* and *Oscillatoria Sutured*, I worked in the science laboratory and inoculated the cyanobacteria onto agar plates containing the fabrics. The collaborative projects *Lo Lamento*, *Azazel* and *Living Light Dress* required an agar and nutrient solution for the bacteria. Both the scientists and I as fashion-led researcher applied this solution, and all the human actors disinfected the mannequin during the installation set-up – showing the hybrid roles taken on by disciplines. In all collaborative projects bar *Living Lace*, testing fabrics and materials was a role designated to the scientists – although in fashion design this might typically be the domain of a fashion practitioner. These examples suggest a blending and blurring of practices and methods between science and fashion practitioners operating within interdisciplinary teams.

Key findings ascertained from the workshop participants show that fashion practitioners wanted to partake in interdisciplinary collaboration as a result of wishing to exchange expertise, leading to the potential for unexpected outcomes. Workshop participants reported that collaborating outside their discipline enabled a sharing of different perspectives, considerations and a unification of voices. Participants sought out collaborations to exchange expertise and draw on different knowledge sets. Interdisciplinary collaboration made participants' own disciplinary characteristics clearer, which helped them to better understand the key roles and aspects of fashion. Reasons given for collaborating were novelty, intellectual curiosity and

extra enrichment. This links directly to Part 1 of this Discussion chapter and Scallon's reasons for wanting MMM to collaborate, because of curiosity and the potential of a new terrain to bring about 'unforeseen aspects and surprises' (Scallon, 2019b). Furthermore, during fashion and science collaborations, workshop participants suggested that fashion practitioners could disrupt in order to bring about creativity and question existing systems. Interdisciplinary collaboration was suggested as leading to innovation, which is important, as it links to fashion's desire for the new (Pajaczkowska, 2016:90). The main barrier was around authority language, which fashion practitioners tried to break down – leading to the roles of translator and communicator.

These findings contribute to understanding the potential of fashion-led research to offer a sense of freedom and new types of discussions, which may not occur for scientists working in intradisciplinary teams. Park described a sense of freedom and evolution at the start of our process of working together, which can be viewed as part of the early concept and ideation phase of a fashion design process, opening up possibilities during the discussion of ideas and inspiration (Burke, 2011:14–16). Park enjoyed this part, and the fact that 'we didn't have set ideas at the beginning and it sort of evolved as an interaction between the two of us, sharing our expertise' (Park, 2019). This suggests how a fashion-led research approach in collaboration can offer value to each discipline.

Agency: New Terrains

A core group of the workshop participants were fashion practitioners whose work intersects fashion design and aspects of microbiology, biotechnology or synthetic biology. Alice Potts, Louis Alderson-Bythell, Maria Arroyo I Bacete and Piero D'Angelo[66] provided insights into their collaborative ways of operating and reflections on the value and roles assumed by fashion in interdisciplinary teams. A key insight from this sample is that the roles of participants had shifted away from fashion design and towards new spaces following collaboration. Just as discussed in Part 1 of this chapter, as Helen Storey did not have a set pathway and has forged a career through operating in new terrains for fashion, scientific collaborations have acted as a

[66] Potts, Alderson-Bythell, Arroyo I Bacete and D'Angelo are all graduates from the Masters in Fashion at the Royal College of Art. Potts and D'Angelo are discussed in the Contextual Review. Here, I ran workshops that included these fashion practitioners who have worked in interdisciplinary ways, blending biological design and fashion in their practices. Alderson-Bythell co-runs the Bio Platform, as part of the Masters in Fashion at the Royal College of Art, and conducts interdisciplinary practices and research working between biology and design. I Bacete works as Textile Innovation Manager at Albini Group, supporting research and development between biology and materials.

catalyst for these practitioners in shifting their practices towards novel and interdisciplinary roles and directions for fashion. This is evidenced in Potts' trajectory following her graduation from the Royal College of Art, first in gaining an Onassis Artistic Research Fellowship and now as a biomaterial designer for biotechnology and biomaterial company Modern Synthesis. D'Angelo runs his fashion studio from Open Cell London – primarily a space for biotechnology start-up companies – and was selected as a semi-finalist for the LVMH[67] Prize in 2020. This signals how operating in interdisciplinary collaborative assemblages has offered new spaces and opportunities for fashion practitioners.

An unexpected finding of the thesis arose from the workshop data findings. When asked why, as a fashion practitioner, participants wanted to collaborate with scientists, participants reported wishing to be a non-expert. This was related to wishing to avoid having preconceptions about the topic, in order to generate their own creativity from the unfamiliar. The 'unexplored terrain' was felt to be useful as inspiration. The workshop participants also reported that collaborations led participants to unexpected outcomes, with one participant stating that it was the process of the collaboration itself that was important rather than the outcomes produced. Scientists were viewed as holding specific scientific knowledge that would help turn the dreams of fashion designers into reality. However, my fashion-led research approach showed that value emanated from the shared and relational approaches of collaborations, involving each of the actors within these assemblages.

The collaborative assemblages provide evidence that interdisciplinary collaborations can lead to unexpected outcomes, both for biologists and the fashion-led researcher. The outcome of our projects took Park by surprise, as he had not expected the material and cyanobacteria to integrate as they did (Park, 2019). Overall, the scientific collaborator interview findings are again useful here in showing that the projects enabled the scientists to think in different ways about the bacteria, to move outside normal laboratory methods and to solve problems such as the most suitable materials for bacterial growth (Kan, 2019). Posing these fashion-led research questions outside the scientists' usual remit meant they had to enter into fashion-led research processes, which allowed for different ways of thinking and a feeling of freedom during our generative approaches.

[67] The Moët Hennessy Louis Vuitton (LVMH) Prize is a prestigious industry accolade awarded to talented young fashion designers, including a monetary prize and mentorship to support and nurture new generations in the fashion industry (LVMH Prize, 2020).

Following collaboration, some workshop participants stated that fashion practitioners shifted their own conception of fashion and their ways of working towards discursive methods. A key role suggested here was facilitator. One participant described how she had become far more rigorous in her questioning, following her collaboration with scientists.

Materiality: Questioning Human-Centred Design Approaches

The key difference in working with bacteria is shown in the role of the fashion-led researcher designing for bacterial requirements. The design considerations for the final outcomes suggest a shift away from a human-centred approach towards a bacteria-centred design approach. This relates to the theoretical context and lens through which I undertook this study, in understanding the collaborative projects as assemblages of humans and nonhumans, suggesting a shift away from a human-centred standpoint at both design and theoretical levels. In particular, working with bacteria highlighted the roles of a fashion-led researcher as co-creator, observer and provocateur, in enabling co-agential relations to develop within these collaborative assemblages.

The collaborative projects can therefore be understood from one perspective as forms of human-bacterial-material assemblages, suggesting the possibility of designing for an 'array of bodies' (ibid.) towards the notion of a bacteria-centred or considered approach. As discussed in Volume 1: Collaborative Projects, to produce the installations *Lo Lamento*, *Azazel* and *Living Light Dress*, the biologists and I tested and soaked the material fibres in agar, yeast and nutrients to provide a solid growth medium for the bacteria. Through material testing in the laboratory, we were able to perceive the bacteria and its preference for certain materials, particularly absorbent, natural fibres and raw materials. In this way, designing for the bacteria, or as per its requirements, opened up roles of care and nurture for the fashion-led researcher and the reliance of the bacterial material on its caregivers (fashion-led researcher and biologists).

Overall, the collaborative projects led to the realisation that human-nonhuman relations can interrogate preconceptions of human-centred fashion. In *Lo Lamento*, *Azazel* and *Living Light Dress*, the garment operated as a material scaffold to grow bacteria over, rather than a wearable and usable human-centred application. Here, the garment is arguably not for human wear but

a material surface selected to encourage bacterial growth. These garments raise further questions for this research in terms of functionality and what it means to not function effectively as a garment, if we are still considering design's value in terms of its usefulness to humans and within human-centred design, fashion and its preoccupation with the human body. I would argue that these pieces are still human-centred, in my employment of them as provocations through which to examine fashion-led research in collaborative assemblages. In this way, I created the very condition of anthropocentrism that decentred philosophical and design approaches are questioning, and I realise that we can never truly escape a human-centred approach – but I find instead that these projects can ask us to question it, in order to understand the human as part of a much wider ecosystem that affects, and is affected by, multiplicities of assemblages comprising human and nonhuman actors. This is critical to fashion design research, in operating and negotiating actors in a relational and interconnected context, for areas such as biofashion and biofabrication.

The research interrogated traditional making methods for fashion design by incorporating living bacteria onto materials, opening up bioethical issues. The pieces were designed in accordance with bacterial requirements, designed with the use of layers of material to increase the surface area, and employing materials that were absorbent and less heavily treated to hold greater amounts of agar and nutrients. However, bioethical issues affected these interactions, and it is acknowledged that each of the works, and therefore bacteria, were destroyed following our installations. An additional and unexpected role of the fashion-led researcher here is of destroyer. These pieces act to raise questions about the ethics of working with living systems, as well as offering an understanding of how my agency as fashion-led researcher, the scientists, the fabric and bacteria affected the final outcomes.

Materiality: Shifting Roles

Shifting roles and discursive methods were understood as more pronounced during and through working with living systems. This links and extends the workshop data finding, in which participants reported that after interdisciplinary collaborations, these fashion practitioners shifted their own conception of fashion and ways of working towards discursive methods. Bacteria affected the designs through its preference for certain materials, highlighting fluctuating agencies and active materialities in these forms of assemblages. This is highlighted in *Living Light Dress* and *Azazel,* where the bacteria did not glow on certain fabrics, therefore

altering the human design and highlighting the impact of bacterial agency within the pieces. The agency of the final outcome was altered by the requirements of nonhuman elements, which could be further understood as part of an approach questioning the human as the central user. This in turn shifted the role of the fashion-led researcher to one of facilitator within assemblage configurations with active materialities.

During the collaborative projects, operating within collaborative assemblages meant that agential relations between the fashion-led researcher, bacteria and biologists fluctuated and sometimes shifted in unexpected ways. In particular, a combination of bacterial and human agency was shown during *Azazel*, when the bioluminescent bacteria did not react or grow on the wool and cashmere blended material on the lower part of the garment. The fact that the bacteria did not grow on this part could demonstrate that the material did not have the requisite properties to enable bacterial growth. Alternatively, this could have been due to the conditions, nutrient solution or quantity of bacteria with which this part of the garment was inoculated. Either way, the fact that the bacteria did not grow affected the final outcome. Working with living systems asserted the individual agencies of both human and nonhuman actors.

Within this enquiry, the distinct project drivers and logics are useful to articulate how, and at which points, conflicts and differences of opinion occurred within the collaborations. Looking back on the tensions, these tended to occur when different logics and aims within the project did not match. For example, during *Azazel*, the scientists and I differed in opinions on the title and concept behind the work given its religious connotations. This led to the simplified name for our third collaboration – *Living Light Dress*. The concept for *Azazel* was not mentioned in promotional materials, as the biologists were not in agreement about its use in the public domain.

Here the biologists exerted agency, affecting how the outcome was disseminated. Arguably, I was working from the perspective of the 'logic of ontology' (Born & Barry, 2010:105), thinking about what the idea of 'alive' meant when we were working with living bacteria. I was interested in the idea that we could use the bacteria for the cause of our installation and what it meant to be sacrificed, encompassing philosophical, ethical and moral themes of nonhuman co-creators. The synthetic biologists were unhappy about the title, *Azazel*, as they felt this term had religious connotations and was therefore potentially contentious. This concept was at odds with the 'logics of innovation and accountability' (Born & Barry, 2010:109) that

the scientists were trying to fulfil in wishing to showcase the beauty and innovative nature of a biologically alive and glowing dress, highlighting their research and satisfying their funding body. Resolution occurred through negotiation. I explained that my drivers lay in the art and design research area, and that it was important to have these concepts, even though they challenged and questioned what we were doing, whereas the biologists wanted to showcase the phenomenon of bioluminescent bacteria to a wider audience. We agreed that I would use the concept in my research and in forms of dissemination within art and design research settings, but not in public spheres such as the exhibition publication or promotional materials.

This indicates that the logic of ontology (Born & Barry, 2010:105) played a significant role in the dissemination of my projects, in contrast to the logics of innovation and accountability (Born & Barry, 2010:109), which also operated within the *Primitive Streak* collection and *9/4/1615* exhibition. The drivers for Helen Storey encompassed logics of accountability and innovation (ibid.), as the funding was awarded by the Wellcome Trust; however, this funding allowed Helen Storey the freedom, time and space for the production of a collection, the outcomes of which have been far more widely disseminated in research, cultural and educational settings. The logic of accountability (ibid.) was also seen in *9/4/1615*, which was commissioned and funded by Museum Boijmans Van Beuningen. These cases show that the logics can operate simultaneously, as in this study, which was made possible by funding from the Arts and Humanities Research Council (AHRC), providing the driver for accountability. However, my collaborative projects highlight that when actors are concerned with or driven by differing logics, frictions can occur. Again, this shows how understanding the differing drivers and logics during interdisciplinary modes of operating is useful to a fashion-led researcher, and highlights the shifting agencies and negotiations which can occur during these forms of collaborations. This shows the importance to fashion design research of relationality and responsiveness towards actors, materials and context.

Summary

The collaborative projects, scientific collaborator interviews and workshops signalled a need for a fuller understanding of the roles of a fashion-led researcher, some of which were proposed as: intuitive and sensory; curious; translator; able to zoom in and out to see minute details, as well as the overall picture; facilitator; provocateur and risk-taker; creating desire and user-centred; and seducer and societal or outward-facing communicator and storyteller. Fashion-led

research was identified as an area that can set its own agenda, through sharing new knowledge found in its processes, and as an area that can initiate collaborations and act interchangeably between Born and Barry's logics of interdisciplinarity, but with an emphasis on the logic of ontology (Barry et al., 2008; Born & Barry, 2010).

It was found that the roles of the fashion-led researcher were not static but negotiated, configured, reconfigured and multiple, at different stages of the collaborative processes. Furthermore, working with living systems led to new modes and roles than those typically expected of a fashion practitioner, encompassing care, responsibility and destruction. Compared to the case studies, which demonstrated the close working collaborative assemblage between Helen and Kate Storey and far looser relational ties between actors in MMM, the collaborative projects suggested an approach that may be described as somewhere between these models. However, I found that this still enabled the formation of hybrid and shared working methods between the disciplines and, at times, unexpected outcomes. An unexpected finding was that participants reported value in being a non-expert in a setting, such as a laboratory. The process of collaboration led some practitioners towards new pathways for fashion, with emerging roles and within hybrid biotechnology and fashion spaces.

The collaborative projects and assemblages that consisted of me as a fashion-led researcher, biologists, bacteria and material have shifted my own ways of working, particularly in embracing the active materiality and fluctuations in agential relations within the collaborative assemblages. These forms of assemblage led me to design according to bacterial requirements and cultivation, but still ultimately led back to an anthropocentric approach, which I concluded I could not escape. Instead, working with living systems led to a more relational perspective, considering humans and nonhumans as an interconnected web of relations and assemblages that are reliant on one another: this research is therefore important in acknowledging nonhumans, such as bacteria and materials, in the context of fashion. Shifting roles led to discursive and relational methods, which I argue are even more pronounced through, and because of, the inclusion of bacteria within these assemblages.

To conclude, these findings are suggested and may be difficult to replicate in different collaborative assemblages and arrangements. This is due, in part, to the qualitative methods of data collection used, which are grounded more in individual experiences, both in terms of the workshop sample and in drawing on my own reflections and experiences within collaborative

projects. I argue that these were the types of roles that I undertook at these points in my projects. I have shown what the assemblage arrangements looked like at specific points and suggested that these assemblage arrangements brought into play these types of roles, which were more prevalent at these stages of my processes. These types of roles may be unique to these particular assemblage configurations and multiplicities in terms of the agency and materiality at play at any one time during the processes.

Overall, these are some of the more prevalent types of roles that I have found during my collaborative assemblage arrangements; however, I intend that this research will grow, new accounts and experiences will be shared, and the suggested roles here will be added to by me and by future fashion-led researchers operating in interdisciplinary teams. This research adds to understanding the types of roles that fashion-led researchers can play in interdisciplinary teams rather than offering replicable and definitive propositions.

CONCLUSION

This research charts the transformation of my role as a fashion-led researcher, beginning in 2015 from a background in fashion design, via the employment of collaborative, interdisciplinary assemblages with biologists, bacteria and material. My study began with the intention to research the potential of biotechnology for fashion futures. As the project developed, my focus shifted onto the processes of collaboration, their arrangements, and how this affected and asserted the importance and variety of roles that a fashion-led researcher can play within interdisciplinary teams.

This study was fashion-led, and collaborative practices with biologists enabled the demarcation of individual disciplinary practices. This approach differs from those of other studies within fashion theory, fashion studies and fashion design research, which have typically offered contributions to furthering cultural or contextual fashion theory and thinking, practice-led and practice-based research approaches. This study presents the value that a fashion practitioner can bring to collaborative practices and offers some proposals for the types and sets of roles arising in negotiation with agential relations and in different arrangements of assemblages.

This thesis started from the proposition that there is potential for sharing new knowledge gained through interdisciplinary collaborative practices between fashion and biology, for fashion design research. This was from the perspective of fashion in an academic context, and I located fashion-led research as a tool with which to think through and understand what underlies fashion practices and processes, rather than being bound by fashion's commercial, production and application aspects. Fashion-led research was used as a perspective and research approach to step outside fashion design and enter into interdisciplinary exchanges with microbiology, synthetic biology and biological art and design. This led to the first research question:

> *What can collaborations between a fashion-led researcher and biologists contribute to fashion design research?*

I focused my enquiry on researching and analysing collaborative approaches between fashion practitioners and biologists, working primarily with bacteria, and creating and bridging collaborative practices between biology and fashion-led research. A gap was identified in the

literature on how collaborative fashion and science operated, as this was an emergent space at the periphery of current fashion design praxes, and existing literature has focused on discussing outcomes rather than revealing the processes of collaboration. This necessitated further investigation and reflection upon microbiological and scientific collaborations that have involved fashion practitioners, via two case studies, to understand how fashion and science approaches have operated which include fashion from the outset.

For the case studies, I sought to foreground examples of collaboration between fashion and biology practitioners in which fashion led or played a key part in interdisciplinary projects, from their inception. In addition, I interviewed multiple actors from such collaborations, including my own, to gain plural perspectives from fashion designers and biologists. This was to understand how these relationships operated and ultimately the potential of collaborations between these disciplines. The research led me to discover and consequently seek out the original microbiologist, Dr Ad van Egeraat, from the Maison Martin Margiela *9/4/1615* exhibition, tracking him down through his previous work colleagues at his university (having retired). I was invited to visit him and his wife Marianne in their home near Ede Wageningen, in the Netherlands. This allowed me to see the original bacterial cultures, material samples, large-scale photographs and exhibition and fashion show paraphernalia that he has kept and archived since the exhibition, and to hear his version of the project, his understanding of his role and feelings about working with fashion, as well as revealing how he views the collaboration now. I traced the original Maison Martin Margiela Art and Communications Director, Patrick Scallon, who I interviewed as he travelled in a taxi around Paris, hearing how it was his mother in Ireland who used to age plant pots using yoghurt and moss that triggered the thinking and concept behind the idea to collaborate with a microbiologist, during a conversation between himself and Jenny Meirens at the time (Scallon, 2019b). The information that the idea behind the exhibition was conceived by Meirens and Scallon rather than Margiela himself was considered a long-held secret but had previously been uncovered in the documentary *We Margiela* (2017). However, during my research, I was able to reveal more information about the genesis of the ideas that Scallon discussed, which had not previously been shared. The case studies allowed me to understand the first central contribution of this thesis:

> This project demonstrates the agility of fashion's role within collaborations between a fashion-led researcher and biologists, specifically in response to actors, materials and context.

Practice-led research focuses on the processes undertaken rather than the knowledge bound into the final outcome or object produced. As a practice-led – but more specifically a fashion-led – researcher, I contended that there was specific primary knowledge to be gained from working within interdisciplinary collaborations, which was not possible to comprehend from secondary sources, such as the case studies. Therefore I conducted a series of six explorative collaborative projects, which allowed an understanding through practice – working as a fashion-led researcher to initiate and operate from the conception of collaborations. This led me to ask my second research question:

> *What types of distinctive and shifting roles can fashion-led researchers take on in interdisciplinary teams?*

Working with bacteria and viewing other nonhuman actors as key agential parts of the collaborative assemblages considerably shifted my ways of thinking from those typical of a fashion designer. In this sense, working with nonhuman living systems brought up new sets of considerations, requirements and roles: operating as a provocateur, cultivator and also destroyer. These types of roles were afforded through being brought into contact with bacteria during my collaborative assemblages. What this suggests in a wider sense is that fashion's emotional, relational and sensory characteristics towards material and bodies are drawn upon when working with and integrating living systems, materiality and distributed agencies.

These affective modes of operating reveal very different ways of working to design science or employing rigorous scientific methodology. This allowed an expanded understanding of fashion that works around bodies – human and nonhuman – understanding fashion practices as distinctive because of the reciprocal agential relationship between human and bacterial bodies and cloth. What is useful is that this questions the centring of the human in our thinking and allows a far more interconnected way of seeing and acting, understanding the human as part of a much wider web of perspectives and assemblages. It is the importance of care, consideration and much wider ecosystems thinking that can take us forward in fashion and biofashion, gained through sharing in biological practices.

Examining interdisciplinary collaboration has ultimately led me back to examining the nature of fashion, and to understanding and sharing the key aspects of the discipline that have been identified by its participants and practitioners. The workshop data findings proposed understandings of fashion from the perspective of insiders operating within it, or from a fashion background and now collaborating with biologists. Fashion was proposed as: emotional and related to feelings and behaviours; as social and direct; as fantastical, and a dream space; as communicative, poetic and a form of storytelling; and as functional and material. Fashion-led research was suggested as a research lens and perspective, related to fashion design practices – and therefore bodily and sensory aspects – and a space that could lead to building new methods and alternative routes for researchers.

Interdisciplinary collaboration is understood as enabling fashion practitioners to share different perspectives, to exchange and draw on different knowledge sets and to create unexpected outcomes, as well as making clear own disciplinary characteristics. Collaborations were undertaken for novelty, intellectual curiosity and extra enrichment. Fashion practitioners without a science background reported enjoying feeling like a non-expert, in order to generate their own creativity from the unfamiliar. A key barrier was identified as authority language understood as being used by scientists, but fashion practitioners adapted by taking on the roles of translator and communicator to break this down. Collaborating led to shifts in fashion practitioners' understandings of fashion, leading to far more rigorous ways of working and questioning. The roles and characteristics that fashion practitioners brought to interdisciplinary collaborations included: intuitive and sensory, curious, translator, facilitator, provocateur and risk-taker, seducer and societal or public-facing communicator.

The collaborative projects, scientific collaborator interviews and workshop data findings led to the second central contribution to knowledge for the field of fashion design research in this thesis:

> This project identifies a typology of roles that the fashion-led researcher takes on within interdisciplinary teams, including ways in which they are negotiated in the process in the context of materiality, agency and assemblage.

I have argued in this thesis that fashion-led research operates in assemblages and its practitioners are constantly negotiating sets of agencies, multiple roles which are in-becoming or in flux, and that fashion is dependent upon differing configurations of materialities at any one time. Fashion has been discussed as inherently intradisciplinary, but this study sets out to argue that the key facets of fashion-led research are of value to interdisciplinary ways of working and thinking, from the inception of projects. Therefore, at the very heart of this PhD is the sharing of the value of fashion-led research. In an era of increasing interdisciplinarity I have argued that it is time to foreground the fashion-led, particularly in light of emergent interdisciplinary spaces such as biofabrication and biofashion, in which fashion and its practitioners can hold a key role. While previous research written on fashion and biology has concentrated on the production of biomaterials, circularity and sustainability practices, this research set out to reveal the characteristics of fashion-led research which make its practitioners valuable assets much earlier in interdisciplinary projects, in order to show that fashion-led research can initiate and lead such projects from their inception. This is not through employing a top-down approach but rather in developing a fashion-led approach, which operates as relational, experimental, discursive and reflexive.

This project demonstrates that working at the intersections of biology and fashion has led to new knowledge for fashion design research in terms of understanding fashion-led research's role as negotiated, responsive and relational to shifting agencies, materialities and assemblages. The research presents what can happen when a fashion-led researcher initiates scientific collaborations, and what happens when these cultures collide – whether this is fashion and bacteria or the fashion-led researcher, fabric, bacteria and biologists, or all of these. This fashion-led research approach differs from the research conducted by biologists working with bacteria. It has offered me a space to question, enquire, interrogate and reflect on these collaborations and on the discipline of fashion. The study indicates the potential for new relationships, processes and roles that can be opened up between fashion-led research and biology, showing the value of fashion designers to operate and advance into fashion-led researchers and future fashion design leaders as part of interdisciplinary teams.

GLOSSARY

Accountability (Logic of Accountability)

The 'logics of interdisciplinarity' are descriptors used by social scientists Born and Barry (Barry et al., 2008; Born & Barry, 2010) for drivers that scientists may encounter or reasons they may hold for entering into interdisciplinary collaborations. The logics refer to particular rationales, motivations or sets of drivers to qualify the necessity for collaborative and interdisciplinary, art-science approaches. The logic of accountability is specifically rooted in being accountable to a wider audience, such as funding bodies or the public (Born & Barry, 2010:109).

Actor/ Actant

See also: Actor-Network Theory. An actor (or actant) is a human or nonhuman 'entity that modifies another entity in a trial' (Latour, 2004:237). Latour's actors perform and modify other actors and their actions within an assemblage. If the entity modifies the behaviour of other actors, then it can be described as an actor (or actant). Latour uses the terms actors and actants interchangeably (Latour, 1996:369).

Actor-Network Theory

A theory proposed by Science and Technology Studies scholars John Law, Michel Callon in the social sciences, and developed by Bruno Latour. Actor-network theory (ANT) focuses on the relational connections and modes in which actors are modified by other actors within networks or webs. The network, or actor-network, is intended as a non-hierarchical or flat ontology between objects, entities and humans. The network can be used as a way of understanding connections and relational ties, inclusive of humans and nonhumans (Law, 1999:4–5; Latour, 2005:75–77).

Agency

The term agency is used here in relation to the way an actor modifies or exerts a certain force or action which affects the final outcome, or the collaboration.

Assemblage The term assemblage is used in this thesis to describe the relations between the fashion-led researcher, scientists and bacteria during the collaborations, the outcomes of which are seen as co-creations. This draws upon the term assemblage, as discussed by Deleuze and Guattari (1987:22–23) and Latour (Callon & Latour, 1981; Latour, 2005).

Anthropocene A term used in geology, and increasingly the humanities, to describe a structure of feeling whereby humans adversely affect nature.

Bacterium 'A member of a large group of unicellular micro-organisms which have cell walls but lack organelles and an organized nucleus, including some which can cause disease' (Oxford University Press, 1998:126).

Bioart 'Bioart' combines the words 'biology' or 'biotechnology' and 'art'. Bioart is used to describe an intersecting space comprised principally of art and design practitioners and practices concerned with biology and biotechnology. Bioart is a 'practice that utilizes living biology as an artistic medium, or addresses the changing nature of biology's meaning through its output' (Myers, 2015:7). Bioart therefore tends to directly make use of living systems as its medium or as subject.

Biodesign Biodesign is an area which actually makes use of the living matter, unlike biomimicry, which looks to nature as inspiration. Biodesign actively uses living systems either during its production or in its outcome. Therefore, just as in bioart, biodesign also encounters and can offer ethical, moral and critical dimensions and perspectives, in working with living systems (Myers, 2015:7).

Biofabrication Biofabrication (biological fabrication) is a term appropriated from the medical, bioprinting and tissue engineering disciplines to describe the production of living, or derived from living, biological materials in a

	design context, specifically using microbiology, synthetic biology and bacteria (Collet, 2015a:12).
Biologists	In this thesis, the terms biologists (and scientists) are used more broadly to encompass human practitioners working with biology and biological systems, including those studying or working with microbes (microbiologists) and those undertaking engineering using DNA to create new biological systems (synthetic biologists).
Biology	In this thesis, the terms biology (and science) are used more broadly to describe the discipline of the study of biology and biological systems, including the study of microbes and DNA.
Biomaterials	Living materials or materials derived from living biological materials produced during biofabrication, specifically using microbiology, synthetic biology and bacteria.
Biomimetic	Taking inspiration or mimicking elements within nature and biology, for example a material which takes inspiration from a shark's skin. Biomimicry does not make use of the biological source itself, but is inspired by the engineering or working of nature.
Body	Within this thesis, this term is used in an expanded sense to describe the space occupied by both human and nonhuman bodies, such as bacteria and micro-organisms.
Clothing	Items worn to dress, adorn or cover the body (Oxford University Press, 1998:346–347).
Co-Creation	Within my study, co-creation is understood as an outcome completed by a collaboration between humans and nonhumans; a form of making or provocation (Sanders & Stappers, 2008:6).

Co-Design	'Collective creativity as it is applied across the whole span of a design process' (Sanders & Stappers, 2008:6). The process includes designers and non-designers, participating collectively in a design development process (ibid.).
Collaborate/ Collaboration/ Collaborative	Working 'jointly on an activity, especially to produce or create something' (Oxford University Press, 1998:358).
Cross-Disciplinary	A mode of working that allows participants to 'view one discipline from the perspective of another' (Stember, 1991:4).
Fashion Design/ Designer	Fashion design is the discipline and practice of producing fashion.
Fashion-Led Research/ Researcher	Research that leads to new understandings about fashion practice (Candy & Edmonds, 2018:64).
Fashion Thinking	Fashion thinking aims 'to stimulate critical thought on culture through the study of fashion' (Petersen et al., 2016:2).
Garment	A garment is an item of clothing, for example a dress or a shirt (Oxford University Press, 1998:756).
Human	Of, relating to, or characteristic of humankind or people (Oxford University Press, 1998:892).
Innovation (Logic of Innovation)	The logic of innovation refers to particular rationales, motivations or sets of drivers as reasons for interdisciplinarity – predominantly to bridge gaps between scientific research, specifically for wider business or economic gains and relations (Barry et al., 2008:22).

Interdisciplinary	Of, or relating to, more than one branch of knowledge (Oxford University Press, 1998:951). The combination and interaction of at least two disciplines (Darbellay, 2015:165–166). Stakeholders bring specific knowledge and thinking as experts from their own fields and disciplines, producing an integrative approach that works towards a shared purpose (Darbellay, 2015:165–166).
Microbe	A ‘micro-organism, especially a bacterium causing disease or fermentation' (Oxford University Press, 1998:1167).
Microbiology	A discipline within biology dealing with the study of bacteria and microbes.
Microbiota	The ‘micro-organisms of a particular site, habitat or geological period’ (Oxford University Press, 1998:1168).
Mixed Methods Approach	Research practices using a combination of qualitative and quantitative research methods.
Multi-Method Approach	Research practices employing a range of methods within a qualitative research method tradition.
Multidisciplinary	‘Combining or involving several academic disciplines or professional specializations in an approach to a topic or problem’ (Oxford University Press, 1998:1215).

New Materialism	A new materialist turn in the humanities was identified by Braidotti and DeLanda, in the late 1990s and early 2000s (van der Tuin, 2018:277). New materialisms are 'a research methodology for the non-dualistic study of the world within, beside and among us, the world that precedes, includes and exceeds us' (ibid.). New materialist theory represents a shift away from linguistic, semiotic and cultural turns in the humanities towards viewing matter (for example: things, objects, entities, particles) as 'active participant[s] in the world's becoming' (Barad, 2003:803).
Nonhuman	A living or non-living organism, entity or object which is not human. Within this thesis, there is a distinction between the human as a whole (referred to as human or humans) and living organisms such as bacteria, which may use the human body as a host (referred to as nonhumans).
Ontology (Logic of Ontology)	The logic of ontology, or 'beliefs about the nature of being or reality' (Twining et al., 2017:A2), refers to particular rationales, motivations or sets of drivers as reasons for collaborative and interdisciplinary (art-science) approaches, rooted specifically in 'effecting ontological change in both the object(s) of research, and the relations between research subjects and objects' (Born & Barry, 2010:105).
Participatory Design	See also: Co-Creation; Co-Design. Participatory design is an area of design which incorporates the expertise of users and stakeholders and their experiences into the design process. (Sanders and Stappers, 2008:7).

Posthumanism	Posthumanist theory interrogates anthropocentric attitudes and is therefore concerned with the critique of 'species hierarchy and human exceptionalism' (Braidotti, 2018:339). Posthumanism looks at human and nonhuman relations, with particular regard to technology and the environment, deconstructing purely human-centred viewpoints and understanding that the human 'is in a constant state of change' (Vänskä, 2018:27).
Practice-Based/ Practice-Led (Art and Design Research)	In relation to art and design research: 'if a creative artifact [sic] is the basis of the contribution to knowledge, the research is practice-based […] if the research leads primarily to new understandings about practice, it is practice-led' (Candy & Edmonds, 2018:64).
Science Fashion	The term 'Science Fashion' (Tillotson, 1997:i; Smelik, 2018b) refers to an integrated approach featuring elements of, practitioners of, or researchers of science, together with elements of, practitioners of, or researchers of fashion.
Synthetic Biology	Synthetic biology is a discipline within the biological sciences which enables the design and engineering of biological systems and machines at a genetic level.
Vital Materialism	Vital materialism is a philosophical theory based in political ecology proposed by Jane Bennett (2005; 2010; 2018), drawing on ideas from philosophers such as Spinoza, Nietzsche, Deleuze and Hans Driesch (Bennett, 2010:viii). It seeks to critique and move away from human-centred ideas of agency and towards understandings of human-nonhuman agential assemblages by elevating the vitality of matter or nonhuman 'things' (Bennett, 2005:446; 2018:447).

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Figure 9: Geaney, V. and Park, S., 2016. *Living Lace (photosynthetic Cyanobacteria Oscillatoria grown on agar plate with laser-cut cotton)*. [photograph] (Guildford, Surrey University).

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APPENDIX 1 – CASE STUDIES

This appendix employs a case study method and reflexivity to examine the following:

Case Study 1:
Primitive Streak Collection (Helen Storey, Kate Storey, Caroline Coates)
Case Study 2:
9/4/1615 Exhibition (Ad van Egeraat, Thimo te Duits, Patrick Scallon)

The case studies were selected as examples where a fashion practitioner has been involved from the outset of a collaboration when engaging with biologists. Primary interviews were conducted from three perspectives: fashion, science and museum or producer. This was intended to build understandings from the plural experiences of the key actors in each of the assemblages.

Case Study 1: Helen and Kate Storey's *Primitive Streak* collection

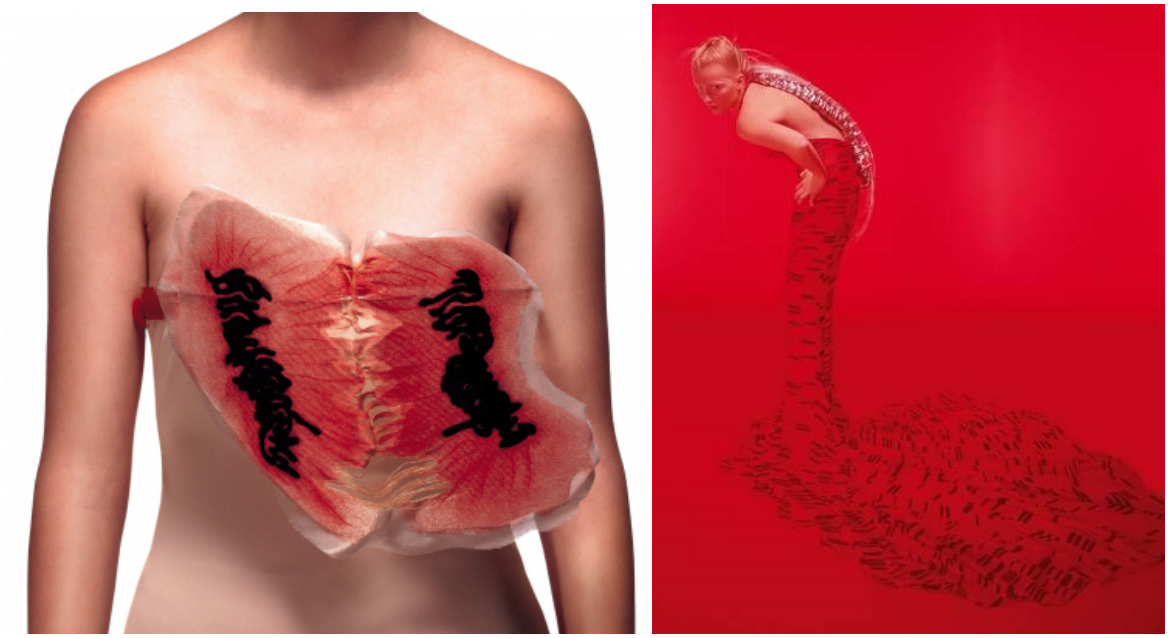


Figure 1: Anaphase Dress (left), from the *Primitive Streak* collection (Laeufer, 1997). © Helen Storey, Kate Storey and Justine Laeufer all rights reserved.

Figure 2: Spinal Column Dress (right), from the *Primitive Streak* collection (Laeufer, 1997). © Helen Storey, Kate Storey and Justine Laeufer all rights reserved.

In 1996, the Wellcome Trust launched the first in a series of funding initiatives to encourage, showcase and promote interdisciplinary partnerships (Glinkowski & Bamford, 2009:7). The Sciart programme[68] ran from 1996-2006 and, from the Wellcome Trust's perspective, aimed to facilitate engagement by funding selected projects between artists and scientists which would be showcased by the museum (Born & Barry, 2010:108).

Professor Helen Storey, along with developmental biologist and sibling Kate Storey, was awarded one of the first grants; theirs was the only fashion collaboration in the first cohort (Storey, 2018). They used the funding to produce the *Primitive Streak* collection (Helen Storey Foundation, 2008a; 2008e). This comprised 27 dresses and was initially exhibited at the Institute of Contemporary Arts, London (6-12 October 1997). Each dress in the collection

[68] The Sciart programme was established under the belief that art – as a public form of dissemination – could be employed as a tool to help engage society through communicating political, cultural or ethical elements of science to a wider audience, whether aesthetically or conceptually (Barry & al., 2008:31).

documented the stages of human embryonic development in the first 1,000 hours of life (Riddell, 1997:32). *Primitive Streak* functioned as a collaboration between Helen Storey as fashion designer and Kate Storey as a biologist. Helen's business partner, Caroline Coates, worked as producer, organising the marketing and business aspects of the project (Coates, 2019). The production of the fashion collection was itself an assemblage, conducted by Helen in conjunction with milliner Philip Treacy, Helen Bailey Studio and Atelier, Trish Belford (textiles) and staff and students at the University of the Arts London (Primitive Streak, 2019; REF 2014, 2014). Helen Storey's intention was that design would explain a 'scientific event in cloth and on a moving female body' (Helen Storey Foundation, 2008b). The dresses were viewed by visitors to the exhibitions and galleries and used as educational tools for schools and through workshops run in conjunction with the exhibitions.

Roles and Methods Within Collaboration

The shared brief from the Wellcome Trust was the impetus for the collaboration, both in concept and funding, and enabled a collective focus from the two disciplines. The collaboration was initiated via the platform of the Wellcome Trust, bringing fashion design into contact with biology from the inception of the project.

The design and making process took place over four months, from April to October 1997. Kate Storey described the project as a 'true collaboration', as the sisters worked closely, undertaking the process together:

> It became a true collaboration, not just each doing their part, but real interchange, perhaps made possible by being sisters, by trusting and easily speaking our minds (The Helen Storey Foundation, 2003:11).

After Kate had talked through and shown Helen the main parts of the embryonic process using the microscope, the sisters selected ten key events on which they would base the dresses. They began a process in which Helen would fax drawings to Kate, who would draw on and annotate them, exchanging information on factual details for visualising the scientific elements (The Helen Storey Foundation, 2003:10-11). Accuracy was important for Helen, but Kate was interested in how the forms were interpreted to create designs and dresses that were beautiful in themselves (Storey, 2019a). This back-and-forth process occurred between meetings, as a

way of communicating through paper and using drawing as a method. They would have meetings either at the laboratory, at Helen's home or at the design studio at the London College of Fashion (The Helen Storey Foundation, 2003:11).

Experimental cross-disciplinary methods included the development of a new language which made use of amalgamated science and art terms, and Helen begun to use a form of Tai Chi hand signalling to convey biological forms and processes to members of the design studio (The Helen Storey Foundation, 2003:9; Kohn, 2011). These forms of translation helped to describe what Helen had viewed through the microscope to those who had not seen the embryonic processes at first hand. Further shared methods included Kate suggesting suitable materials to best convey properties of the embryonic tissues, and performing a form of draping by rolling fabrics into forms evoking the tissue shapes (The Helen Storey Foundation, 2003:11).

Key elements of Helen Storey's method for *Primitive Streak* differ from a conventional fashion design approach, showing a shift from fashion into interdisciplinary practice. Design and science are integrated from the inception. The design brief is typical of fashion design practice; however, here the Wellcome Trust set a collaborative and practical art-science brief, for which there were few existing precedents (Storey, 2018). The integration of science allowed Helen to shift her practice from working solely in the studio to fluctuating between studio and laboratory – visiting and gaining access to a scientific laboratory at the start of the design process; viewing live chicken embryos using a microscope, and listening and responding to Kate's explanation of the scientific process through the medium of dresses.

Helen's role was principally one of fashion practitioner and designer. She drew from her background in fashion to design and lead the making of the garments. The project followed a standard fashion design process, from design brief, research and sourcing, design development, prototyping, final collection to promotion (Burke, 2011:14–16). Its trajectory then shifted away from the next phases, which would have been industrial production and business in a standard commercial fashion design process (ibid.). This was firstly because funding was awarded for the collection, which removed the need to have to sell a fashion product. The absence of commercial drivers also meant that the dresses did not need to be mass produced. Working with the Wellcome Trust and with a biologist allowed Helen Storey the freedom to explore, play and experiment, which she had not found as possible within the constraints of operating a fashion design business (Storey, 2018).

There were still boundaries to the project and its objectives: the Wellcome Trust specifically asked the sisters to document the creative process between designer and scientist, and the outcome was a collection of 27 dresses. Documentation was carried out by both sisters writing diaries and sharing images and information about the project, the garment designs and final outfits and the scientific process. This information is openly accessible online (see: Primitive Streak, 2019; Helen Storey Foundation, 2008a). Images show illustrative coloured drawings of the final garment designs, and the fully realised garments of the collection styled and documented in the style of a professional fashion photoshoot.

Impact

Glinkowski and Bamford produced the report *Insight and Exchange: An Evaluation of the Wellcome Trust's Sciart Programme* (2009) discussing the outcomes of the Sciart programme. Although written principally in relation to artists and scientists working together, it offered further insights into the processes and outcomes of the works produced. The report described a negative aspect of the term 'sciart' as expressed by some participants in the initiative, indicating there was a danger of an ineffective merging of the two disciplines: 'the difficulty with this was that it might lead to a kind of compromise or dilution that could be detrimental to the integrity of both' (Glinkowski & Bamford, 2009:30). However, in working and collaborating with scientists, Helen Storey instead discusses finding a form of liberation and an 'opportunity to be free of those sorts of constraints that you have to honour if you want to stay in business' (Storey, 2018), which allowed her to create what she described as 'different forms of hybrids […] unique depending on who the collaboration has been with' (ibid.). Therefore, rather than feeling her work had been compromised, Helen Storey found a sense of freedom through the project.

Overall, Glinkowski and Bamford's report found that the impact from the projects undertaken as part of the Sciart programme was more valuable for the arts than the sciences (Glinkowski & Bamford, 2009:9). Although the Sciart projects enabled greater communication of their scientific research to the public, the collaborations did not significantly impact towards a 'shift or development in scientific processes or outcomes' (ibid.). Following the Sciart projects, the scientists involved reported that the collaborations had enabled them to develop knowledge of

a broader contextual understanding, inspiring them to work more speculatively and to take more risks in their research (ibid.).

Helen reported initially feeling concerned about the impact for Kate Storey as a female scientist beginning her career, and how Kate may have been perceived and taken seriously, or not, in scientific circles because the project involved collaborating on a fashion collection (Storey, 2018). Although Kate explained that she was also concerned about this, and that this did occur, she stated that in the long term, the collaboration was 'a very positive thing for my career' (Storey, 2019a). Both the REF case study and Kate Storey's laboratory website evidence *Primitive Streak's* impact by detailing additional funding that was awarded by the Wellcome Trust in 2010-11 (The Storey Laboratory, 2007; REF 2014, 2014:2–3). This demonstrates a wide reach in evaluating the significance of the project and highlights its personal importance to Kate Storey, due to its inclusion on her laboratory website.

In addition, the appointment of Helen as Professor of Fashion and Science at the London College of Fashion (in 2008) and the award of an MBE in June 2009 demonstrate Helen's accomplishments, effectively shifting her role from commercial fashion designer to academic professor, activated by her collaborative science and fashion work which started with the *Primitive Streak* project.

Helen Storey did not describe the collaboration as either successful or unsuccessful at the time, as she explains that she did not know or understand what had been created (Storey, 2018). However, since the *Primitive Streak* collection there has been an increase in fashion, art and science collaborations, which she views as a success in itself (ibid.).

In terms of reception, the *Primitive Streak* collection was not viewed as fashion by a fashion audience:

> I think quite early on the fashion world deemed what I was doing wasn't fashion because it wasn't on a catwalk, you couldn't buy it […] and a celebrity wasn't wearing it (Storey, 2018).

Helen Storey explains that although the project used 'clothes as a medium […] it was never intended to fulfil a fashion brief' (Storey, 2018). *Primitive Streak* therefore used fashion and

the garment as a tool, as mechanisms for communication rather than the production of a commercial fashion collection. The dresses showcased scientific information and thus acted as a method of accessing and opening up biological principles, whilst simultaneously highlighting making, the craft of creating dresses, and demonstrating how fashion can collaborate with science. Helen is drawn to dress, the female form, the experiential qualities of cloth, wearing and being worn, and the idea of dress as a second skin (Storey, 2018). The garments were not intended to be sold, but fashion design methods were utilised, such as showcasing the dresses in fashion photo shoots (for example, for a catalogue and in *Vogue* magazine) and using mannequins in exhibitions.

Summary

Although unclear about the potential purpose of the collection at the time, Helen Storey has found that the collection is now more meaningful for educational, social and cultural purposes (Storey, 2018). *Primitive Streak* has been used as a learning tool in schools, to access collaborative practice, to explain the term 'primitive streak' in relation to processes of developmental biology, and to show how hybrid methods of working can help children with alternative styles of learning (ibid.). The project provided the foundations for the *Creative Lab* concept, developed with Creative Partnerships, Arts Council England (The Storey Laboratory, 2007). The collection has toured extensively in many cultural venues, including galleries and exhibitions such as 'ICA, London (1997) then venues including Quartier 206, Berlin (1998); Hayward Gallery (1999); World Financial Center, New York (1999); Oksnehallen, Copenhagen (2000) and Textile and Costume Museum of Barcelona (2005)' (REF 2014, 2014:2).

Case Study 2: Maison Martin Margiela's *9/4/1615* exhibition

Figure 3: Photograph from the *9/4/1615* exhibition (left), (Museum Boijmans Van Beuningen and Evans, 1997). © Museum Boijmans Van Beuningen and Caroline Evans, all rights reserved.

Figure 4: Photograph showing a garment in detail from the *9/4/1615* exhibition (right), (van Egeraat, 1997). © Ad van Egeraat, all rights reserved.

The *9/4/1615*[69] exhibition was the first retrospective and solo exhibition by Maison Martin Margiela (MMM), and took place from 11 June to 17 August 1997 (Grant, 2009:155). The *9/4/1615 exhibition* was first shown at the Museum Boijmans Van Beuningen, for which MMM produced a series of bacterially dyed garments in collaboration with Dutch microbiologist Ad van Egeraat (van Egeraat, 2018b) thus offering an example of high fashion collaborating with microbiology. Furthermore, it came at a time when it was rare for fashion houses to hold retrospectives curated by, or in conjunction with, a living designer (Granata, 2017:113).

Key Drivers for Each Actor

Belgian fashion designer Martin Margiela graduated from the School of Fashion at the Royal Academy of Fine Arts, Antwerp, in 1980, and founded MMM with business partner Jenny Meirens in 1988 (Margiela et al., 1997; Scallon, 2019a). Although Margiela graduated a year

[69] The title of the exhibition – *9/4/1615* – refers to the number of years Margiela had shown for, '9'; the number of days required for bacterial growth, '4'; and the amount of hours the exhibition would be shown for, '1615' (Evans, 1998:77).

before the famous 'Antwerp Six',[70] he was viewed as part of a new wave of Belgian designers establishing themselves internationally. After working as a fashion assistant for Jean Paul Gaultier he set up his own design house in Paris (Grant, 2009:153). In 1997, there were 15 team members operating as MMM (Margiela et al., 1997). As well as working on the retrospective exhibition, the fashion house was also launching its menswear line, and Margiela became Creative Director of Hermes in 1997 (Grant, 2009:153; te Duits, 2018).

In 1997, Chris Dercon was Director, and Thimo te Duits[71] worked as Exhibition Curator of Design, at the Museum Boijmans Van Beuningen in Rotterdam. The museum had begun acquiring garments by Comme des Garcons, Yohji Yamamoto and MMM for the fashion collection (te Duits, 2018; Evans, 1998:85).

The museum wanted to organise an exhibition with Margiela as part of a larger series of ten exhibitions focusing on collaborations between architects and designers (te Duits, 2018).[72] Te Duits was persistent in trying to contact MMM in Paris via fax[73] and telephone, and eventually the fashion house agreed to produce an exhibition with the museum (te Duits, 2018).

Patrick Scallon worked at MMM from 1993 to 2008 and was Art and Communications Director at the time of the exhibition (Showstudio, 2020). Scallon liaised with Jenny Meirens and Martin Margiela at the fashion house, and worked with Thimo te Duits and Chris Dercon from Museum Boijmans Van Beuningen and Ad van Egeraat on the collaboration (te Duits, 2018; van Egeraat, 2018a; Scallon, 2019a; *We Margiela*, 2017).

Several factors were key for MMM in agreeing to the exhibition. Scallon describes how important it was for MMM, as a fashion brand, to also present work in galleries and museums in the context of the late 1990s, alongside peers such as Viktor and Rolf, Yohji Yamamoto and Comme Des Garcons (Scallon, 2019b). The main reasons why MMM wished to expand into

[70] The 'Antwerp Six' comprised a group of graduates from the Royal Academy of Fine Arts, Antwerp, who were recipients of the Golden Spindle competition. The competition helped to invigorate the Belgian fashion industry during the 1980s and 1990s including: Ann Demeulemeester, Dries Van Noten, Walter Van Beirendonck, Marina Yee, Dirk Van Saene and Dirk Bikkembergs (Debo & Loppa, 2010:66–67).

[71] Thimo te Duits had previously studied History of Art in Utrecht, specialising in glass and ceramics before working initially as an assistant, then as curator of glass and ceramics, before becoming Exhibition Curator of Design at the Museum Boijmans Van Beuningen (te Duits, 2018). *9/4/1615* was te Duits first exhibition as Exhibition Curator of Design.

[72] The funding source was the Stimuleringsfonds voor Architectuur en Stedebouw (Netherlands Architecture Fund) which was a cultural fund in Holland, predominantly for architectural projects, design research and interdisciplinary collaborations promoting architecture (te Duits, 2018).

[73] Thimo te Duits tried to contact the house but he only received a response after sending a fax written in Dutch, knowing Martin Margiela to be the only member of the team who could read the language (te Duits, 2018).

an art and museum space were: brand promotion; experimentation and as internal inspiration at Margiela; the touring aspect of the exhibition (from Rotterdam to New York and then Japan) which Scallon describes as justifying the time spent on the project; and timing, as Jenny Meirens was 'looking for an interesting project to work on' (Scallon, 2019b). He further elucidated that 'we also wished for a terrain that could bring us unforeseen aspects and surprises […] and in this it didn't disappoint' (ibid.). Therefore, an impetus for the fashion house to work with microbiology was the potential for the unexpected.

Although te Duits had originally pitched the exhibition as a collaboration between the fashion house and an architect, MMM instead came up with a concept for an outdoor exhibition, to make use of the glass pavilion space at the museum (te Duits, 2018). The concept was for the garments to be green and moulding, inspired by statues covered with a patina of mould and moss which had grown over time that demonstrated ageing (*We Margiela*, 2017; te Duits, 2018; Scallon, 2019a). Te Duits explains that the fashion house wanted the garments to be presented outside: 'to leave the people inside and fashion outside – was like inversion' (te Duits, 2018). This pivotal idea shifted the collaboration away from architecture and towards fashion and microbiology.

Ad van Egeraat was Assistant Professor at the Wageningen Agricultural University.[74] Van Egeraat was contacted initially by the Museum Boijmans Van Beuningen, and he agreed to the collaboration, stating that this was not due to any prior interest in fashion but because he 'was always in for these kind of strange things – outside just normal microbiology' (van Egeraat, 2018a). Van Egeraat thus explained that it was the crossing of disciplinary boundaries which fascinated him – 'I'm not a fashion guy, absolutely not. But it was the idea – is this possible? Can we do this? Well, yes' (van Egeraat, 2018b). The potential for a bacterially dyed fashion collection came from merging microbiology and fashion, and the possibilities which could arise from this amalgamation acted as a driver for van Egeraat in agreeing to the collaboration.

Roles in Collaboration

The exhibition was initiated by the Museum Boijmans Van Beuningen, which led to a collaboration between a microbiologist and a fashion house. Te Duits first contacted MMM,

[74] Van Egeraat completed his doctoral thesis in 1972, titled '*Pea-root exudates and their effect upon root-nodule bacteria*' (Margiela et al., 1997; van Egeraat, 2018a).

who eventually agreed to the exhibition. The fashion house then came up with the idea of placing the apparel on mannequins outside, and incorporating mould and bacteria onto the surface of the garments (te Duits, 2018; Scallon, 2019a; Scallon, 2019b).

Te Duits was looking for a microbiologist who was interested in working on the project in order to colour or dye Margiela's clothing using bacteria (te Duits, 2018). He contacted van Egeraat, who agreed to work on adding bacteria to the garments which MMM would produce. Te Duits thus acted as a conduit between the fashion house through Patrick Scallon, director of Art and Communications at MMM, and the microbiologist van Egeraat (ibid.).

The idea was pitched to the microbiologist from the fashion house via the museum: therefore this project was organised by the museum, which was effectively working in the service of the fashion house. In this way, the collaboration was fashion-led – questioning and opening up the possibilities surrounding a collaborative approach instigated between fashion and microbiology.

MMM reconstructed 18 outfits, one from each of his nine collections to date, which were made completely in white fabric (Margiela et al., 1997; Evans, 2003:253; Grant, 2009:153). Although the fashion house originally wished the garments to be coloured with green mould, van Egeraat produced a range of colours which Margiela could then select from (te Duits, 2018; Scallon, 2019a).

Van Egeraat's method for collecting the bacterial samples was to place hundreds of open petri dishes containing agar around the university in order to capture 'all bacteria and moulds and yeast from the air' (van Egeraat, 2018a). He closed the petri dishes and left the cultures to grow for a couple of days. Van Egeraat then looked for the fastest-growing, most aesthetically pleasing and brightest colours. He stated, 'I don't know – still not – the names of all these bacteria and moulds' (ibid.). He was not interested in the types of bacterial and yeast cultures collected, and thus his research aim was singular and purely 'interested in fast growing organisms on this medium and then of course the colours of the bacteria' (ibid.). This shows a shift away from the privileging of scientific drivers, which may involve classifying the bacterial samples, towards valuing aesthetic drivers within art and design disciplines.

Van Egeraat worked at the exhibition site, with a team including Scallon, to coat the garments in agar, yeast and nutrients, which acted as a solid growth medium for the bacteria (van Egeraat, 2018a; Scallon, 2019a). The garments were dried and then sprayed in order to inoculate them with the various coloured bacteria and moulds before undergoing incubation in wooden structures constructed for the purpose, complete with lighting and water basins (Margiela et al., 1997). Large buckets of water and filter paper were used to keep the environment humid, and van Egeraat used lighting to retain the temperature in each container at 25 degrees, as he had found that this was the best temperature for growth in his earlier fabric experiments (van Egeraat, 2018a). These box-like structures were covered in plastic to protect the inoculated garments and to enable faster bacterial growth on the clothing in the gardens at the museum (Granata, 2017:113; Evans, 2003:253).

In terms of a method for the spraying and placement of the bacteria during inoculation, van Egeraat explains that this was carried out by him 'not in a real pattern, but what I did was [spray] on some places more than on the other places so you get a variety of growth and density' (van Egeraat, 2018a). This shows that boundaries between designer and scientist and their roles can blur during collaboration, as the microbiologist may be viewed here as participating in the design of the fabric through his choice of where to spray the bacteria, and thus colour the materials. When interviewed, van Egeraat did not view this as participation in the design, although he stated that he felt the choice in bacterial placement was his (van Egeraat, 2018b). The scientist was able to apply agency as part of the collaboration at a level similar to that of (for example) a person responsible for the embellishment of a haute couture item of clothing. The scientist effectively decided where to spray the growth medium, determining the pattern of bacterial growth. Other conditions, and arguably the notion of the growth of the bacteria itself, conflate here to determine the overall outcome, which therefore can be said to be a co-creation between human and nonhuman actors.

Impact

The *9/4/1615* exhibition continues to have an impact through photographs, in accounts from the press, visitors, theorists and in film. There is sustained interest in Martin Margiela, highlighted by the production of the 2019 film *Martin Margiela: In His Own Words.*[75]

[75] However, unlike *We Margiela* (2017), the 2019 film does not include the *9/4/1615* exhibition.

Although the impact of the *9/4/1615 exhibition* cannot be quantitatively measured, in interviewing the collaborators over twenty years after the exhibition, the responses I have gathered from each actor provide an indication of their experiences of the collaboration.

The exhibition curator, te Duits, stated that he liked the outcome and found the interaction between fashion and microbiology very interesting, leading to the inclusion of van Egeraat in the catalogue (te Duits, 2018; Scallon, 2019a). He explained that although the fashion house was hard to work with at times, the press reception indicated that it was a successful exhibition (te Duits, 2018). In terms of visitors' reception of the work, te Duits reported that the exhibition was impressive, and he found the juxtaposition between the visitors on the inside and the mannequins and bacterially coated garments outside to be surreal (te Duits, 2018). Although the exhibition toured from Rotterdam to New York, and then Japan, the one-off nature of the project meant that a long-term mode of engagement was not possible (te Duits, 2018). This was because the fashion house returned to its primary focus as a commercial fashion business and van Egeraat to his work at the university.

When asked to select one work from his career of which he was most proud due to its creativity rather than measured in terms of industry success, Scallon stated: 'Bacteria Exhibition for MMM – Boijmans Museum in 1997' (Le Book, 2019)[76]. This shows the affiliation Scallon had to the exhibition and the value and impact his part within the collaboration played as a personal highlight in his overall career both as Communications Director at MMM and now at Dries Van Noten.

The microbiologist van Egeraat noted how the collaboration and exhibition led to publicity and interest from visitors and the press, which he enjoyed: 'it was a really international attention for this, for this exhibition – I was proud yeah, absolutely I was proud. I worked it out: I did it and it was good' (van Egeraat, 2018b). His joy and pride in the work was clear during our interview, and demonstrated by the fact that he keeps the original photographs, bacterial cultures and fabric samples from the project, along with fashion show invitations and exhibition catalogues given to him by MMM (van Egeraat, 2018a). However, in thinking about further collaborative works, van Egeraat stated that 'for me, it was just a one-time adventure' (van Egeraat, 2018b).

[76] Scallon was interviewed as part of a questionnaire when he was a Jury member for Connections Paris (Le Book, 2019).

In this sense, all three actors engaged with the project at the time, and they each expressed the view that the work had a personal value to them, and that it was, however, a unique endeavour. They did not work together again, and MMM did not engage with microbiology again following the exhibition. Furthermore, due to the nature of the use of bacteria on the clothing, it was agreed that the garments were to be destroyed following each exhibition (van Egeraat, 2018b; Scallon, 2019a). The exhibition, however, has had an arguably more long-term and impactful mode in its dissemination through journal articles and books by prominent fashion theorists and practitioners (Evans, 1998:73–93; Evans, 2003:253–256; Lee, 2005:72; Granata, 2017:113–118). Additionally, it is the only exhibition to feature in the film *We Margiela* (2017) and the book *Maison Martin Margiela* (Maison Martin Margiela & Luna, 2009).

Evans and Lee focus on the themes of decay and decomposition as the inspiration for Margiela's use of bacteria on garments (Evans, 1998:77; Lee, 2005:72). Although the fashion theorists point to the use of bacteria and its links to notions of decay, in interview Scallon clarified that the idea behind the employment of bacteria was not to indicate decay but to use a natural method of embellishment: 'there was something a little bit almost more plastic and more facile about the Margiela exhibition because it wasn't about decomposition, it was about embellishing and bringing a natural beauty' (Scallon, 2019a). This highlights the importance of first-hand collaborator reflections and perspectives in a practice-led or fashion-led research approach, to offer clarity of vision from the practitioner's own perspective.

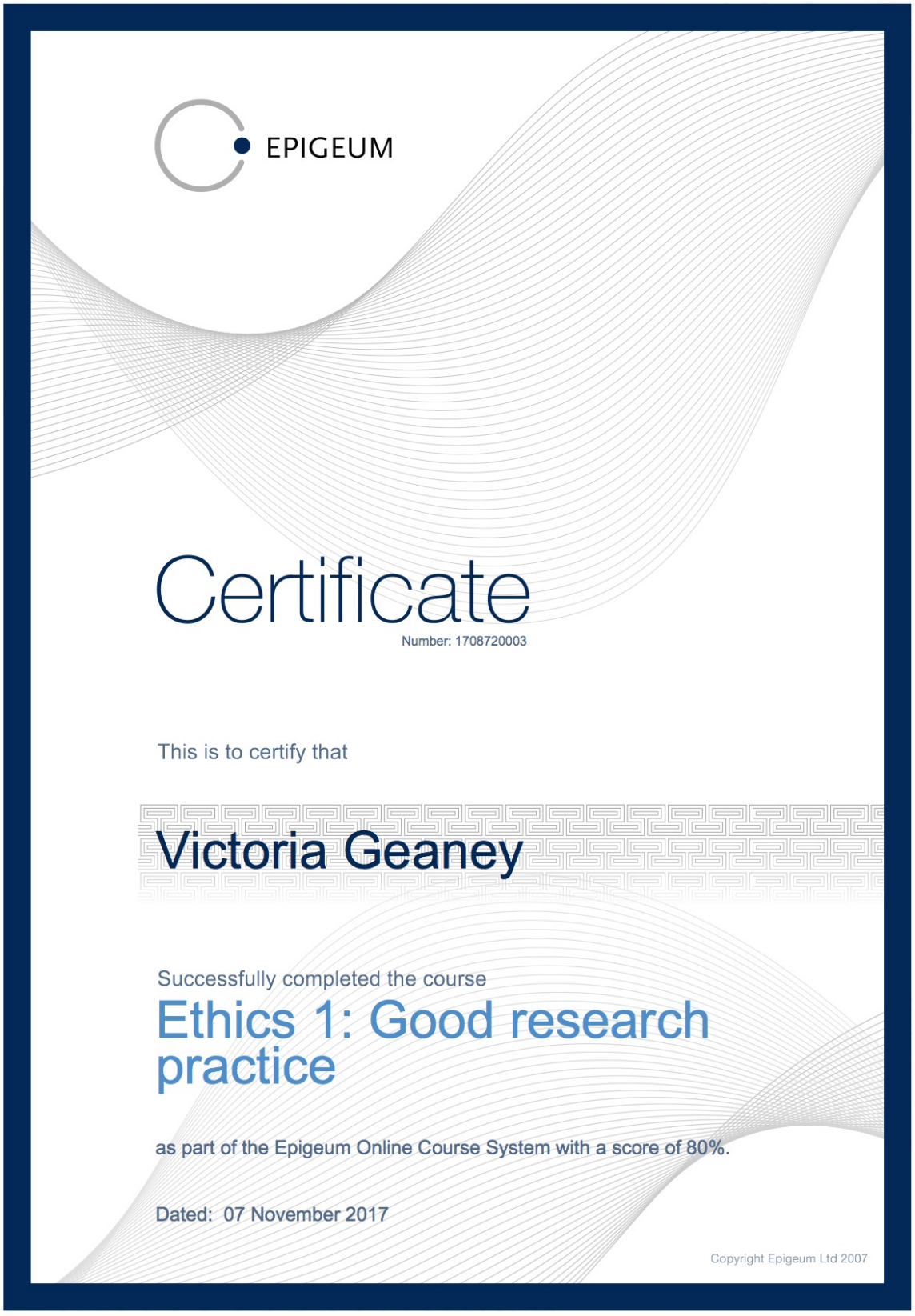
Summary

The case of the Maison Martin Margiela's *9/4/1615* exhibition highlights how roles in the collaboration were distinct and typically set within their own disciplines: MMM produced the garments and van Egeraat operated to produce the bacterial colouration for the project. However, roles did intertwine at specific points, such as the preparation phase for the public exhibition. Here, for example, Scallon worked with van Egeraat to dip the garments in agar and prepare them for the exhibition (Scallon, 2019a). The project was not repeated and the actors each returned to their own disciplines following the *9/4/1615* exhibition.

The impact from *9/4/1615* can be suggested, but not proven, in the work of practitioners using bacteria to produce dyes. Dissemination of the project via major fashion theorists and

practitioners such as Evans, Lee and Granata has also enabled the work to be revisited and new understandings of it gained (Evans, 1998:73–93; Evans, 2003:253–256; Lee, 2005:72; Granata, 2017:113–118).

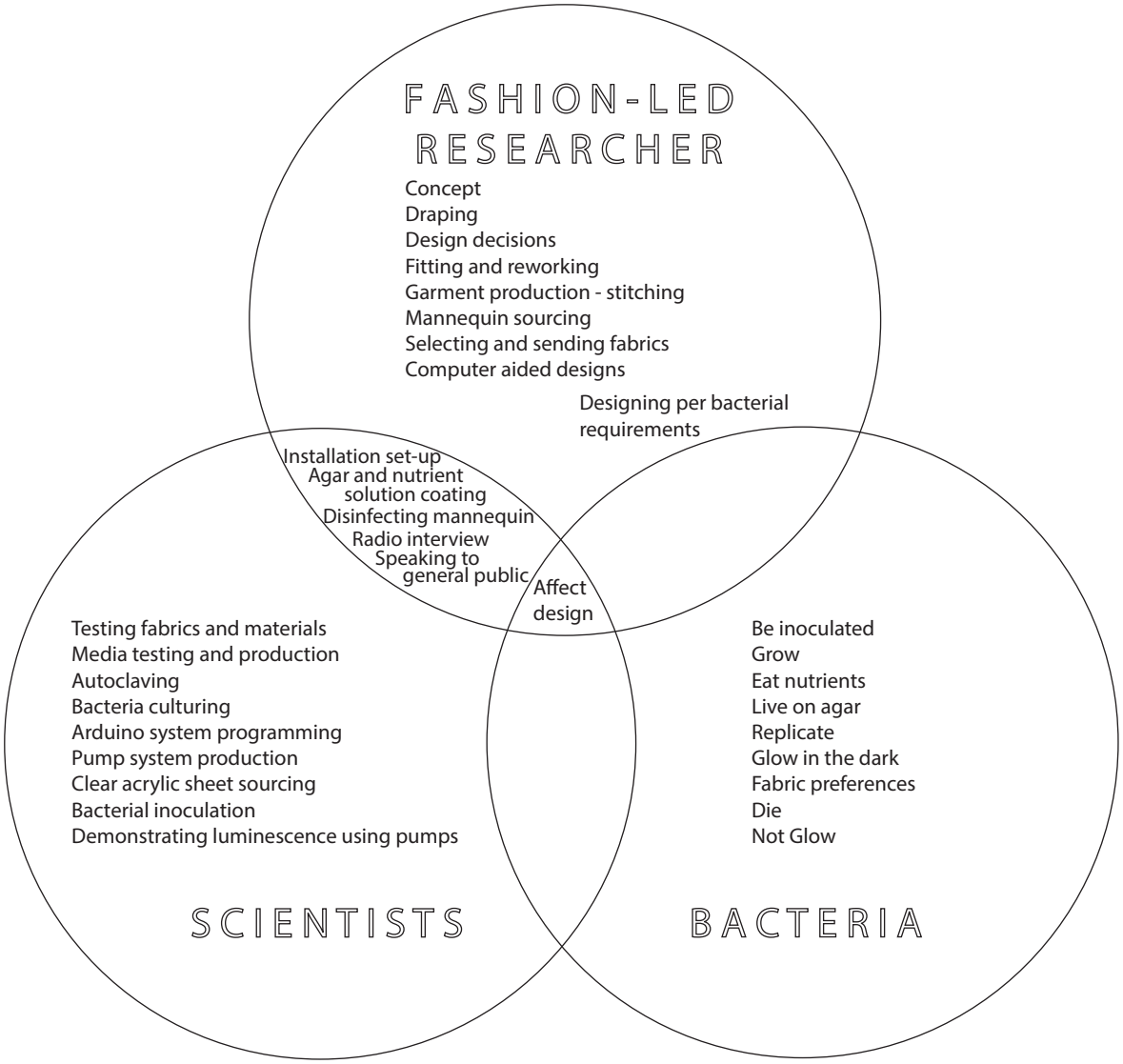
APPENDIX 2 – EPIGEUM ETHICS TRAINING CERTIFICATE



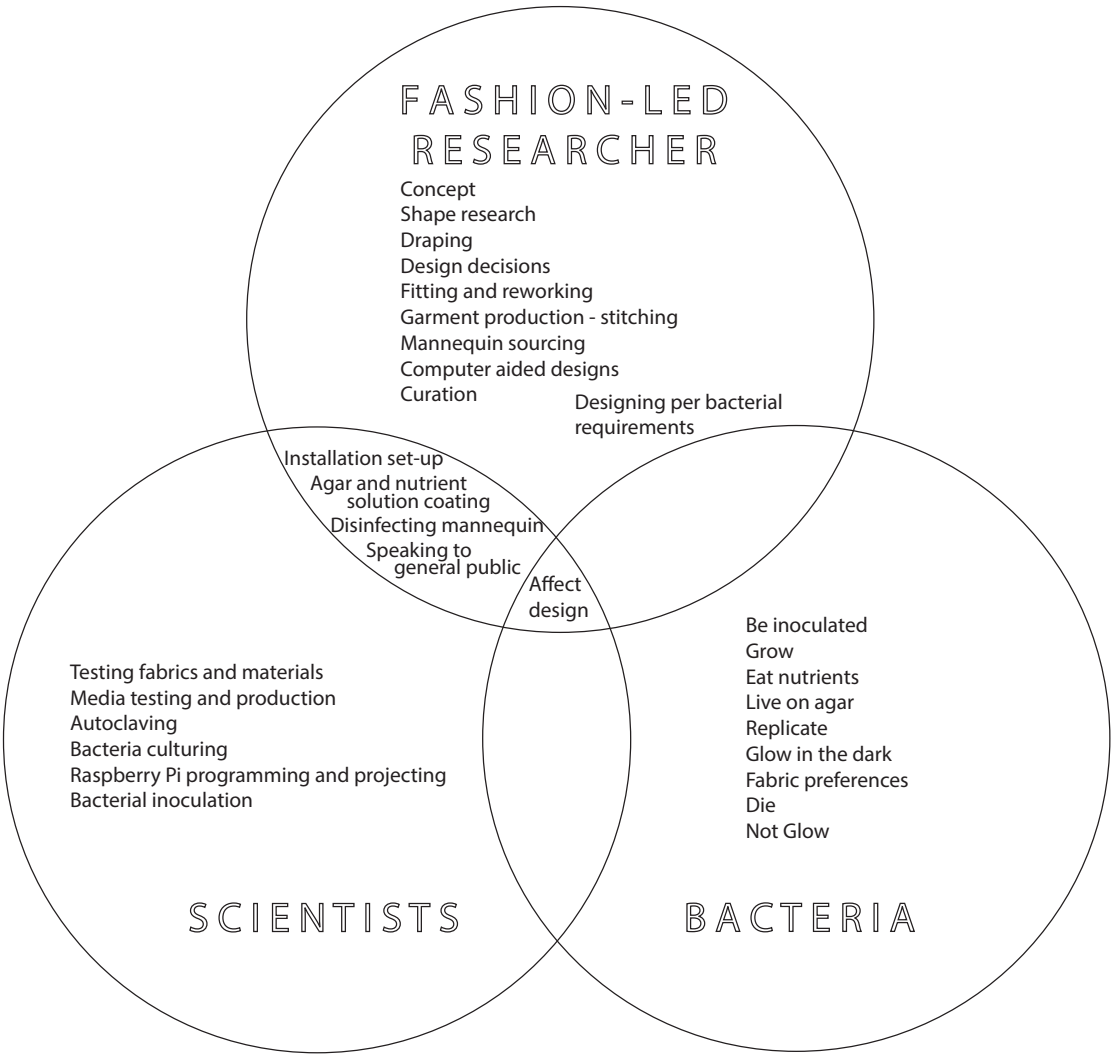
APPENDIX 3 – VENN DIAGRAMS

The Venn diagrams map the tasks or agential processes of the fashion-led researcher, biologists and bacteria within each of the six collaborative projects. These diagrams take into account human and nonhuman agential relations and how these three actors intersect to affect the design or outcome. In this way, the collaborative projects are viewed as co-creations between the assemblages of three actors.

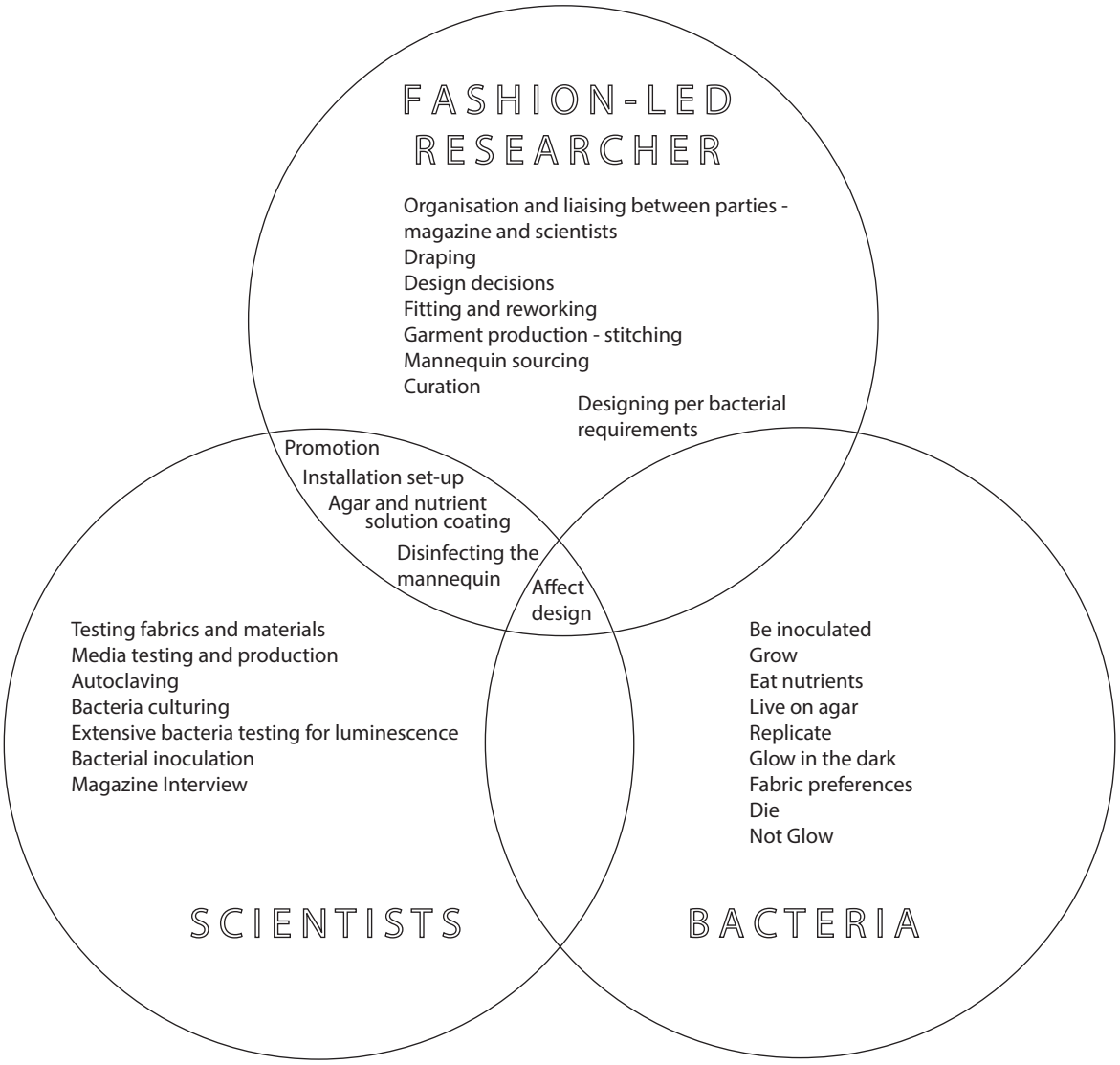
Lo Lamento



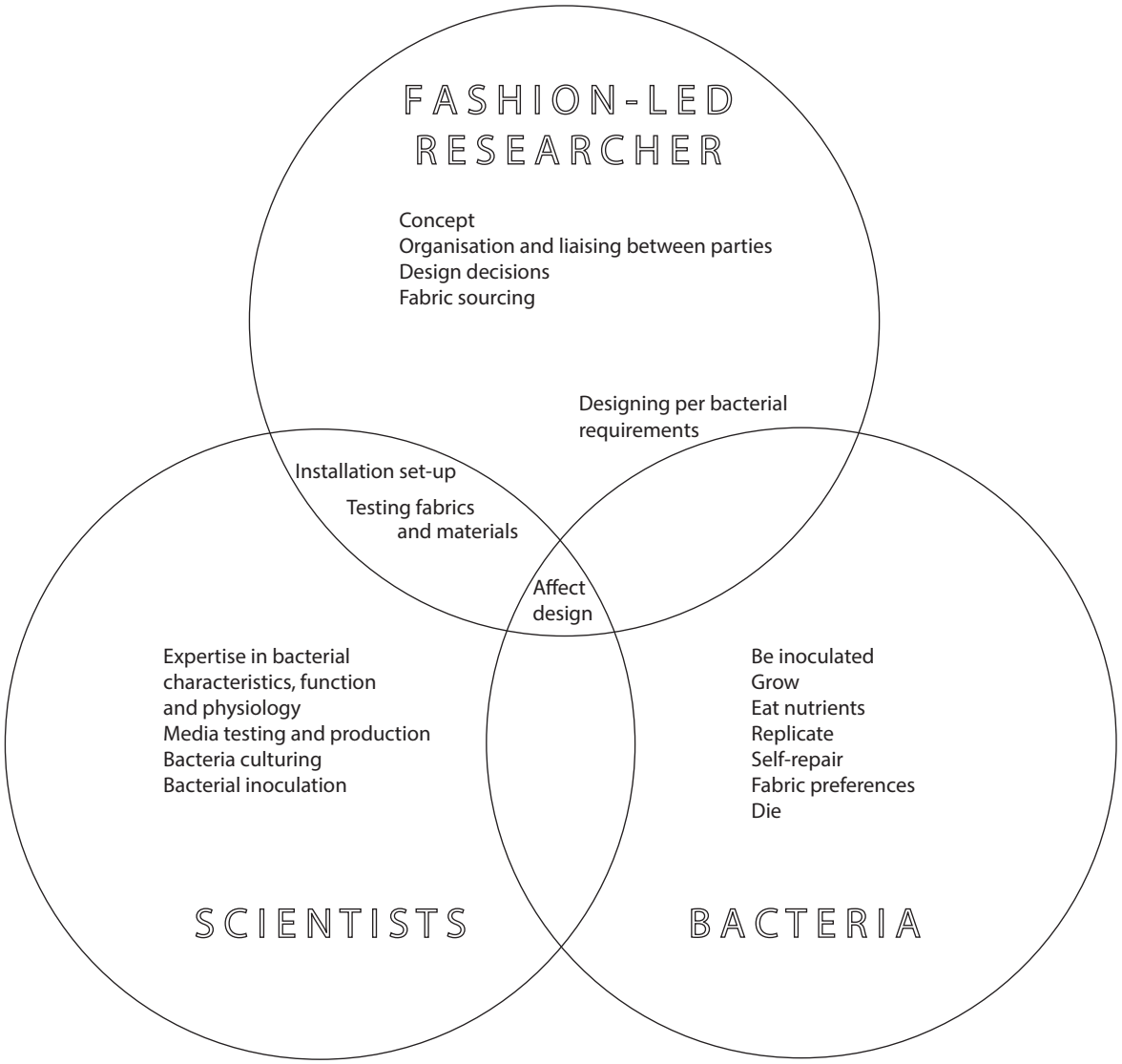
Azazel


FASHION-LED RESEARCHER
Concept
Shape research
Draping
Design decisions
Fitting and reworking
Garment production - stitching
Mannequin sourcing
Computer aided designs
Curation
Designing per bacterial requirements
Installation set-up
Agar and nutrient solution coating
Disinfecting mannequin
Speaking to general public
Affect design
Testing fabrics and materials
Media testing and production
Autoclaving
Bacteria culturing
Raspberry Pi programming and projecting
Bacterial inoculation
SCIENTISTS
Be inoculated
Grow
Eat nutrients
Live on agar
Replicate
Glow in the dark
Fabric preferences
Die
Not Glow
BACTERIA

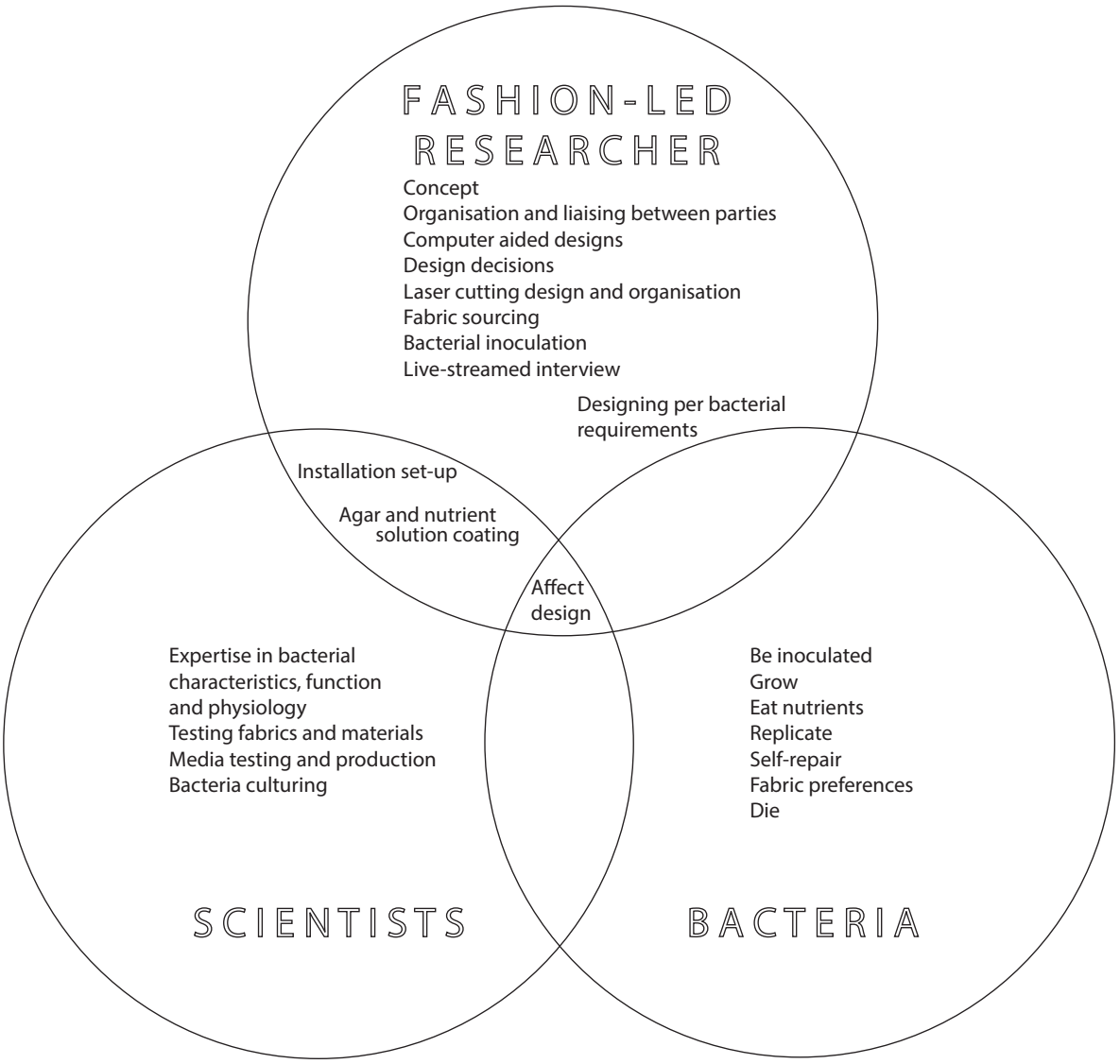
Living Light Dress



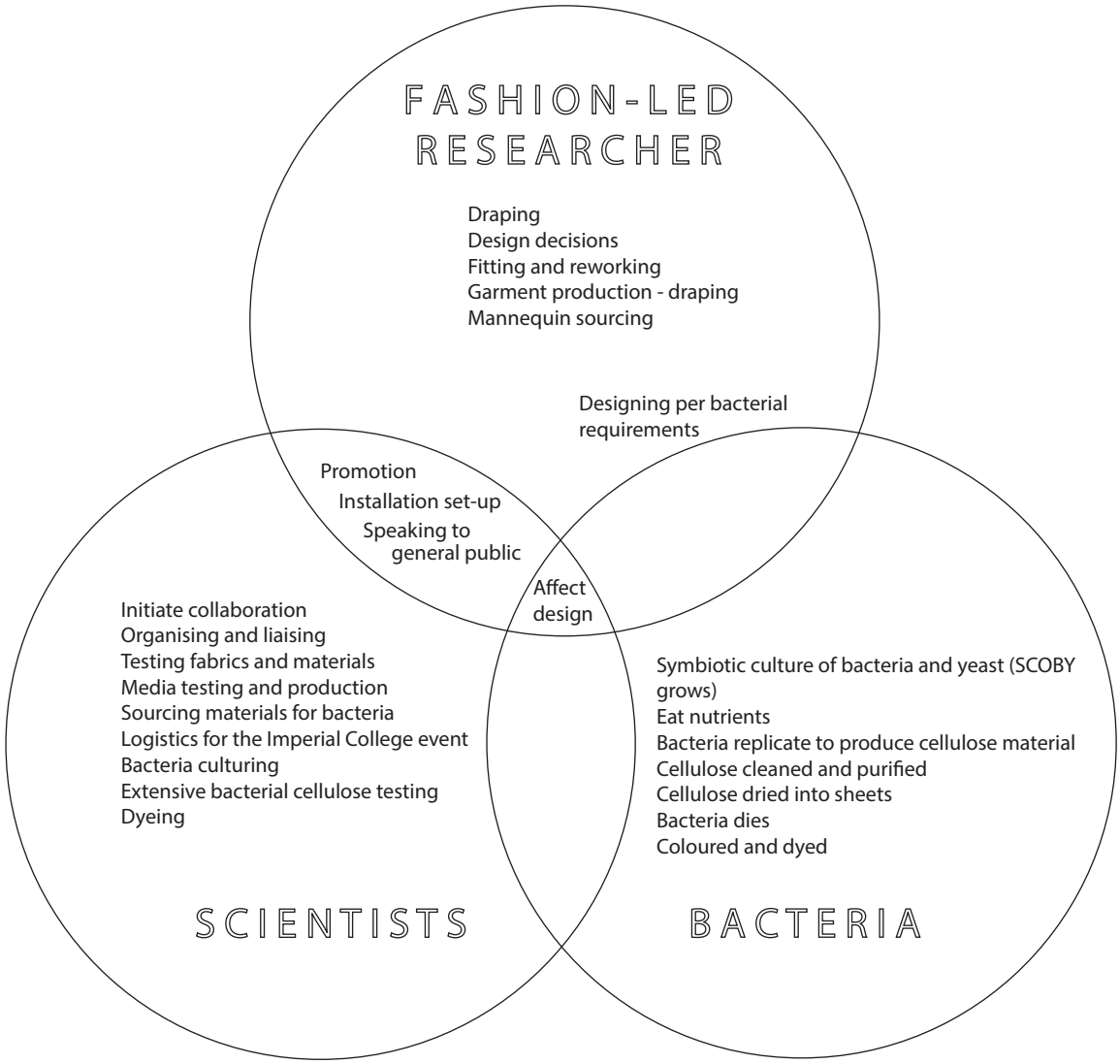
Living Lace


FASHION-LED RESEARCHER
Concept
Organisation and liaising between parties
Design decisions
Fabric sourcing
Designing per bacterial requirements
Installation set-up
Testing fabrics and materials
Affect design
Expertise in bacterial characteristics, function and physiology
Media testing and production
Bacteria culturing
Bacterial inoculation
Be inoculated
Grow
Eat nutrients
Replicate
Self-repair
Fabric preferences
Die
SCIENTISTS
BACTERIA

Oscillatoria Sutured



Aequorea


FASHION-LED RESEARCHER
Draping
Design decisions
Fitting and reworking
Garment production - draping
Mannequin sourcing
Designing per bacterial requirements
Promotion
Installation set-up
Speaking to general public
Affect design
Initiate collaboration
Organising and liaising
Testing fabrics and materials
Media testing and production
Sourcing materials for bacteria
Logistics for the Imperial College event
Bacteria culturing
Extensive bacterial cellulose testing
Dyeing
SCIENTISTS
Symbiotic culture of bacteria and yeast (SCOBY grows)
Eat nutrients
Bacteria replicate to produce cellulose material
Cellulose cleaned and purified
Cellulose dried into sheets
Bacteria dies
Coloured and dyed
BACTERIA