Material Kin:

A Maker's Guide

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Nahum McLean declare that this thesis, is submitted in fulfilment of the requirements for the award of Master of Design, in the Faculty of Design, Architecture and Building at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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The Indigenous peoples of this land are the traditional custodians of knowledge of the land on which we live, make and work, and it is their knowledge and respect for Country which I draw upon for this project. Whilst I merely allude to these ideas, caring for Country and forming kinship relations have long been expressed by the Gadigal People of the Eora Nation, and their elders past and present.

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Abstract

Using readily available ingredients and processes and a practice-based approach, *Material Kin* seeks to answer the question: how can sustainable materials be developed in preparation for a range of possible futures?

I started this project by researching a wide range of sources while experimenting by mixing different types of ingredients. These investigations in the studio led to unexpected discoveries forming relations and connections between the ingredients, processes and myself as a designer. Drawing on Donna Haraway's use of the term 'kinship', I have called the results 'material kin', which are linked by relationships rather than genealogy or hierarchy. Tony Fry's theory of sustainment and a quality economy have also informed this project by offering a post-natural position on sustainability. An outworking of post-natural sustainability is that hybridity is encouraged through the substitution of various ingredients and processes.

As I became more involved with the process of creating new materials for possible futures, my emphasis shifted from generating new materials and exploring their uses, to developing a process of making materials through kinship. The method of creating Material Kin is carefully articulated through the rubric of a game, whereas the specific Material Kin remain speculative, ambiguous and contingent of possible futures. In addition to articulating the process of creating the materials, I wanted to be able to share this knowledge easily with other DIY material makers both now and in the future, finding an aesthetic and design approach that were appropriate for DIY maker communities. *Material Kin: the guidebook and game* is the designed research artefact for this project.

1 Introduction

1.1 Research Question

Using readily available ingredients and processes, how can sustainable design materials be developed in preparation for a range of possible futures?

- How does the value of readily available ingredients change, as they combine together to create design materials?
- How does a relational ontology approach shift the role of the designer from the master, manipulator and author of materials, to a collaborator and curator of materials?
- How can this approach to material making be shared with other designers and makers?

1.2 Background and Scope

I am an interdisciplinary designer who works primarily with fabric and the body. When designing garments I respond to the particular qualities, handle and drape of the materials. My response to the material informs the direction of my design practice and this research project.

I began this project with the intention of creating 'garments' that are structures in their own right, and that relate to the human form, like architecture, but exist independently of the body when not worn. I started by investigating materials that physically respond to different stimuli and environments so that I could create a structure that sits between architecture and fashion in which the user is aware of the agency of the structure.

I experimented with temperature as a variable to cause this change to the material. I was specifically looking for a change in material properties around 36° C, the average temperature of a human. I tested and experimented with a range of ingredients[1] readily available to me as a designer working in Sydney. Table 1. outlines the ingredients used; they are grouped with other ingredients that are similar in composition or have similar properties. I mixed the ingredients and heated the mixtures until they combined. I then documented what happened once they returned to room temperature.

[1] This research project uses the term ingredient to indicate premade materials or resources that are then used to create a material.

Table 1. List of tested materials

Category	Ingredient	Source
Oil, wax	Palm oil	Asian grocery store
	Paraffin oil	Hardware store
	Soy Wax	Candle suppliers
	Crayons	Craft store
	Stearic Acid	Candle suppliers
Starches	Corn flour	Supermarket
	Cassava flour	Asian grocery store
	Tapioca starch	Asian grocery store
Salts and minerals	Glauber's salt	Laundry suppliers
	Borax	Hardware store
	Gypsum	Hardware store
	Cornice cement	Hardware store
Polymers (Thermoplastics)	Polycaprolactone (PCL)	Craft store
	Low melt glue gun stick	Craft store
Proteins and enzymes	Gelatine	Supermarket
	Agar	Asian grocery store
	Transglutaminase (Meat glue)	Specialty food suppliers
	Tinned chickpea liquid	Supermarket
Plasticisers	Glycerine	Supermarket
	Bycol (concrete plasticiser)	Hardware store
Emulsifiers, Gums and Resins	Xanthan gum	Health food store
	Locus bean gum	Health food store
	Guar gum	Health food store
	Mastic (Arabic gum)	Mixed business store
Mixers	Tap water	Sydney Water
	Vinegar (Acetic acid - 5% strength)	Supermarket

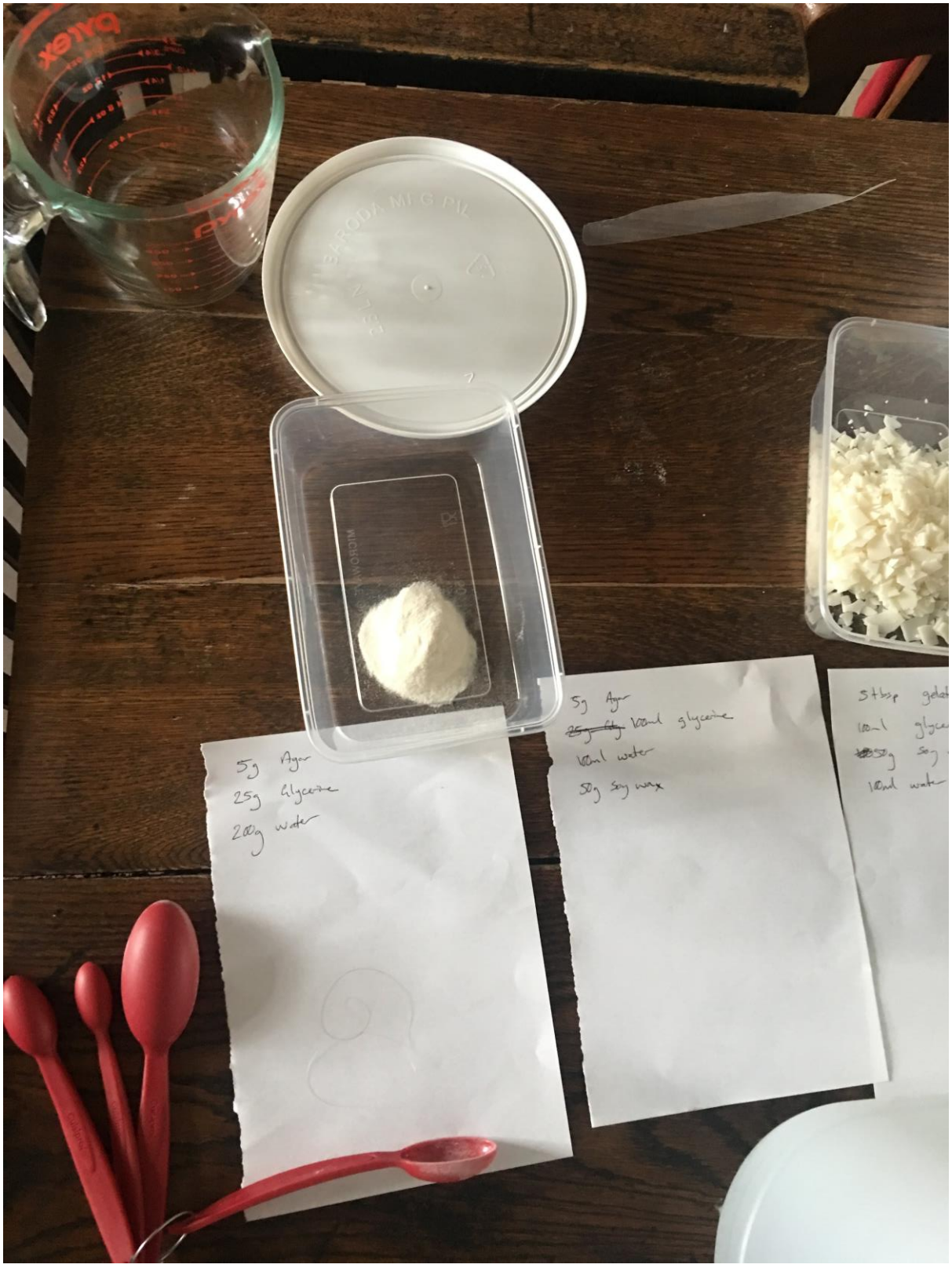

Figure 1: Agar and Gelatine experiments

Figure 2: Stearic acid combined with Palm oil.

Figure 3: Aerated chickpea liquid with meat glue.

Through my experiments and testing, I found that gelatine, a protein used in cooking, was the ingredient with the greatest potential for the experiments I wanted to conduct, as it transitions between a solid and liquid at 36° C. Further experiments with gelatine led me to focus on investigations to combine proteins with other ingredients to develop structures.[2]

By limiting the scope of the research project to readily available ingredients and processing techniques, I focused on food-based proteins and their potential to combine with other materials. Food-based ingredients are both readily available and generally combine easily with other ingredients using basic equipment found in the home kitchen.

Some of the ingredients I was working with are used in lab environments, with specialised machinery to produce both plastics and bioplastics. However I did not have access to these resources, and the technical skills required are beyond those I have as a designer.

When I considered the value of the materials I created, I found that there were more durable and better performing synthetic materials available for many design applications. For example, creating a shoe sole is a potential use for one of the materials I have created called Collagenated Plaster. However, its durability and performance would be less than a regular sole that is already commercially available. So I began to consider how the creation of these materials could be of value

[2] **Proteins:** Proteins are an essential and necessary part of living bodies and life. Proteins are made from combinations from 20 different types of amino acids. The amino acids join together to form a chain. These chains of proteins then join together, either as a twisted helix structure (α proteins), or in layers and sheets (β proteins). The bonds between the protein chains are weaker in the α structure than the β structure. Some examples of α proteins are elastin, collagen and gluten. Examples of proteins made from β structures include, hair, nails, beaks, feathers and scales. This research will focus on α protein structures, as these proteins can be altered without breaking the proteins down into their original amino acid state. Proteins can be partially denatured so that the original structure collapses and then can be reformed with other material in the mix. Fully denatured proteins become tough and lose their ability to hold water. The denaturing process is irreversible and can be caused by agents such as heat, acidity, salt, enzymes and agitation. It is this denaturing process that enables the mixing and addition of other materials and elements.

to designers as a provocation to consider more sustainable futures, where creating new synthetic materials is more restrictive than today.

1.3 Significance

My research and experimentation generated many possibilities for different materials. There are other designers and DIY material makers who start from a similar premise to this project, of using readily available ingredients and processes to make materials. However, most designers working in mainstream industries and DIY material markers continue to refine and develop their materials until they have utility in today's context, whereas I was interested to find materials inspired by the speculative worlds imagined by artists and fiction writers.

Paolo Bacigalupi's novel *The Windup Girl* (Bacigalupi 2009) and Margaret Atwood's MaddAddam trilogy that begins with *Oryx and Crake* (Atwood 2008) both depict environments which have scarce petrochemical resources, less fluid circulation of materials and labour, and food and materials that are locally sourced and cultivated. No longer able to rely on creating new synthetic materials and plastics, humans in these future worlds need to repurpose existing materials and work with grown and cultivated ingredients to create solutions to challenges such as containment and separation.

Atwood's second book in the MaddAddam trilogy, *The Year of the Flood* (Atwood 2009), introduces us to a group called 'God's Gardeners' who are self-sufficient, exist off the grid and are untraceable by authorities. The gardeners scavenge, salvage and repurpose discarded materials to survive.

> *"That day was Saint Farley of Wolves — a Young Bioneer scavenging day, when we had to tie sucky green bandanas around our necks and go out gleaning for the Gardeners' recycled-materials crafts. Sometimes we collected soap ends, carrying*

wicker baskets and making the rounds of the good hotels and restaurants because they threw out soap by the shovelful." (Atwood 2009, p. 68)

Bacigalupi builds detail into his description of a possible future in *The Windup Girl* by proposing different ways of valuing everyday materials. The novel describes future materials such as algae kinetic springs, palm oil polymer curtains, and corn resin which is used to lubricate wooden gears.

Theorist Donna Haraway's imagined future, which she calls the 'Chthulucene' shares similar environments to the futures speculated by Atwood and Bacigalupi. In Haraway's depiction of the Chthulucene, however she imagines assemblages made up from recompositions of biological, cultural, political, and technological entities. Haraway describes a relations-based system which she terms 'kinship'. Haraway proposes 'biotic and abiotic sym-poietic collaborations' to create kin that are not linked by genealogy or hierarchy, but rather linked through relationships (Haraway 2015, p. 161). Forming relations and connections between the ingredients, processes and myself as a designer - is what started to drive this research project.

As I became more involved with the process of creating new materials for possible futures, it became clear that using these materials to design structures was outside of the scope of this Masters project. My emphasis shifted from generating new materials and exploring their uses, to developing and articulating a process of making materials through kinship.

The decision to limit the scope of ingredients and processes allows for the replication and sharing of this method of generating materials with makers who have limited facilities in a vast range of different environments.

1.4 Approach

This project's research approach is practice-based. I have adopted a designerly knowledge production approach outlined by Wolfgang Jonas, where theory and practice occur simultaneously in a hypercyclic loop (Jonas 2007).

Working with Jonas's model, I used a mixed method approach to making. Drawing from academic research papers, YouTube tutorials, I conducted material experimentation, game design and mind mapping, then researched, tested, reflected, refined and then repeated the process. My process journal, as well as a collection of scrap paper used to document various ingredient tests, contains a body of specific material knowledge that I have generated. This knowledge was later collated and published in the guide and game. During this time of testing and knowledge production, I worked on the theoretical framework surrounding the materials and game design so that the designed objects (materials and the game) impacted the theory which in turn affected the direction of the designed objects.

I used mind maps in the initial stages of the project as a way to document ideas, and I found that it was helpful to see a clear overview of the possible terrain that could be explored. Using mind maps as a tool with an open ended approach is how the project started and took shape.

1.5 Project

In this project, I have worked with and responded to readily available ingredients to develop experimental materials. The experiments draw on knowledge and processes developed for the use of proteins as glues and resins, as well as for molecular gastronomy. In my experiments, proteins are combined with architectural building materials, enzymes, and other synthetic ingredients to create new materials that propose more sustainable ways of designing.

The guide and game together form a designed object that is intended to help the discovery and development of sustainable materials in preparation for a range of futures, as well as the present. We are currently living in the Anthropocene where humans have moved from being biological agents to geological agents (Chakrabarty 2009), and the natural and non-natural are no longer easily separated. Therefore the ingredients in the guide are both 'organic', 'natural' materials as well as synthetic materials. Hybrid materials challenge the binary between the natural and the non-natural, help us to think and create through a post-natural lens, and challenge designers to consider sustainable value systems for materials.

The guide and game promote experimentation with ingredients that people usually take for granted, with the aim to facilitate the transmission of knowledge generated through play. The game format allows the player to become more immersed in the game world and to start to value ingredients and materials in a context of speculative futures. The game adopts the form of trading cards thereby referencing non-monetised systems of exchange. The game is a starting point, and the maker's location and available ingredients alter the game's outcome.

Through mapping relationships between ingredients, processes and time, this guide illustrates 'Material Kin' using relational ontology. Material Kin is my term for the materials that have been created within the relational system; Material Kin share connections with ingredients and other Material Kin as well as the material maker. The combination and interaction of synthetic ingredients

with ingredients that are living–grown, ingested, cultured, and cared for–reclaim the synthetic materials' past that drew its utility from death and extinction millions of years ago. They are made 'living' again through their interactions with the living materials. These possibilities shift the roles of the designer from the master, manipulator and author of materials, to a collaborator and curator of materials.

The guide and game are intended for citizens rather than industries, amateurs rather than professionals, and people driven by curiosity rather than profit. They are for use in design studios or domestic kitchens rather than laboratories. The recipes are designed to be replicable and adaptable. The heuristic process contained in the guide can be modified, changed and tweaked for different material outcomes, depending on the ingredients at hand in the life of the maker.

In making this guide, I have removed the standardised metric or imperial measuring systems and converted the measurements to a volume-based relational system. Ratios negate the need for specialised or existing measuring equipment. Rather the maker can use a single readymade object such as a container or scoop found from their immediate environment. As such the recipes are not exemplars to be exactly reproduced, but examples created from my immediate environment, with my available resources in my context. These recipes serve as inspiration for adaptation rather than replication.

2 Literature Review

2.1 Sustainability

This chapter functions as a literature review to frame an experimental design practice by sustainability. Sustainability is a complex concept with impacts on a personal and societal level, and also has repercussions globally. There are many different competing ideas on how to achieve sustainability which increases the complexity of the subject. As sustainability encompasses such a large scope theoretically, practically, conceptually, and methodologically, it is challenging to review. I will consider the literature from a diverse range of theorists such as Bill McKibben and Stewart Brand, design theorist Tony Fry and science historian Donna Haraway. The Brundtland Report is also a useful reference point to provide structure for the comparison of different approaches to sustainability. I will consider ecology, economy and equity in a range of theoretical and practical approaches to sustainability.

This chapter is arranged in two broad parts. The first summarises six key pivot points in sustainability thinking, drawing out debates on the Anthropocene, differing ways to implement sustainability theories, the level of human and technological interventions in the environment, and alternative economies, which culminates with my position on sustainability for this research which I call 'post-natural'. This approach synthesises aspects from various key sustainability concepts. Embracing hybridity with the non-natural and technology through the creation of kin will be explored as well as expressing care and concern for other parties. Post-natural sustainability offers a way of doing, making and navigating that will be explored further in the project. The second part of the chapter applies these concepts to design by drawing on examples in fashion, architecture, performance, art and product design.

2.1.1 The Anthropocene and the Post-natural Age

While there is debate about the specific definition of the Anthropocene, it is a useful concept which captures the vulnerability of the relationship between humans and the planet that we live on. Whilst contested, a definition for the Anthropocene is the condition where humans have now become substantial geological agents affecting change in the ecosystem (McNeill 2001). There is disagreement about the catalyst for the beginning of the Anthropocene; was it the industrial revolution which began in the 18th century, or more recently from the great acceleration after WWII in 1945? Haraway is not concerned with the semantics of the term but instead focuses on the implication of the Anthropocene, and what we should do now to change and improve this situation that we are all in (Terranova 2016). Taking a similar approach and accepting the use of Anthropocene as a description of our current situation, I will address the implications of the Anthropocene on sustainability approaches.

The use of fossil fuels initiated the transition into the Anthropocene as they had a vast store of solar energy from life millions of years ago (Steffen et al. 2011). Fossil fuels such as coal and oil can be transported and then used later for the generation of heat. Significantly fossil fuels enabled the development of the steam engine (McNeill 2001). The invention of the steam engine and later the petrol engine increased efficiencies as the physical energy generated from the engines was far superior to the energy output of humans or animals. Today one barrel of oil (119L) has been calculated to be equivalent to 25 000 hours or 10 years of human labour (McKibben 2011, p. 27) – a huge increase in efficiency. The demand for and use of these fuels have brought about scientific and technological advances which in turn have created more efficient ways to extract minerals and resources from the earth. Humans are now very intimate with oil; intertwined with it politically, socially, and economically (Bellamy, LeMenager & Szeman 2016). Oil is a core driver in today's global society, enabling transportation, generating wealth as well as power creation and retention.

Oil is the primary substance used in the creation of plastics. Plastic is the material of a range of daily interactions with our clothes, eating utensils, phones and food packaging. It is in everything from what we wear, touch, lick, smell and ingest (Davis 2015). Plastic is a visible, physical material that embodies this entanglement between oil and humans, and this material is now responsible for damaging the environment on a global scale. Plastic as a sedimentary deposit has become a marker for this present time, and in the future plastic will likely become the geologists' modern fossil used to characterise and date layers of the earth (Zalasiewicz et al. 2016).

The collapsing boundary between the natural (fossil) and the non-natural (plastic) is also evidenced by recent studies that found microplastics in sea salt from countries around the world (Karami et al. 2017). Ironically lab-made salt is now more pure and 'natural' than organic sea salt, which is contaminated by manufactured plastics.

The classification of a new type of rock, plastiglomerate is another example of where the natural and unnatural boundary is blurred by the ubiquity of plastics in the world. This new rock classification has been added to the categories of sedimentary, metamorphic and igneous rocks. A plastiglomerate is a hybrid of sand, basalt, plastic and other debris, examples of which were first categorised at Kamilo beach in the Hawaiian islands (Corcoran, Moore & Jazvac 2014). The plastiglomerate heralds the current transition of nature into these new hybrid environments that are intimately human yet starkly hostile and alien (Heise 2011).

Photographic artist Chris Jordan captures another aspect of the relationship between natural and unnatural in his series, *Midway* (Jordan 2011). Jordan photographs the remains of baby albatrosses found on Midway Atoll, a territory of the United States. The baby albatrosses have died from plastic that was mistakenly fed to them by their parents who believed the plastic to be food. The Midway Islands are situated more than 3,200 kilometres away from any major landmass, highlighting the far-reaching, insidious effects of plastic pollution.

Figure 4: Plastiglomerate (Jazvac 2014)

Figure 5: Midway: Message from the Gyre (Jordan 2011)

Plastic, however, is only one embodiment of our entanglement with oil. Rob Nixon writes about a slow violence enacted against the planet, which cannot compete with the dramatic terrorism of 'falling bodies, burning towers, and exploding heads' (Nixon 2013). Instead the slow violence occurs gradually and out of sight enacted through climate change, land clearing, chemical and heavy industries.

Climate change is a marker of the Anthropocene, where pollutants that have been released into the atmosphere are altering the ways the earth functions. Scientists predict average temperature level rises of more than 2 degrees which will dramatically change ecosystems on the land and in the water (New et al. 2011).

These human infractions on the earth are encroaching more and more onto our current way of life and the life of future generations. As humans have moved from being solely biological agents, to also becoming geological agents (Chakrabarty 2009), the definition of the Anthropocene is both, a description of the events that led to this condition, as well as a description of the new relationship between nature and society (Arias-Maldonado 2013). Haraway disagrees that the Anthropocene describes a new type of relationship with the blending of natural and non-natural in our systems. Rather she sees the Anthropocene as a transition period before another major epoch (Haraway 2015) and we should be focusing our efforts on learning how to live in the next epoch. While existing plastics will be in our environment for centuries, the production of new plastic will decrease as fossil fuels become scarce. Our current trajectory points to a future that is closely aligned to the speculative futures depicted by Atwood and Bacigalupi. Our future will be shared with plastic and so we need to learn how to live with plastic and incorporate plastic in a relational way in the making of Material Kin.

2.1.2 The Brundtland Report

Sustainability as a concept has gained momentum in recent years as people become aware of how the environment is changing and in particular the impact current lifestyles have on the environment. The Brundtland Report written in 1987 formalised the principles of sustainability by drawing together three different concerns about life on earth and attempting to unify them. These concerns were the environment, social justice and wealth or growth. The idea of sustainability or sustainable development attempted to bring together these ideas to create a way of living that enables the flourishing of humans, the environment and human enterprise. The United Nations established the Brundtland Commission and released a paper titled, 'Our Common Future', which later came to be known as the Brundtland Report (Keeble 1988). This report defined sustainability as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Keeble 1988). The report's definition of sustainability unified countries through this goal of considered and restrained development and living. Nation states and organisations across the world have adopted the Brundtland definition including the University of Technology, Sydney (UTS 2015).

One model of sustainability developed by the Brundtland Report is the three pillars of sustainability. These pillars are also known as the three Es (Edwards 2005) or the triple bottom line. The pillars refer to the three categories that need to be satisfied for an entity or system to be considered sustainable:

1. Ecology, Environment, Place	Is there sharing and regeneration of resources in this system so that there is enough for future generations to flourish?
2. Economy, Employment, Profit	Is this system productive, can people have a livelihood and earn a living?
3. Equity, Equality, People	Does everyone in this system get treated equally and fairly?

While in principle and intent this definition unites people and governments across the world through common goals, scholars have identified a range of issues which show that the practice and application of the definition can be divisive, as the implementation of these principles can be difficult, varied and contentious (Trainer 1990). Fry and Arias-Maldonado have compelling reasons arguing that this pillar model of sustainability is flawed and needs significant altering. Fry calls for a change in the system and the intrinsic values that the system represents. Arias-Maldonado also believes that the sustainability framework needs to be updated to account for the Anthropocene, which is sidelined by the pillars.

For designers, the Brundtland report offers no practical application advice or ideas on how to implement these principles. As a result, some design positions can and do oppose each other under this framework of sustainability. Working within the three-pillared Brundtland sustainability model, two theories bookend the arguments about how to achieve sustainability: These are ecological sustainability and technological sustainability. They are at opposing ends of the scale and both present different ways to solve these problems and achieve sustainability.

2.1.3 Ecological Sustainability

Ecological sustainability evolved from the environmentalist movement of the 1960 and 70s. Aldo Leopold's book, *A Sand County Almanac* (Leopold 1949), and later Rachel Carson's *Silent Spring* (Carson 1962), were instrumental in the development of environmentalist awareness amongst the general public in the United States. Leopold and Carson argued for the rights of the environment and the protection of nature against humans. Leopold wrote about ethics of treating the land respectfully rather than like a commodity which, along with *Silent Spring,* helped change the way Americans understood nature and the natural environment.

Carson raised awareness of human interventions in the natural environment. She documented the dangers of chemicals that were discarded into waterways and caused harm to aquatic life. As a result of Carson's book and the awareness that it created, the US government changed its policy regarding insecticide use (Maguire & Hardy 2009). While the impact of *Silent Spring* in the Global North is undeniable, Fry argues that the environmental movement merely altered the violence enacted against nature from overt to benign (Fry 2003b). For example, the hunting of species to extinction has been replaced by biological and chemical interventions to control the environment, however both approaches have similar levels of damaging environmental impact.

Ecological sustainability advocates point to limiting development, resource use, and technology as measures to combat the violence against nature. This branch of sustainability is radical as it demands a large change or reversal of current practices in order to interrupt the existing trajectory. Bill McKibben's book, *Eaarth: Making a Life on a Tough New Planet* (McKibben 2011) outlines not only the problematic symptoms of climate change but offers a new kind of lifestyle as a potential solution. McKibben argues for 1950s scale farming where there are still economies of scale but goods are grown locally with more direct human interaction and exchange. The internet remains a vital part of life in the future and this future scenario must be prominent to ensure that communities do not become 'stifling' (McKibben 2011, p. 205). The permaculture movement in Australia of the 1970s offered a similar lifestyle to McKibben's proposal of smaller scale local farming (Crosby, Lorber-Kasunic & Accarigi 2014).

Returning to the three pillar approach to sustainability, the Brundtland report is described as a three-legged stool, as it is only functioning when the stool comprises legs of equal length and strength which comprise of: Environment, Economy and Equity. Not all theorists agree on this analogy, however as they award greater weight to certain legs or pillars. Environmentalists Neil Dawe and Kenneth Ryan argue that this analogy is flawed because the environment leg should take precedence over the other two because the existence of the economy and equity require a

functioning environment (Dawe & Ryan 2003). Ecological sustainability likewise elevates the rights of the environment above economic concerns as a key moral argument. Radical ecological sustainability not only prioritises the environment ahead of productivity (the economy) but also ahead of humans. The result of this ethical shift is significant and means that humans are no longer privileged over other living things and must recede from their position of power.

In addition to elevating the power of the non-human, environmental activist and ecofeminist Vandana Shiva advocates for minorities and oppressed people groups, arguing that we should listen to their voices and heed their knowledge. A condition of sustainability for Shiva is 'not violating the rights of other human beings or other species' (Shiva 2011, p. 23). Shiva argues that shrinking resources and inequitable distribution of resources is the main underlying cause of conflict in the world, rather than ethnic or religious causes. Equity of ecological space, equity of knowledge and equity of rights is the pathway to bring forth a sustainable future. Similarly, environmental academic David Orr encourages a sustainability that includes a re-learning of longevity from non-Western cultures without resorting to nostalgia for lifestyles of earlier cultures (Orr 2002, p. 11). For both Shiva and Orr the ability to build a sustainable future comes through listening and knowledge sharing.

Journalist Martin Lewis in his book *Green Delusions: An Environmentalist Critique of Radical Environmentalism* outlines four beliefs that he finds problematic with radical environmentalism: That indigenous people of the lands lived in harmony with nature; that we stop globalisation and instead form isolated autarkies and communities; that technological advance comes at the detriment of nature; and that we must overthrow the capitalist system which is inherently broken (Lewis 1994). Lewis agrees that the current trajectory of progress needs to change, but he disagrees with the ecological sustainability position. Instead he proposes 'promethium environmentalism', where we can protect nature if we remove ourselves from it and embrace synthetic materials and development so that nature can survive without human meddling (Lewis 1994). This argument

references 19th century conservation movements set up for the protection of nature and the establishment of National Parks in the United States. Lewis' environmentalism relies on the idea that nature and society can be separated, but the Anthropocene shows that this idea is becoming increasingly redundant. Lewis's argument for promethium environmentalism is similar to other positions found in technological sustainability as embracing technology and development to find solutions.

2.1.4 Technological Sustainability

Advocates for technological sustainability do not argue for separation of nature and society like Lewis, rather they look for technological solutions for sustainability. Stewart Brand is a technological sustainability advocate and is best known for the counterculture magazine *Whole Earth Catalogue*, which was published several times a year between 1968 and 1972, and then occasionally until 1998. In the late 60s and early 70s, Brand's work was aligned with Carson's and could be described as an ecological sustainability position. However, he has more recently argued for more technological solutions to environmental problems. In a revised position published in 2009, *Whole Earth Discipline: An Ecopragmatist Manifesto,* Brand argues that both governments and industries need to invest in technological development to combat climate change. Brand sees large cities as the way to achieve sustainability by attracting subsistence farmers and villagers to the city for increased opportunity and education. The flow of people to the city, he argues, will free up more land for efficient farming while decreasing birth rates because families in cities require fewer children for security than in rural settings. According to Brand, this decline in the birth rate will allow for the population to reach a sustainable equilibrium.

Brand proposes further technological solutions to the challenges mass urbanisation will bring. He proposes nuclear power as the solution to urban energy needs which, he argues, is environmentally on par with hydro and solar power. To feed the populations of cities, Brand proposes the genetic

engineering of crops to become more efficient. Finally Brand proposes technological interventions or geoengineering to repair the environments that have already been damaged. For example sulphur stacks, he claims, could be constructed to release sulphur dioxide into the atmosphere to slow down climate change. The sulphur dioxide pumped into the stratosphere would mimic the effect of a volcanic eruption and the released gas would cool the earth down by reflecting the sun's rays.

Another advocate of technological sustainability is atmospheric chemist Paul Crutzen who popularised the term Anthropocene. Crutzen like Brand believes in technological determinism, where further technological intervention into the earth's systems is needed to rectify earlier interventions. Crutzen argues that investments in geoengineering technologies need to be made as the cost of putting atmospheric particles in the sky, far outweighs the damage and cost of further climate change. Crutzen has a hopeful but technological dependent vision of the future, where he imagines limited use of the earth's resources as well as a reduction of human and animal populations. Crutzen justifies his position with an economic rationalist argument that weighs up the costs involved for implementing one kind of solution or another.

Critics of technological sustainability and technological determinism such as Fry argue that technological sustainability is a continuation of the current trajectory. Since the 1970s, industries have been developing 'green' products as a marketing and business strategy to capitalise on the growing awareness of sustainability and the environment's demise. The development of green products can be sceptically viewed as 'greenwashing' by company's marketing departments (Delmas & Burbano 2011). 'Eco-friendly' and 'organic' are examples of terms used in greenwashing campaigns where vague language is employed to describe a product with little information to back up its claims. However, Fry argues that both green and greenwashed products are still attached to economic growth as it operates in the current capitalist system. Technological sustainability also instils a techno functionalist way of viewing and managing the world, which ignores the biophysical systems (Fry 2003b). Fry is one of the strongest critics of both technological and ecological

sustainability in design theory arguing against the Brundtland definition of sustainability because 'what gets sustained is the unsustainable' (Fry 2003b, p. 44).

2.1.5 Quality Economy / Sustainment

While Fry argues that the Brundtland Report is still subordinate to the economic system and that there is no other common way to consider exchange apart from the money/commodity relationship of exchange, John Robinson Professor at the University of British Columbia believes the Brundtland Report is vague, attracts hypocrites, and fosters delusions (Robinson 2004), Robinson contends that the Brundtland Report is geared towards governments and companies that make collectivised institutionalised responses and efficiency gains rather than focussing on the individual accountability and spiritual values (Robinson 2004, p. 373).

Fry also argues that sustainability has become a stopgap or 'coping' measure produced to offset technological system malfunction. Fry envisages a new system, and proposes another type of economy rather than the quantity economy which he calls 'sustainment' (Fry 2003a).

For Fry, individual responsibility is obscured by the monetised exchange process where information, materials and knowledge are all bound up together. As such Fry proposes a quality economy where the quality of the product or service, as well as the enhancing or enriching values of the product, are more highly regarded than its monetary potential (Fry 2003a). Fry is not just proposing a limiting of economic growth but a redirection of growth. He calls for a reduction of consumption and the development of more efficient systems to eliminate excesses. For example, an efficient kitchen system could provide the energy required for cooking through a heat storage system powered by the heat output produced by a fridge. Fry advocates for an environment of care as a starting point for this new economy. By displacing some machines with hand tools (or better-developed hand tools) an environment of care can be fostered by introducing personal, handworked elements back into society. Fry believes that this redesigning of systems with a value for quality will remind people

about the expenditure of energy involved in creating products, which in turn will start to shift the economy from a quantity-based system to a quality-based system.

Related to the idea of sustainment are the concepts of 'substitutability' and 'irreversibility'. Substitutability, growth, limits and scale are all terms that are used as metrics to quantify sustainability (Goodland 1995). In particular, substitutability is a useful term that is used to help evaluate different positions on sustainability and inform design approaches. Substitutability considers how much of a particular natural process or natural resource can be substituted or replaced by another material or process. One outworking of this theory is that natural capital or resources are available for use as long as equal or greater amounts of substituted capital can replace them. The goal of substitution revolves around the efficiency and suitability of the substitution. Substitutability helps to evaluate what can be substituted rather than asking if a resource should be substituted (Arias-Maldonado 2016). Irreversibility brings more nuances to substitutability as it considers finite or critical natural resources that are not suitable for substitution, and the depletion of such resources will be irreversible.

Substitution approaches require careful quantitative auditing as well as a holistic view of the system which makes it a process often out of reach of regular citizens. Arias-Maldonado uses the substitution example of whale oil previously used for lighting in some societies and now substituted by electricity. This particular substitution might help preserve whale populations but without knowledge of the specific processes, the source generating the electricity supply, and the details about the infrastructure needed to deliver the electricity, it is hard to make a definitive value judgement about the overall merits of this particular substitution.

2.1.6 Post-Natural Sustainability

Implied in the Brundtland definition of sustainability is the existence of separate domains of 'nature' or the environment, and the human domains of the economy and equity. This separation comes

from Western civilisation and was developed through what Bruno Latour calls the 'modernist constitution'. By the creation of discrete categories such as 'humans' and 'nature', this categorisation ontologically separates humans from nature, disables nature's agency, and relegates the non-human world to a passive recipient of human interference (Anderson 2009). This separation becomes problematic, however, when considered in the context of the Anthropocene where the natural and non-natural have become intertwined. Arias-Maldonado identifies this issue and suggests that a post-natural interpretation of sustainability is needed which is neither ecological nor technological (Arias-Maldonado 2013).

Recognising the complex entanglement between technology and humans means a technology-free future is implausible. Fear of technology (technophobia) and the love of technology (technophilia) seem to define the current ecological and technological sustainability standpoints respectively (White & Wilbert 2006). Sociology academic Damian White and environmentalist Chris Wilbert in *Technonatural time–spaces* argue that the ecological sustainability and environmental movements are increasingly becoming redundant as participants in the movement realise the existence of a value gap between their ideals of the natural and their present environment, which is full of hybridity and technological interventions (2006). White and Wilbert believe that sustainability needs to be situated in a position between the binary terms of technophilia and technophobia and start to move away from the standpoint that 'nature' is the final arbiter in hybrid worlds (White, Rudy & Gareau 2015). By positioning herself in this space between technophilia and technophobia, Haraway challenges the boundaries between social, natural, material and human, and argues that these are not stable but rather produced through actions and interactions of active discursive, cultural, social, technological and ecological phenomena (White, Rudy & Gareau 2015). Similarly Latour argues that we should progress beyond the modernist standpoint which implicitly separates nature, science, society and politics, and struggles to engage meaningfully with hybridity (Latour 2012). The impact of such hybridity on sustainable design is exemplified in the following excerpt from architect Sim Van der Ryn and author Stuart Cowan:

> *We live in two interpenetrating worlds. The first is the living world, which has been forged in an evolutionary crucible over a period of four billion years. The second is the world of roads and cities, farms and artefacts that people have been designing for themselves over the last few millennia. The condition that threatens both worlds—unsustainability—results from a lack of integration between them* (Van der Ryn & Cowan 2010, p. 33).

The idea that there is a living world (environment) and a designed cultural world (humanity) is also articulated by Fry who states 'humanity is trapped within the unsustainable situation of its own making' (Fry 2016).

To progress beyond modernist binaries, Arias-Maldonado suggests 'cultivated capital' as a meaningful term for use in sustainability discourse as it refers to both natural and human capital. Cultivated capital denotes a natural resource that has been influenced by humans, such as livestock, and farm crops, thus beginning to break down the binary between natural and human.

In the book, *Staying with the Trouble: Making Kin in the Chthulucene* (Haraway 2016), Haraway proposes a radical shift to open up possibilities of interacting in this post-natural, sustainable environment. She begins by defining trouble, by tracing it back to the 13th century French root verb, 'to stir up', 'to make cloudy' or 'to disturb' (Haraway 2016, p. 1). Haraway envisages a future where we immerse ourselves in murky waters with unclear distinctions and unstable definitions. For Haraway, the staying requires active engagement in the present rather than looking to the future or remembering the past.

Haraway has long been intrigued with the space in between the boundaries of humans, technology, gender and animals. In her earlier work from 1992, *The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others (Haraway 1992)* she uses Greimas semiotic square to examine space between categories. In *Staying with the Trouble,* she has proposed one way to reimagine this space using the game Cat's Cradle. This game can help to map potential connections and both inter and intra-relations. String Figures (SF) is Haraway's terminology for the Cat's Cradle game. However

SF is also a sign for Science Fiction, Speculative Feminism, Science Fantasy, Speculative Fabulation and Science Fact. SF is a game, a process and a way of thinking, which encourages collaboration in exploring new multispecies combinations and permutations.

> *Playing games of string figures is about giving and receiving patterns, dropping threads and failing but sometimes finding something that works, something consequential and maybe even beautiful, that wasn't there before, of relaying connections that matter, of telling stories in hand upon hand, digit upon digit, attachment site upon attachment site, to craft conditions for finite flourishing on terra, on earth.* (Haraway 2016, p. 10)

However SF is more than storytelling, it becomes a material practice that creates space for, and imagines new modes of being (Rosner 2018). Haraway also speaks of a wild open-ended kinship which is based on string theory relations that is not separated into hierarchical categories. The expanded model of kinship troubles the current system and alters our relationships and responsibilities to one another and non-humans. This model compliments Fry's proposed economy of quality, care and concern, which places value on relationships and interactions over monetary concerns.

Haraway articulates her vision of a sustainable future after the age of the Anthropocene, which she calls the era of the Chthulucene. In Haraway's depiction of the Chthulucene, the population returns from its current levels to between 2 and 3 billion people. Society, she speculates, will mourn the irreversible losses of diversity and a large loss of human and non-human life, and there will be a need to create refuges for all. Recompositions of biological, cultural, political, and technological entities in assemblages are encouraged and these entities can include the human, non-human, or more than human. By staying with the trouble we will learn how to live well and die well. Haraway proposes to 'make kin, not babies' so communities are built and connections occur through the process of gathering kin rather than creating families or individuals (Haraway 2015, p. 161).

> *I think our job is to make the Anthropocene as short/thin as possible and to cultivate with each other in every way imaginable epochs to come that can replenish refuge* (Haraway 2015, p. 160).

Knowing the history and development of sustainability as a concept is important for understanding the role of design for the future. This understanding helps to articulate a post-natural sustainability position that does not differentiate between the natural and the unnatural. Whilst there may not always be a great difference in some of the outworking between post-natural sustainability and the various positions on sustainability, the premise of post-natural sustainability changes the way we consider nature. Both Haraway and Fry challenge conventional ideas of sustainability and propose a different way of relating, that demonstrates care and concern which alters values and the way we interact in society. The maker's guide and game are designed as a process for the making of Material Kin in the context of the Chthulucene, as well as the present.

A post-natural approach to sustainability has influenced my making of the guide and game, and the work is made with these key design principles:

1. We can no longer use the justification of the 'natural' to validate our decision-making; rather we must operate with care and concern towards others, which will result in a quality economy rather than a quantity economy.
2. Substitutions have already occurred, will continue to happen and should be encouraged. In addition, creating multi-faceted substitutions should be the aim of designers.
3. The ownership of knowledge and substitution rights should lie with the community or people, not corporations.

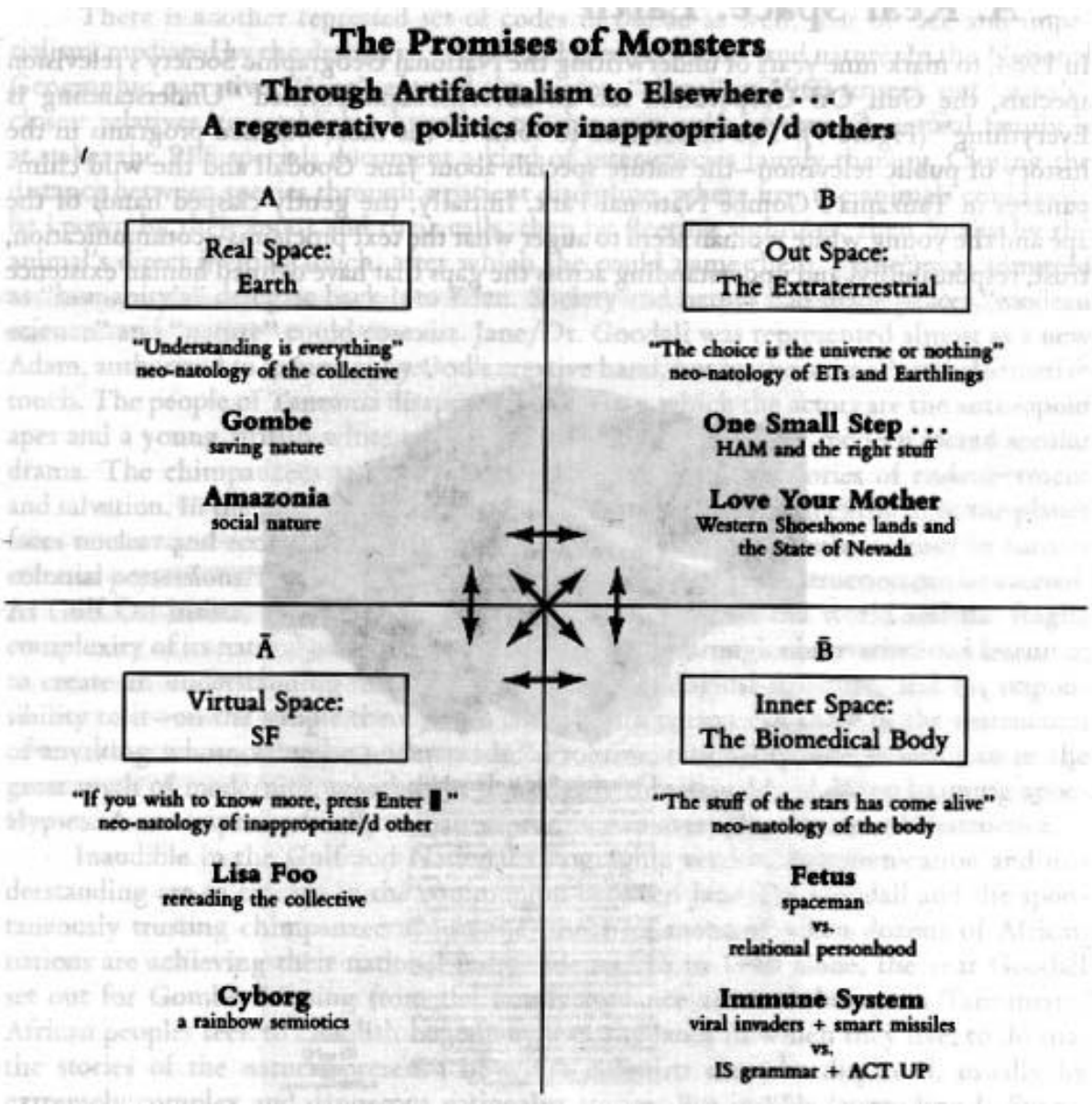

Figure 6: Haraway's semiotic square, The Promise of Monsters (Haraway 1992).

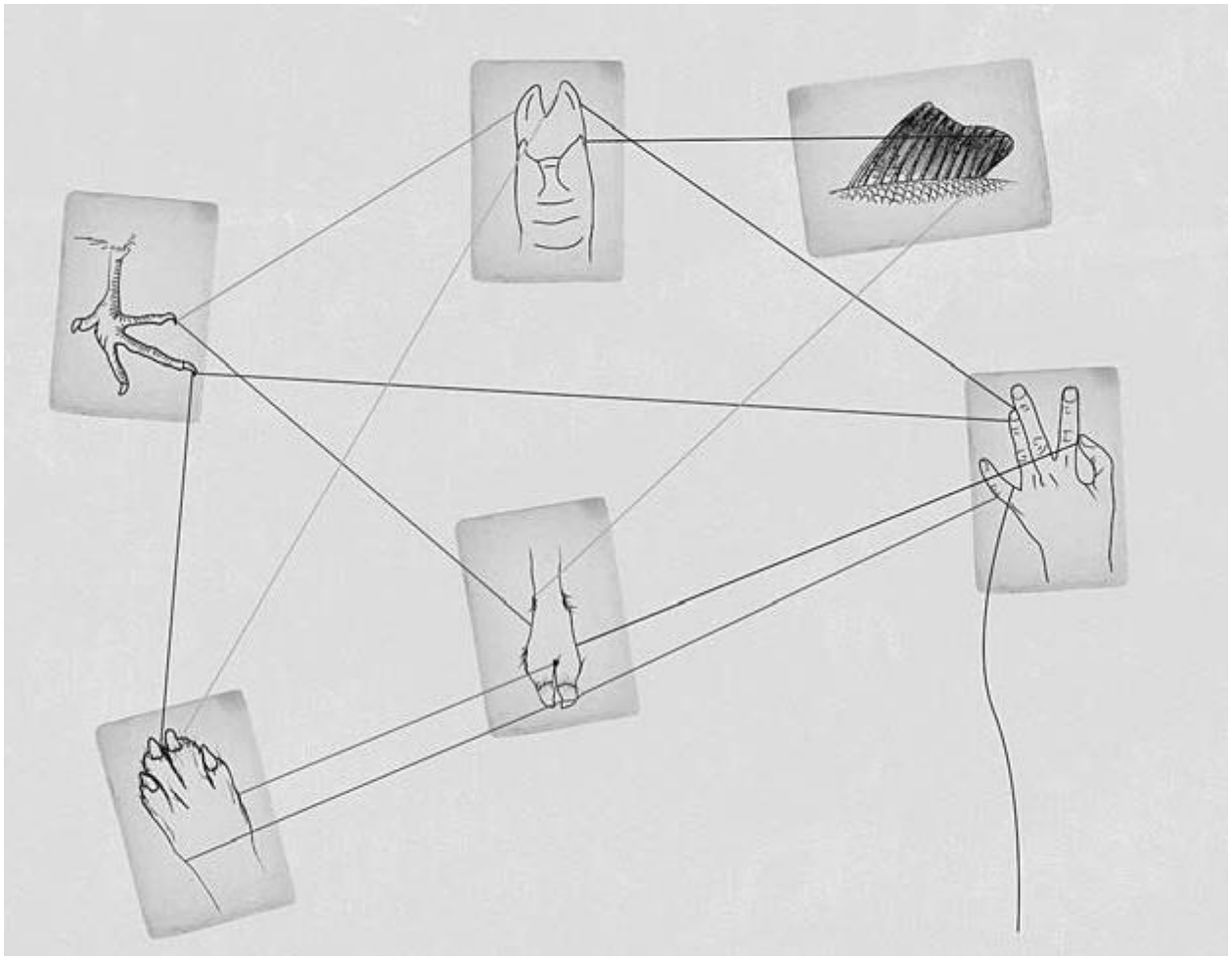

Figure 7: Multispecies Cat's Cradle. Drawing by Nasser Mufti, 2011. (Haraway 2016)

2.2 Applying Sustainability to Design

Having gained a broad understanding of sustainability through the literature review and drawing from the post-natural approach to sustainability of Haraway and Fry, in this chapter I bring together theory and practice to develop my own design approach. I begin by looking at precedents in design to analyse some of the different types of possible relationships between nature and design, and the ways that the idea of nature influences design approaches to materials. I have formed three broad categories of how designers interact with the idea of nature: biological collaboration; biophilia, biomimicry, and biometrics; and thirdly hybridised nature. Biological collaboration is a collaboration between the natural world and humans, where the outcomes are favourable for both. Biophilia, biomimicry and biometrics use nature as inspiration for design. The final section explores hybridised nature which fits most closely with the theoretical framework of this project, such as biofacts which are a combination of the natural and the artificial, where synthetic interventions occur in natural processes.

2.2.1 Biological Collaboration

In his book, *Nature of Design: Ecology, Culture, and Human Intervention* (Orr 2002), David Orr argues that the goal is not mastery over nature but rather the promotion of harmony between nature and humans and the principle of collaboration with nature. This approach seeks to position nature and humans together in a more symbiotic relationship where there are positive outworkings for both parties. This collaborative concept is particularly strong in Indigenous cultures which promote respect and understanding between humans and their environment. For example in Australia, Aboriginal people use the concept of Country to describe the relationship they hold to the land:

> *Perhaps the most significant difference was the attitude to land ownership and resource use. Instead of privately operated small holdings, clans were co-operating to prepare large areas of land for production with burning and tilling methods. There was an underlying conservatism in this approach, a concern for people they might never meet, and a respect for the prey species embedded in the spiritual and cultural fibres.* (Pascoe 2013, p. 145)

Eric Rolls also describes the management of the land and careful husbandry of the soil conducted by Indigenous Australians, before the lands were significantly altered by colonialization with the introduction of sheep (Rolls 1984). The example of Country shows how biological collaboration can drive and shape a mode of living.

The process of collaborating with nature has born many contemporary design projects, including Danielle Trofe's MushLume lighting. Trofe works with mushroom spores along with other matter that is cultivated inside a shaped mould. Once the spores have taken hold and their roots have fused and matted together with the other materials, the mould is then heat sterilised, making the mushrooms inert and stopping any further growth. The shaped material can then be used for a variety of uses, in place of other synthetic materials.

Gavin Munro from the design group Full Grown Design pioneers another kind of collaboration with nature. Munro grows and grafts trees into structures such as lightshades, seats and tables. He collaborates with the growing process of trees, creating forms that are finished once the tree is harvested. Subject to nature's growing cycles, the process takes up to eight years for the creation of the object.

Figure 8: MushLume light (Trofe 2016)

Figure 9: Process image from Full Grown (Munro 2018).

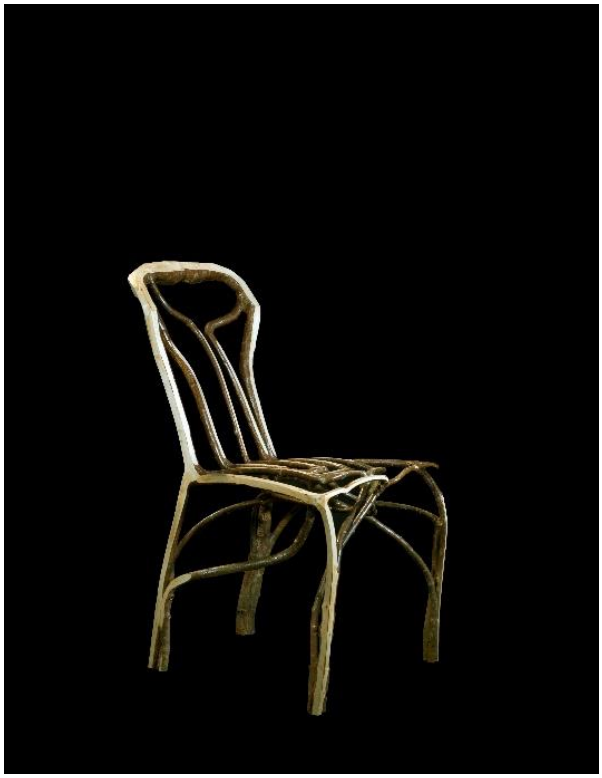

Figure 10: Completed chair, by Full Grown (Munro 2018).

2.2.2 Biophilia, Biomimicry and Biomimetrics

Biophilic design, biomimicry and biomimetrics, are terms that can be grouped together as approaches in which nature inspires culture. Biologist E.O. Wilson coined the term biophilia; defining it as 'the urge to affiliate with other forms of life' (Wilson 2009, p. 85). Environmental features, natural shapes and form, natural processes all are elements in biophilic design (Kellert 2008). Biophilic design theories have helped introduce curated nature into urban spaces. Green walls, as well as the use of natural materials such as timber, rock and wool, are examples of biophilic design principles which promote a reconnection with nature (see Figures 11 and 12). Social ecologist Stephen Kellert argues that a result of this reformed relationship with nature is the increase of human happiness, satisfaction and productivity, with the citation of various scientific studies to support this claim (Kellert 2008).

Biophilia seeks to bring natural elements into human environments to lessen the gap between the natural world and the human. Biomimicry and biomimetics, on the other hand, use nature as a blueprint and seek to remodel elements of the human world into elements based on the natural world. Biomimicry is the use of nature for inspiration and the appropriation of elements found in nature such as forms, textures or colours into a new design context (Benyus 1997). Fashion designer Issey Miyake for his Spring/Summer 2009 collection *'Color Hunting',* sent senior designer Dai Fujiwara and the design team to the Amazon jungle in Peru to source and 'hunt' colours and tones from the environment. These colours subsequently became the colour palette for his collection. Fujiwara continued to develop this method of hunting colours for other collections and held an exhibition about biomimicry at 21_21 Design Sight museum in Tokyo in 2013.

Another example of biomimicry can be seen in Antoni Gaudi's building *La Sagrada Familia* in Barcelona. Going beyond the idea of organic architecture, Gaudi considers nature to be the other half of architecture itself (Illas 2014). Instead of creating traditional cylindrical internal columns,

Gaudi designed columns that emulated tree trunks and limbs, creating the perception of the roof to feel like a rainforest canopy (ArchDaily 2013).

Biomimetics is a scientific and technical subset of biomimicry, also known by its alternative name 'deep biomimicry'. While biomimicry deals with recreating the appearance or feeling of nature, biomimetics is a more technical investigation into the processes of nature. It considers the mechanisms of flora and fauna, which aide survival in their habitat. Today scientists have the technology to study the molecular and nanostructures of flora and fauna, which in turn allows for molecular and nano interventions that are more integrated and responsive, and can mimic natural processes more closely. Robert Cohen, a scientist in the biomimetic field, has been examining the nanostructure of an Australian lizard's skin to understand how it can capture and collect moisture from an arid environment. Cohen is also studying the foot pads of geckos to understand how they can climb up tall glass structures. Cohen only considers a project a success if the outcome can be a useful tool for people. He aims to 'actually transform these [natural] structures into an embodiment with true utility in the real world' (Mueller 2008, p. 81). For a designer, biomimicry and biomimetics provide both inspiration and utility in the design process.

Figure 11: Biophilia - Central Park, Sydney, Australia (Hawkins 2018).

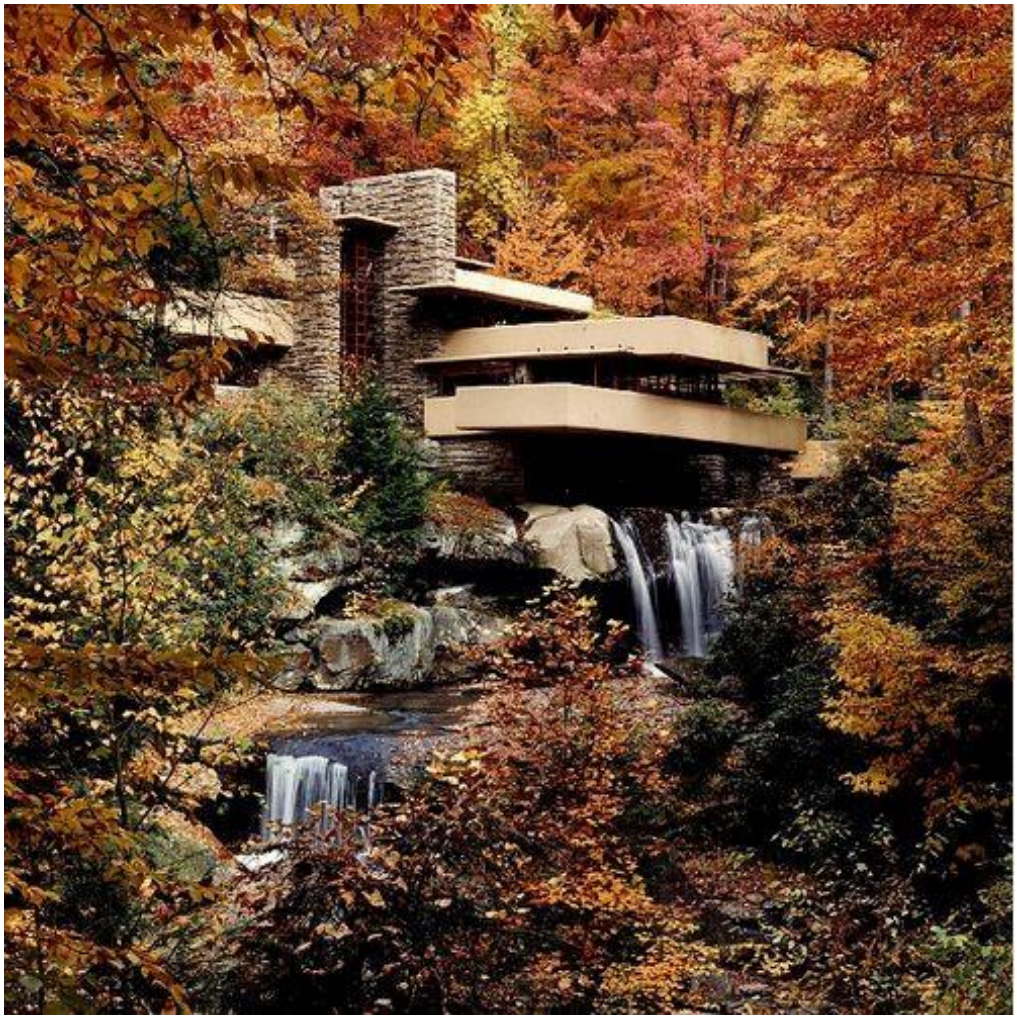

Figure 12: Biophilia - Fallingwater house by Frank Lloyd Wright, Pennsylvania USA. (ArchDaily 2010)

Figure 13: Biomimicry - Color Hunting Exhibition Poster (Fujiwara 2018).

Figure 14: Biomimicry - La Sagrada Familia by Antoni Gaudi, Barcelona, Spain (ArchDaily 2013).

2.2.3 Hybridising Nature

Hybridising nature is combining the synthetic, the technological and the natural. Hybridising nature can operate through the modes of biological collaboration and biomimicry, but it is hybridised nature that collaborates, mimics or is mimicked. Nicole Karafylis proposes a term 'biofacts', which are objects and processes that look natural but have been engineered or designed by humans (Karafyllis 2007). The name biofacts comes from the words artefacts (artificial) and bios (life). Biofacts, bioart and biomediality are areas of research that are reimagining the traditional fields of science, art, and technology through the introduction of biology and biological processes in these fields. Bioart and biomediality is a blending of art and science, where, as explained by Jens Hauser, 'biological components and processes are arranged and optimised to be employed for purposes beyond their organic end-in-itself' (Hauser 2016, p. 203).

SymbioticA is an experimental artistic research lab in Western Australia, with the aim of promoting and developing DIY biology and biohacking. It offers residencies for artists and scientists to use more specialised equipment and access knowledge from biologists and other professionals outside their disciplines. Stelarc is a well-known Australian artist that works in the biohacking space. In the work *Ear on Arm, (2015)* Stelarc grows an ear by surgically inserting an ear shaped implant into his arm. Stelarc is planning now to add a microphone into this ear that is always connected to the internet. This example shows one of many possibilities for hybridisation when the human body is taken as a site for biohacking.

Pinar Yoldas is also an artist exploring hybridity and post-natural sustainable solutions. Her exhibition titled, *Ecosystem of Excess*, in 2014 asked the question 'If life started today in our plastic debris-filled oceans, what kinds of life forms would emerge out of this contemporary primordial ooze?' (Yoldas 2014). Yoldas imagines hybrid extremophile lifeforms which are created from the toxic plastic primordial soup that is the great pacific garbage patch. These lifeforms have evolved to break down different plastics, changed their eggs so that they are concealed amongst the various

plastic, or in the case of the plastic balloon turtle, integrate the plastic into their elastomer back to create extra buoyancy. Yoldas, playing with the notions of life and nonlife, explores how plastic can animate lifeforms and how hybrid creatures can be born amidst the toxic waste.

Hybridising nature is not necessarily mutually exclusive to biological collaboration, biophilia or biomimicry, rather it signals a willingness to form connections with other things and materials different or foreign to them. The processes of collaborating, mimicking and hybridising nature provide a platform for research into design practices and different modes of operating. Hybridisation is a key focus of my studio process, where combinations and mixes between different types of ingredients are promoted. Collaboration between living processes and myself happens as I work with ingredients that are organisms.

In the next chapter I bring together the literature on sustainability and the framework of kinship by outlining my studio practice. Sustainability and kinship are grounded in a DIY approach to the making, generating and sharing of these materials.

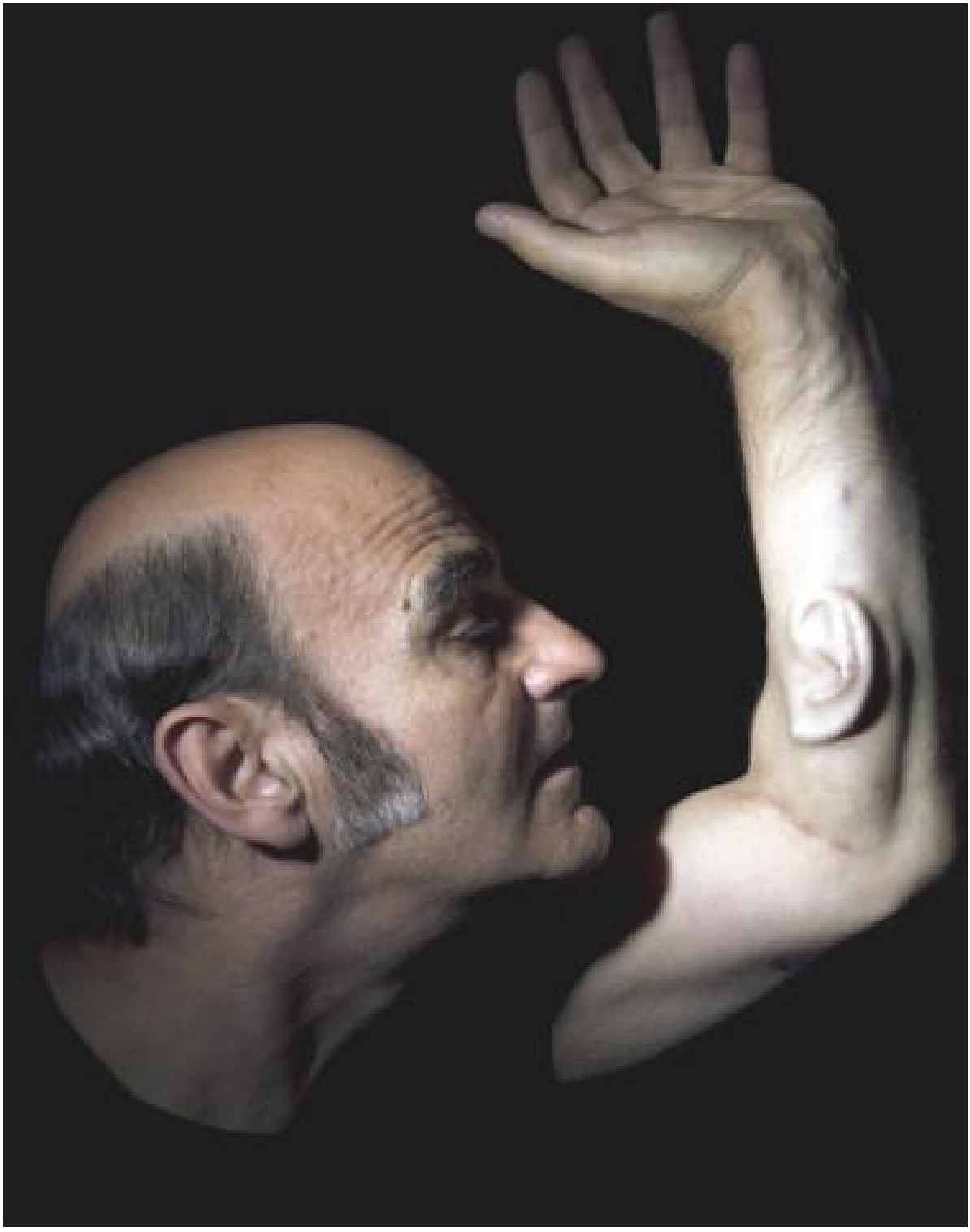

Figure 15: Third Ear by Stelarc (2015).

Figure 16: Plastic Balloon Turtle: Ecosystem of Excess (Yoldas 2014)

3 Studio Practice

3.1 Overview

My studio practice has two objectives. Firstly I engage with unusual ingredients, which led to the creation of Material Kin. Secondly I used the Post Natural design principles (see 2.1.6) to engage with categorisations of matter in order to recover spaces of knowing.

My practice comprises of three stages:

- Material experimentation, creating Material Kin.
- Synthesising, documenting the Material Kin.
- Interaction design, sharing knowledge through 'game like' experimentation.

Stage 1 Material Experimentation

This stage outlines the process of my material experiments and culminates in the development of the C*ollagenated Plaster* and *Biobubble lace* Material Kin recipes. The potential of multiple new materials created from varying combinations of the ingredients quickly became apparent. As a result, I decided to draw the ingredients, processes and relationships between these on a map (Figure 27). My focus shifted from creating one or two singular materials to proposing a method of making Material Kin.

Stage 2 Developing Material Kin.

This stage builds on the preliminary relational map that I developed at the end of Stage 1. As it was quite cryptic and hard to comprehend, I reconfigured the map by categorising materials and processes. These new categorisations helped build the ideas of care, kinship and substitutions.

Stage 3 Designing a Game.

The Material Kin making process was then developed as a proposition for a game. By turning this process into the format of a game, it is hoped that the player will have increased engagement with

the process. The game format allows for the imagining of an environment where this type of making is valued. In this section, I outline the process of developing a game. An overview to the game is attached as an appendix.

3.2 Stage 1: Material Experiments

3.2.1 DIY as an Approach to Making

Do It Yourself (DIY) is the approach of making do with the materials and tools at hand, to rebuild, fix and create objects (Crosby & Seale 2018). This approach of creating with what is readily available fits within the framework of designing materials for different futures. DIY living is exemplified by the group 'God's Gardeners' in Atwood's novel (2009) where materials are created by hand from discarded materials. The DIY approach offers autonomy and empowerment for the individual to create and make outside the bounds of capitalist exchange (Holtzman, Hughes & Van Meter 2007). DIY knowledge and skills are generally freely shared with like-minded people. The *inflatocookbook* produced in 1970 by the collective Ant Farm is an example of freely shared knowledge about how to create DIY inflatables (Farm et al. 1970).

DIY is also adopted by some designers and makers as an approach to materials, whereby designers employ simple processes that use readily available ingredients to create utility. Jenny Lee (2014) provides a thorough overview and selection of DIY material makers who have been creating DIY, hybrid and recycled materials. Catarina Mota and Kirsty Boyle created a website, where different DIY materials are grouped and presented www.openmaterials.org (Mota & Boyle 2018). There are links for additional information, and contact details for the developer of the materials. Many materials are interactive and look into how materials can integrate with technology or transmit information in a novel way.

Whilst looking through these material makers I had trouble identifying other designers aligned to my position on sustainability as informed by Haraway's notion of kinship. Most designers were either making materials in an ecological or technological sustainability framework, whereas I was interested in finding a material inspired by the speculative worlds imagined by artists and fiction writers (See 2.2.3 and 1.3).

I also analysed the categorisations of DIY materials by different designers. Jenny Lee groups materials into one of five types depending on the complexity of the material development (Lee 2014), whilst Mota and Boyle group by material type: paper, textiles, polymers, metals, conductive materials, organic materials, ceramics or glass. Alternatively, materials can be linked by the process used to generate them. Others simply divide DIY materials into two broad groups: those consisting of unconventional ingredients, or materials created by unconventional processes (Rognoli et al. 2015).

The use of unconventional ingredients is common, with makers using ingredients such as coffee grounds, shells, fungus spores, yeast and different biological cultures. Typically these materials are utilised in a specific location where the ingredients can be found as discarded waste. Materials made from unconventional ingredients usually employ biological collaboration where the process and the material fit within a traditional ecological sustainability perspective. An example of this type of material is fish scale plastic (Institute of Making 2012). Eric de Laurens sought to reuse and repurpose fish scales that normally end up in the waste stream from the fishing industry. The creation of the Fish scale plastic used traditional processes of plastic production but applied to an unusual ingredient.

Designer Laurence Humier has also developed an unusual process of making by employing cooking processes to develop potential new materials (Humier 2012). Humier, with the help of a scientist, starts by analysing the molecular properties of a non-food ingredient. She then matches this ingredient to a molecularly similar cooking ingredient and applies the processes used on the cooking ingredient to the non-food ingredient. For example, through the analysis of the molecular properties of sugar and boric acid, Humier discovered that they have a similar structure and applied the process of toffee making to the boric acid (open Materials 2018). The materials that Humier subsequently produced do not yet have a defined role or purpose, with the reader left to contemplate potential uses for these materials.

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Figure 17: Fish Scale Plastic (Institute of Making 2012)

3.2.2 Definitions

As a designer taking a DIY approach to making, It was important to familiarise myself with the common terms that are used in material science to describe material properties in order to understand material science literature and to know the correct term to use when asking for advice about a specific test or experiment. Through learning basic terms and processes I began to interact in an interdisciplinary way with the existing knowledge associated with chemistry, material science and molecular gastronomy. These terms differ from the terms used to describe design processes. For example in fashion design the term material can be used interchangeably with fabric. Whereas the material properties used in chemistry are much more specific than what is generally needed in design disciplines. My working definitions have been synthesised from a range of sources, such as YouTube, scientific journals and online science glossaries and dictionaries (Visionlearning 2018).

Working Definitions:

Ingredient	A premade material.
Material	A combination of ingredients. A material, once it is made, can then become an ingredient with which to make other materials.
Polymer	A long chain of different molecules joined together. Plastics are a subset of polymers, but polymers are not exclusively plastics.
Thermoplastic	A plastic that can be repeatedly melted down and recast.
Thermoset plastic	A plastic that cannot be melted down and remoulded. It has to be broken down and reconstituted to be able to reuse it.
Glass transition temperature	The temperature that is required to change a polymer from a hard, brittle state to a more viscous or rubbery state.
Melt temperature	The temperature required to change the state from a solid to liquid.

Plasticiser	An ingredient that reduces the glass transition temperature and allows a larger temperature window for the duration of the viscous rubbery state. Plasticisers can be added to plastics, concretes and plasters. The addition of a high a ratio of a plasticiser to the original material can also affect the structural integrity of the material.
Miscibility	The property of a material to mix with other substances to form a homogenous mixture.
Emulsion	The mixture of two ingredients that do not normally combine. Salad dressing made from vinegar and oil, and milk comprising of water and fat, are examples of emulsions.

The plasticisers that I started to experiment with were glycerine, bycol and paraffin oil. Glycerine is a sweet tasting liquid that is commonly used in confectionary, electronic cigarettes and antifreeze radiator liquids. Glycerine is also used to stop fondant cake icing from drying out and keeps it malleable. Commercially produced ice cream also usually contains glycerine which helps the material from forming ice crystals. Glycerine is extracted from vegetable and animal fats. It acts as a scaffolding component to link all the other types of the fats together. This property means it has been frequently used in soaps and hand creams as glycerine combines with other ingredients well.

Various plasticisers can be combined with concrete to improve workability and flow of the material. Bycol is one product developed by industrial chemists to achieve a consistent composition of concrete. Through working with it and testing it, I discovered that bycol is also a foaming agent which helps to aerate mixtures. I was unable to determine the exact ingredients formulating bycol as the ingredients are listed simply as 94% water and 6% ‘ingredients at non-hazardous concentrations’

(Recochem 2018). A home DIY hack for an ingredient to use instead of bycol is dishwashing liquid or washing powder.

Milk is another ingredient that plasticises plaster; a well known trick I learnt from my father when he mixed plaster or cornice cement for DIY renovations. The casein protein in the milk may react with the plaster or the casein protein may be aerated and frothed in the mixing stage, which adds air into the mix to aid workability.

The other ingredient that I thought could act as a plasticiser was paraffin oil, as I thought that this ingredient would lower the glass transition temperature. Paraffin oil is a petroleum liquid and used for lubricating machinery and it is used as refined lamp oil. Paraffin oil is miscible in water, which means that it does not combine with water. As such paraffin oil is used as a water tank sealer where the oil sits on top of the water to seal it off from the air which prevents organism growth in the water. The miscible property of paraffin oil proved to limit the usefulness of this ingredient, the only way I was able to overcome this problem was to mix it with an emulsifier to create a suspension. Working with wax as an ingredient had similar challenges to paraffin oil.

3.2.1 Mind Mapping

Mind mapping is a process used in many design disciplines to convey ideas and concepts visually. A mood or inspiration board is an example of mapping that is used by fashion, interior, event and graphic designers. Mood boards can convey information about potential fabrics, colours, imagery, textures and shapes for use by the design and production teams. Mind maps have also been shown to foster unique and divergent thinking in the design process (Leeds, Kudrowitz & Kwon 2018).

During my experimentation with ingredients, I used Coggle, an online mind mapping tool, as a way to help formalise and convey my thoughts and research. Examples of these maps are shown in Figures 18 and 19. I decided to use this software to map all the different ingredients, processes and

materials that I had been exploring. This was a simpler process than creating a map by hand as I could move ingredients around on the map without altering the connections that they shared with other ingredients and processes. It also allowed for increased complexity for relational mapping, with multiple starting points and colour coded paths.

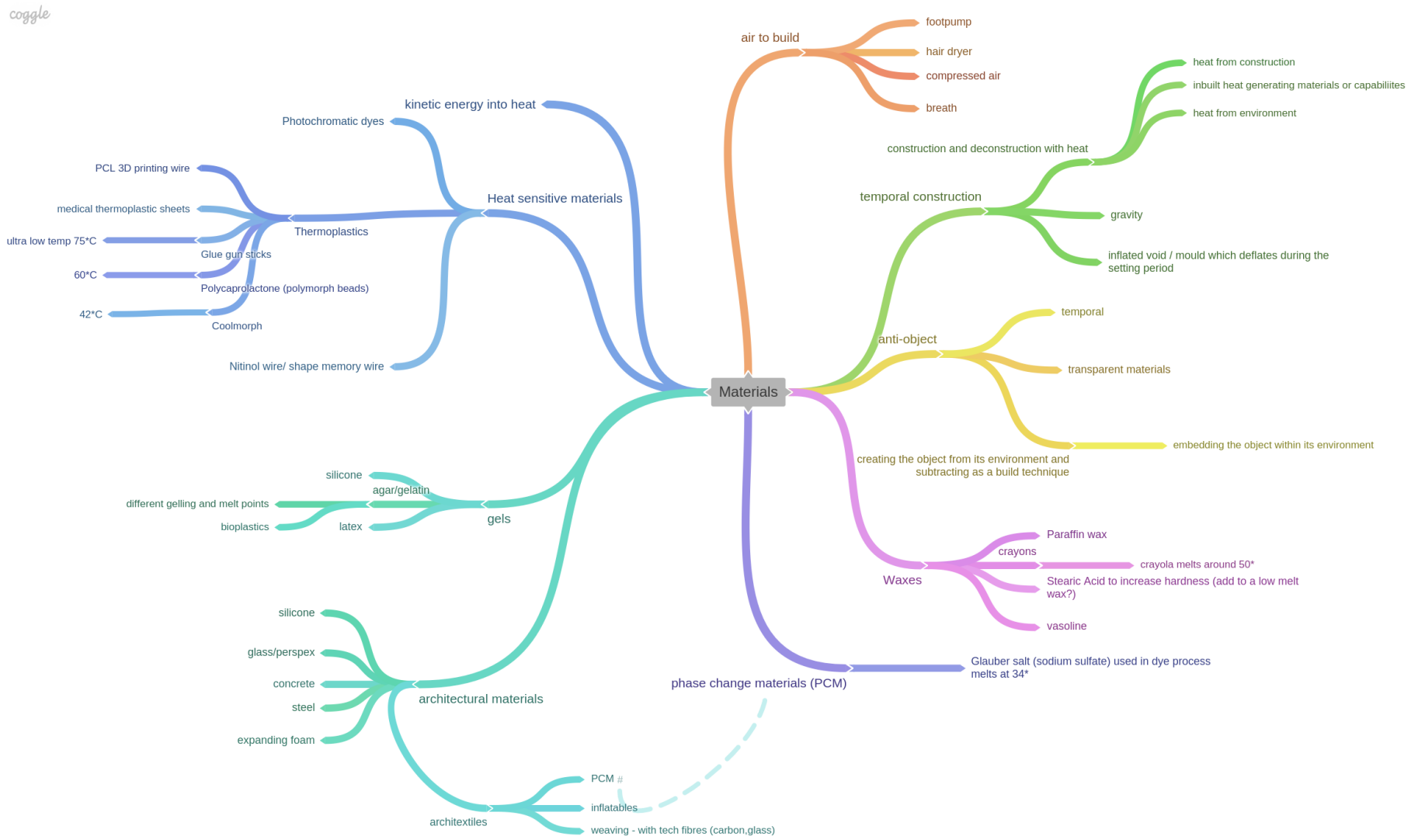


Figure 18: Initial mind mapping.

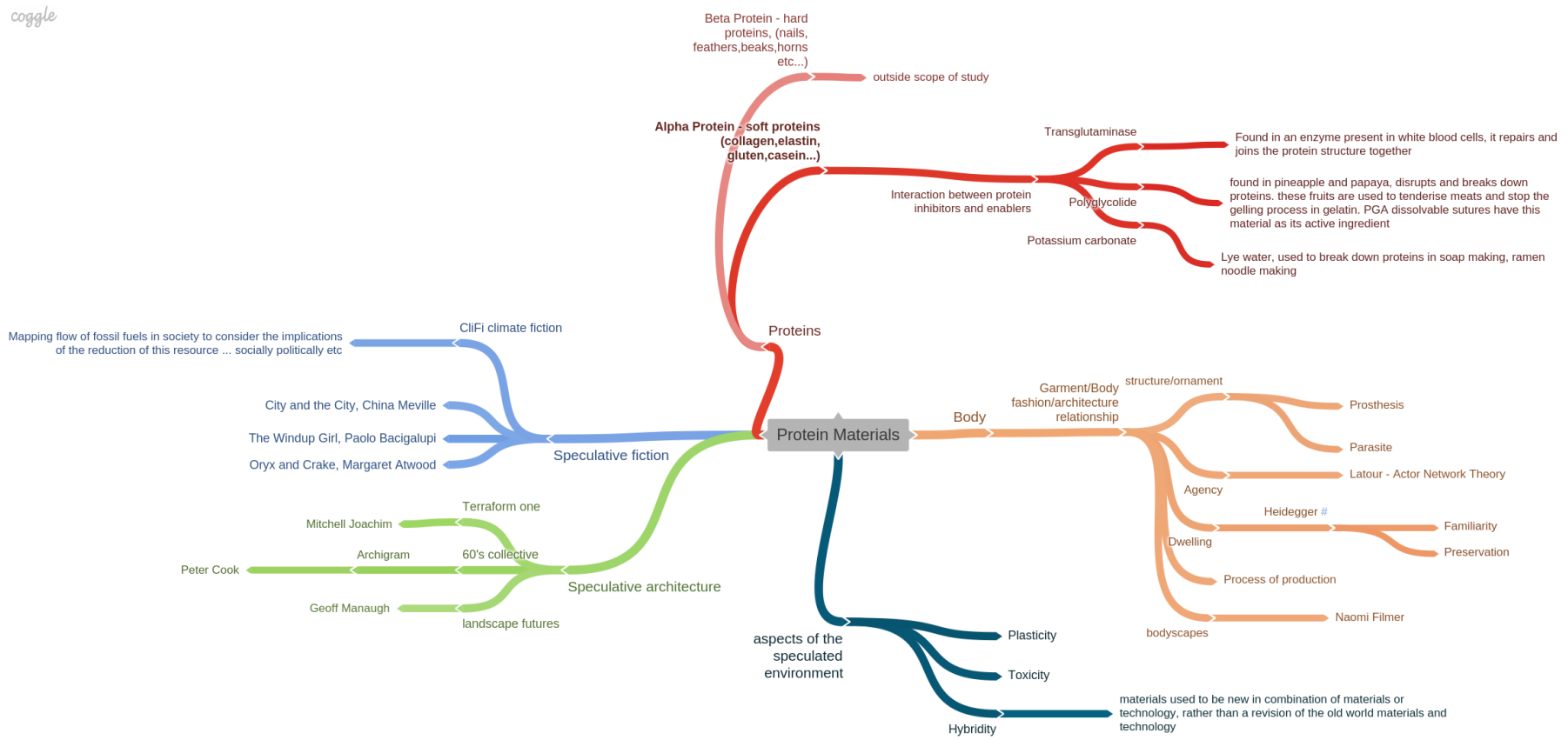


Figure 19: Protein materials exploration

3.2.2 Knowledge Testing

Once I had started to understand different ingredient properties and how they combine to form different materials, I started to test and experiment in my design studio. I also gathered inspiration from various sources such as academic material science papers, online blogs and other video tutorials such as those found on YouTube. I then integrated this knowledge into my studio practice.

Reading scientific studies as a designer presented challenges common to interdisciplinary researchers, I found the research articles to be very scientific and specific; they employed strict controls on variables and used highly refined chemical ingredients. I soon realised that in my practice and home lab-studio, I did not have access to refined chemical ingredients, nor could I guarantee such tight controls over variables. Another issue in consulting material science papers is their use of highly specialised, expensive equipment in a laboratory environment. For example, twin-screw extruders are used to combine ingredients that don't easily combine. The ingredients are inserted into the extruder which operates in a similar way to a meat grinder. The extruder applies heat, pressure, in the absence of air and oxygen to molecularly bond ingredients together. The resulting composite material extrudes out from the end of the machine. This extrusion process as well as other processes in plastic production such as vulcanisation, was far beyond what can be reproduced in the domestic environment. After a period of being stuck in the material science vortex I learnt to blur my eyes to their specific, expert-informed processes, and rather to focus on gleaning a few pieces of knowledge that could be useful in my design process. Academic science literature did offer insights and inspirations, whereby in one instance a paper managed to combine a protein with Polycaprolactone (PCL) plastic (Félix et al. 2015). This achievement opened up a path for my experimentation with PCL and led to further investigations with proteins.

Working as a designer in a studio setting I was limited in the kinds of ways that I was able to create material, employing industrial ingredients and processes was also outside my theoretical framework of futures in which makers rely on the local and easily acquired. *'AlgiKnit'* is a company who are

developing bioplastic yarn made from agar. The company started out by doing DIY tests and experiments with their ingredients, but recently they have been developing their material further in a lab environment (Knitting Industry Creative 2018). It is feasible that some of the materials created in this project may follow a similar development pathway to that of AlgiKnit and through playing Material Kin the materials could be refined and improved. Although outside the scope of this project, materials could be further enhanced by employing some industrial processes in a lab setting.

Another source of knowledge were DIY YouTube videos, albeit the quality of the information contained in the videos varied greatly. Most of the videos I found targeted school science projects or fell into the 'let's make something cool with bioplastics' genre (Green Plastics 2009). Whilst low tech and amateurish, these videos were helpful to see the range of processes used and as a starting point. They did not help to refine or problem solve my studio practice. Molecular gastronomy videos on YouTube were the most helpful as they explained not only the process of what to do but explained the properties of the ingredients they were using. Jacob Burton's YouTube videos on gelatine and gels were particularly useful in explaining the properties of different ingredients and how they can work together (Burton 2014). Through watching these videos, I discovered transglutaminase (meat glue) which became a key ingredient in the Material Kin of Collagenated Plaster. Meat glue increases the strength of the gelatine bond, this meant that I could make a high strength gelatine solution and combine it with heavier materials such as plaster.

3.2.3 Discovering Material Kin

With these various information sources and basic knowledge, I started trying to develop polymers, documenting the results of adding different ingredients and plasticisers together. Starch-based thermoplastics are a good entry point for exploring bioplastics as they can be made easily with common ingredients. I started out with a basic recipe for starch-based bioplastics.

Starch Bioplastic Recipe

60 ml water

8 g starch

5 ml glycerine

5 ml vinegar

- Combine ingredients in a saucepan
- Boil for five minutes on high heat
- Cool and dry until the material is firm and holds together
- It is important at this stage that the material is not disturbed

The resulting material yielded a solid but brittle plastic, but I was interested in one with more stretch and bounce. This material takes a long time to dry, as the excess moisture needs to leave the material. An oven can be used to dry the material which does speed up the process, alternatively with further development I could look into using a dehumidifier. Problematically if the material has too high a water content and takes too long to dry out, it will start to go mouldy.

As documented by Bhatnagar and Hanna, using different types of starch can change the properties of the starch based bioplastics (Bhatnagar & Hanna 1996). So I tried using cornstarch, tapioca starch and cassava flour. I also tested the addition of salt (sodium chloride) instead of vinegar. All these changes of ingredients yielded marginal variations. The various permutations of the material were not very inspiring to me at the time, so I moved on to looking into agar-based bioplastic. This led to the development of the biobubble lace.

Figure 20: Testing of the Thermoplastic Starch.

Biobubble Lace – finding a flexible material

For plastic to be considered a bioplastic, it needs to be either biodegradable or made from a biological source, such as starch or agar. Bioplastic can be an unhelpful term as it is possible for a sustainably sourced plastic to not be biodegradable, or for a petroleum-based plastic to be biodegradable. Figure 21 illustrates this blurry classification which is the basis of finding kinship framing; a new way of valuing and classifying materials for DIY makers.

During the process of testing I continued to come back to the idea of creating hybridity between the natural and non-natural with the ingredients found in my post-natural environment. I attempted to melt and chemically break down different plastics and then combine them with other ingredients. These attempts were repeatedly unsuccessful, so I started to think about how plastic and other ingredients could collaborate in the making process. All the Material Kin have been created using plastic to either contain, shape or mould the materials.

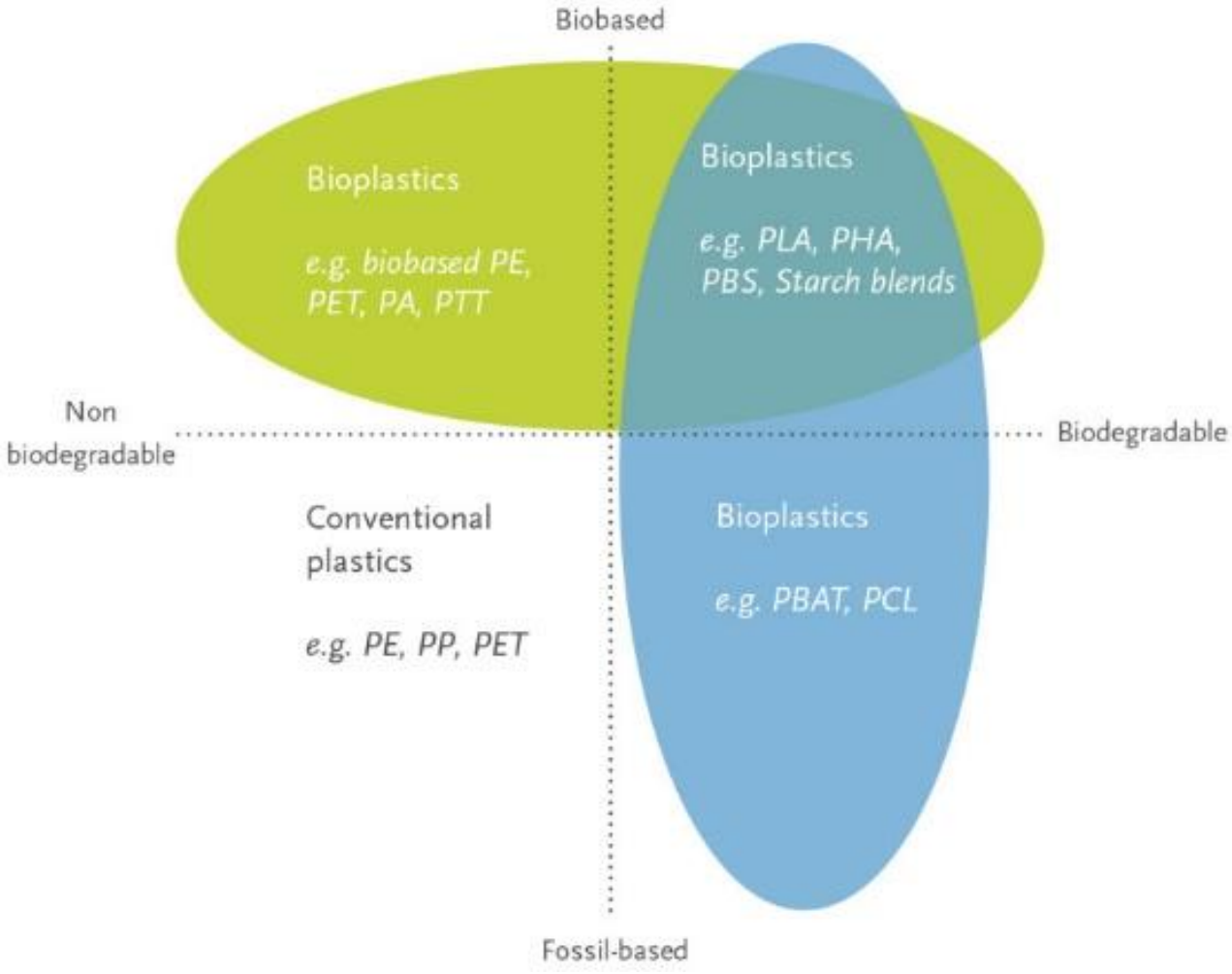


Figure 21: Classification of Bioplastics (European Bioplastics 2017)

Biobubble lace is a combination of agar, glycerine and water. Refining seaweed produces an ingredient called agar; agar is not a protein rather it is a made of agarose polysaccharides (Edinformatics 1999). Polysaccharides are complex carbohydrates and other examples of polysaccharides are starch and cellulose. Agarose, the polysaccharide found in agar, has a double helix as its molecular structure, this structure helps trap and contain water, which is why it forms a gel. Gelatine similarly absorbs water due to its helix structure. Agar has an unusual property in that the gel temperature and the melt temperature are different. Agar needs to be heated to above 85° C to melt, and the gel will form around 30° C - 40° C. Agar gel is firmer and more brittle than gelatine gel. To counter this brittleness, the recipe uses glycerine as a plasticiser. Gums such as guar gum or locust bean gum can also be added to decrease the brittleness. The addition of gums does not make the materials stronger but rather more sticky and chewy. Alternatively, a combination of gelatine and agar could be used to create a material which has a firm hold and does not melt around 35°C (agar properties) but is also rubbery and elastic (gelatine properties).

At one stage I tested the longevity of edible material made from agar and gelatine. I used a model car mould which I had in my inventory and had a capacity of 14L. I needed the material to set at room temperature as the mould was too big to fit in the fridge. The material also needed to be strong so that it could hold together 14kg of material weight. These constraints are not too dissimilar to constraints in other possible futures. Both these constraints suggested to me that I should use agar. However, I was worried that the material would crack and large sections would shear off, similar to cracks in ice shelves on Antarctica. To help offset this potential problem I added gelatine and meat glue to increase the rubbery and elastic properties. I took an educated guess at the quantities required and added a little more for peace of mind.

The material was created and then left outside for a week to observe. I documented its disintegration, and watched as the material gradually collapsed and grew mould. The material was

successful at retaining its shape in an environment of around 25°C. This project was successful due to my previous experiments and testing with agar and gelatine in smaller quantities.

Agar and Gelatine Recipe

91g Agar

200g Gelatine

400g Glycerine

500g Sugar

60g Meat glue

Black food colouring

14 L Water

- Combine agar, gelatine and glycerine. Add 3 litres of cold water. Sit for 20 minutes to allow gelatine to bloom.
- Add an extra 3 litres of water into the mixture.
- Put on low heat and bring the temperature up to 90°C. Add sugar and food colouring.
- Add the remaining water; this should reduce the temperature to below 60°C, add in the meat glue.
- Pour into mould and leave to set for at least 4 hours.

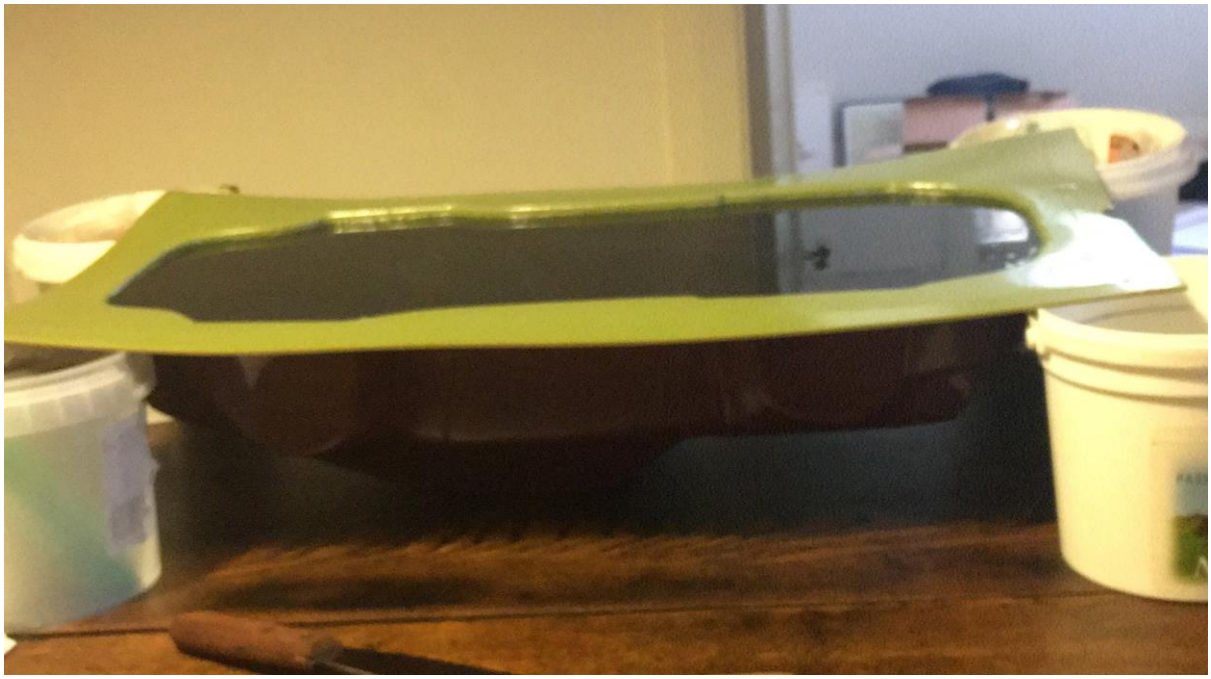


Figure 22: Test material setting in the mould

Figure 23: Test material transferred from mould.

Figure 24: Test material after one week.

I developed the biobubble lace recipe by testing and refining the ratios of the ingredients used in the black car. Despite the recipe being quite simple, it was very formative in developing my knowledge of how agar works. During the testing stage of materials, I learnt to portion the material into three containers. The first container I could touch and play with once it had set, the second I could interact with after one day and the last one after one week. I also learnt to hold judgement on material properties until a week had passed as some materials needed this extended amount of time to form. The biobubble lace is an example of a material that I had initially discarded. I thought that I needed to increase the ratio of agar as it was brittle and broke very easily. However, after a week of drying out, the brittleness of the material decreased and the strength increased so that the material could be picked up without breaking.

The biobubble lace material is an agar-based plastic which is both biobased and biodegradable. When we consider post natural sustainability, where there is no clean break or fresh start from traditional plastics, we must operate in a world with plastic toxicity. The biobubble lace has been cast on reclaimed plastic bubble wrap, reminiscing on the foundation, history and memory of plastic; it explores the changing and tangling relationship between natural and unnatural, as this new material is a strange and altered rendition of plastic bubble wrap.

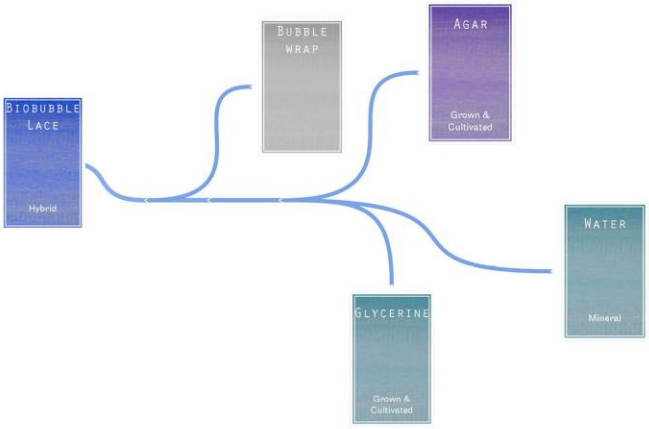
Material Kin
Biobubble Lace

Ratio of ingredients

1 : 22 : 2

Reclaimed object

Map



Material Kin
Biobubble Lace

Steps

1. Put 1 unit of agar into a pot.
   Pour over 22 units of water and 2 units of glycerine. Sit for 10 minutes.
2. Heat mixture until agar is dissolved and liquid is smooth.
   Let mixture cool until around 50° C.
3. Pour liquid out over the bubblewrap.
4. Allow for the mixture to cool and do not disturb for at least one day.
5. Gently remove the material kin from the bubble wrap mould.

Material Kin
Biobubble Lace

Notes

If the Material Kin tears easily when removing from the mould, let the material sit for longer to allow for more water to evaporate from the Material Kin.

The Material Kin should be stable after 2 weeks, as the water should have evaporated. If you find your Material Kin going mouldy before this stage reduce the ratio of water in the recipe.

Keep the Material Kin away from hot objects as this will cause the Material to melt.

Material Kin
Biobubble Lace

Material Kin
Biobubble Lace

Material Kin
Biobubble Lace

Collagenated Plaster

After I had created the Biobubble lace material, I wanted to build on my knowledge and create more diverse bioplastics. I bought Polycaprolactone (PCL), which is a biodegradable plastic that is mouldable around 42°C, and did a series of tests combining it with a number of ingredients including low melting temperature glue sticks, glycerine, polystyrene, paraffin oil, palm oil, agar, stearic acid, egg whites and gelatine. The most successful combination was PCL with gelatine.

An impulsive mixing and combining of the leftover gelatine from the tests with PCL resulted in the Collagenated Plaster recipe. This protein-based material is a fusion between gelatine and gypsum (calcium sulphate), commonly known as plaster. The process of making tofu inspired this specific combination as tofu is made by combining gypsum or Nigari E511 (magnesium chloride) with soybean milk. The gypsum is a catalyst that makes the proteins in the soybean milk change their structure and 'hold' more liquid. As a result the milk transforms from a liquid to a gel. Gypsum is widely used today to make plasterboard, which is a cheap, lightweight cladding for the internal wall frames of buildings. This recipe for Collagenated Plaster inverts the ratio of protein to plaster and substitutes the soybean protein with gelatine. In the formative stages of the material, a mould is required for the material to partially set. Once it has gelled, it can be removed from the mould and draped over and around different objects as it behaves like a rubbery piece of fabric. After a week the material will completely harden and set like plaster. This material has an openness to external influences such as the indentations of the mould as well as the memory of the support; the material carries these traces of past structures as it transitions between states and forms.

Transglutaminase, colloquially known as meat glue, is an enzyme that crosslinks protein structures together to fuse and bond them. Sprinkling transglutaminase on separate bits of protein such as meat which are then placed together for a few hours in the fridge, results in a singular piece of meat. The join remarkably has the same strength as other sections of the meat. Transglutaminase can be used to enhance the strength of gelatine and allow it to be deep-fried without the gelatine breaking

down into liquid. Cultivating transglutaminase can happen artificially in a lab, but it also occurs naturally in human bodies as a blood clotting agent that repairs and fuses together proteins in the body. As such, when using transglutaminase, it is important to wear a mask so that the powder is not inhaled into your lungs and potentially fuse proteins in your lung tissue together (Sisson 2011). After discovering transglutaminase, I was able to make gels that were hardier and could cope with greater weights. For example in making the below recipe without transglutaminase, the material easily tore in the flexible stage.

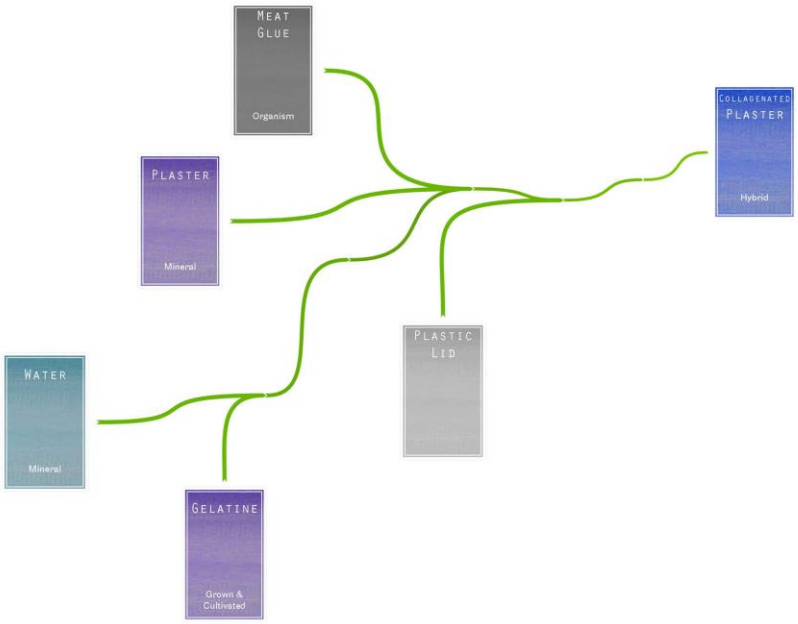
Material Kin
Collagenated Plaster

Ratio of ingredients

3 : 30 : 2 : 24

Reclaimed object

Map



Material Kin
Collagenated Plaster

Steps

1. Put 3 units of gelatine into a pot.
   Pour over 20 units of water and sit for 10 minutes.
2. Heat gelatine and water until gelatine is dissolved and liquid is smooth.
   Let mixture cool till around 50° C.
3. Combine 2 units of meat glue and 24 units of plaster in a mixing container.
4. Pour in gelatine and water mixture and the remaining 10 units of water.
5. Mix until smooth.
   Scoop out and place in found plastic lid.
6. Set aside a small amount of material so that you can check the state the material without touching the main batch.
   Wait 30 - 45 mins until the material is firm but rubbery.
7. Remove material from reclaimed object, drape material over structures and leave to dry (around 3 days).

Material Kin
Collagenated Plaster

Notes

Due to variations in ingredients, the ratio might need to change. If material does not hold together between steps 5 & 6. Add one more unit of gelatine.

If meat glue is not available increase the ratio of gelatine and increase the amount of support for the material in step 7.

Try to keep the thickness of the sheet to a minimum to reduce weight and avoid tears.

Increase the ratio of water by 2 or 3 units at step 4, if the mixture is too thick and gluggy.

Material Kin
Collagenated Plaster

Material Kin
Collagenated Plaster

Material Kin
Collagenated Plaster

Evolving the Collagenated Plaster

I did further testing of the recipe, with the goal of increasing the size of the material sheet for use in larger applications. I increased the volume of the recipe by 20 times. I calculated that this should make a large sheet of around 120cm x 66cm. I built a frame and created a net out of twine to help reinforce the sheet. Rather than just scaling up the material volume by 20 times, I wanted to start playing with colour, texture as well as tweaking the recipe. I added glycerine, bycol, sago balls, and colouring to the recipe, while I removed the meat glue and changed the cornice cement to plaster. Sago balls are made from tapioca starch, the addition of these was to add texture to the material and introduce a bioplastic into this material. In hindsight I was doing more than tweaking the recipe, I was creating another material that evolved from the Collagenated Plaster. I encountered issues with this new recipe partly because it was the first time that I had experimented with sago balls and colouring.

Firstly I didn't cook the sago balls for long enough as I had mixed them with the gelatine and I was worried that I would denature the gelatine. The second time I cooked these ingredients separately and then combined them at a later stage. Then I poured the material into the mould that I had lined with acrylic sheet. The acrylic sheet expanded due to the heat and buckled up at one end forcing the liquid material to the other end.

The resulting material also separated when it was cooling with the plaster settling onto the bottom of the material and the gelatine forming a shiny coating layer. There were patches of foam generated from the bycol and bumpy areas from the sago. The twine mesh system that I had rigged up was insufficient as the twine pulled out of the material.

After initial disappointment due to the failure of this experiment, I recognised the opportunities to expand upon the singular idea of Collagenated Plaster. From this experiment, I could imagine four more material possibilities each with their own unique properties:

- By removing the plaster, bycol and sago balls from the recipe, I could make a shiny gelatine coating material.
- A soft foam material could be made by aerating the bycol and gelatine.
- The sago balls could become an additive to materials for creating texture in a material.
- I could layer the Collagenated Plaster over a fine mesh to make a version of neoprene.
- Bycol appeared to inhibit the mould growth on the materials, so as well as being a foaming agent, the bycol is antifungal.

This was a pivotal moment in my experiments, and it shaped the direction of the project, as I then wanted to investigate and demonstrate how to create a suite of materials that are related, versatile, and non-hierarchical rather than refining and 'completing' a few singular materials.

Figure 25: 1200mm x 650mm mould with twine reinforcements.

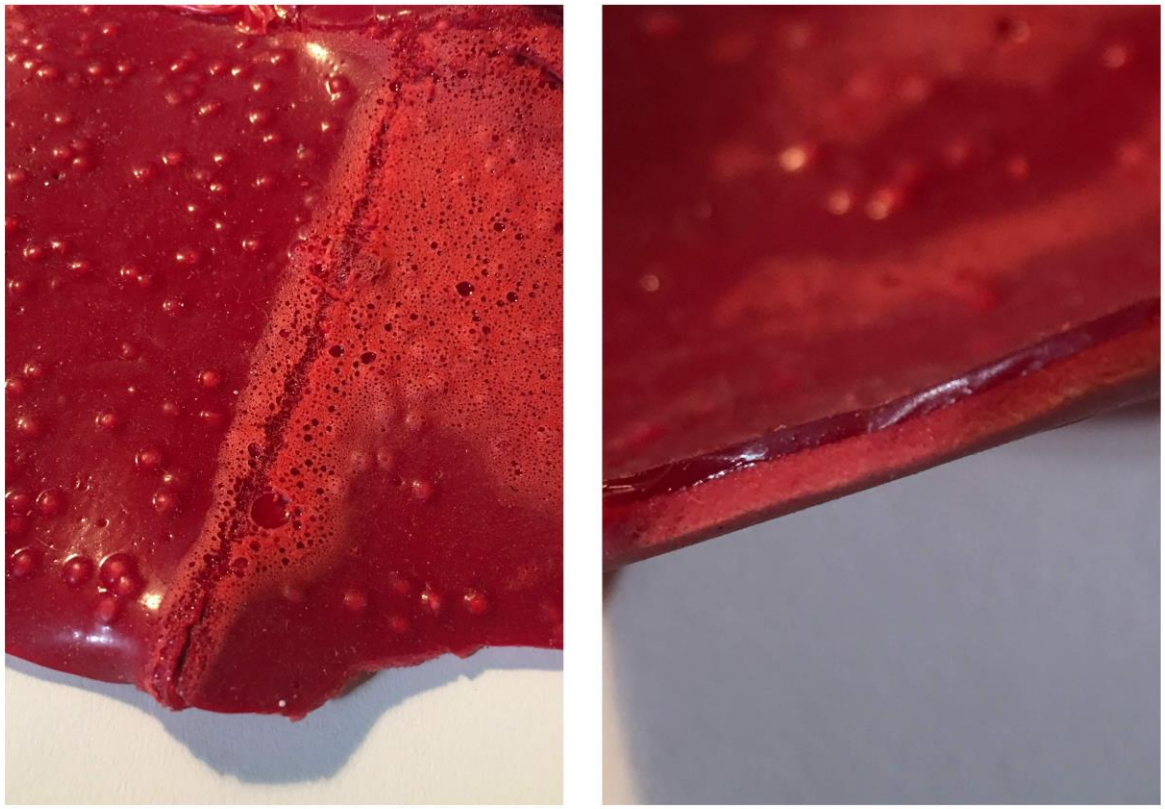


Figure 26: Detail images from the evolved Collagenated Plaster recipe.

3.3 Stage 2: Developing Material Kin

I had now developed two distinct materials as well as imagined a few more potential materials. Using the materials that I had generated, I started to synthesise the post-natural sustainability framework and the material experimentations done in the studio. I created a map of the ingredients, processes, Material Kin and the connections between them. The map reminded me of the image that Haraway used to help explain her version of the game Cat's Cradle, String Figures (see 2.1.6). After making this connection I started to view the map as a helpful tool to navigate and visualise the relationships in a non-hierarchical way. Through this mapping process, kinship relations are uncovered with one another as they share similar base ingredients and processes. This project began to respond to Haraway's call to 'make kin, not babies' (Haraway 2015, p. 161) (see 2.1.6).

The map helps to articulate kinship framing for ingredients and materials investigations however the design principles developed for a post-natural sustainability need to be explored in greater depth. The following sections in this chapter unpack how Material Kin responds to these design principles.

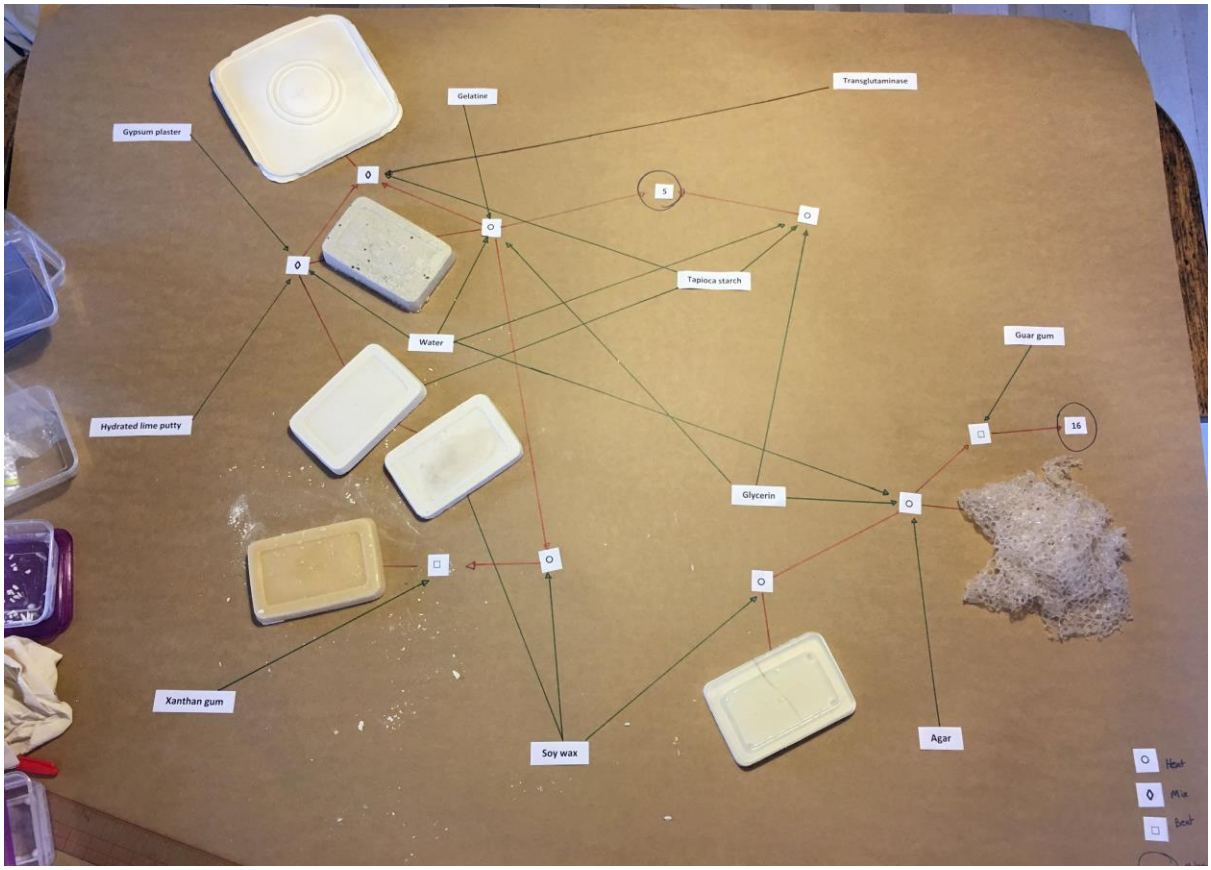


Figure 27: Preliminary map with Material Kin.

Post-Natural design principles.

1. ***We can no longer use the justification of the 'natural' to validate our decision-making; rather we must operate with care and concern towards others, which will result in a quality economy rather than a quantity economy.***

3.3.1 Categorisations, Kinship and Care

Geoffrey Bowker and Susan Star argue that classifications should be recognised as a significant site for political and ethical work, regardless of how dry or formal the classifications seem (1999). Working within a Post-Natural design context we need to look beyond the classic systems of classification to alternative systems to provide another way of classifying Material Kin. Categorising Material Kin in terms of aliveness changes the way we relate towards Material Kin and prompts us to operate with care and concern.

In western scientific tradition, the taxonomy of materials is normally classified using the Linnaean system, which is a hierarchical system containing the kingdoms of Plant, Mineral or Animal (Schuh 2003). Sub-categories such as Class, Family, Genus and Species can be used to locate specific things and their place in the world. Two new classification categories for matter have been put forth in response to new materials that are being developed which do not fit neatly into the Linnaean system (Ayala Garcia, Rognoli & Karana 2017). The proposed classification categories are Recycled and Mutant. The Recycled category includes discarded materials or by-products from another material or process. This waste material can be reconstituted to form another material. The category of the Mutant includes materials which can be transformed and made 'living' through technological or biological processes. Smart, interactive or responsive materials are assigned to this category.

Despite these additional categories, neither the Linnaean system nor the revised categories of taxonomy were particularly helpful ways to try to classify and define the ingredients and Material

Kin with which I am working. As the Material Kin are developed relationally, fitting them into a hierarchal system proved difficult and illogical. Bowker and Star contend that 'Categories are historically situated artefacts and, like all artefacts, are learned as part of membership in communities of practice' (1999, p. 287). Different categorisations are more useful than the historic Linnaean system for designing and relating in a Post-Natural system. I propose to categorise the ingredients by what I have termed of 'aliveness'. Alive, once alive, and have never been alive are the three states of aliveness I have considered. Inspired by Arias Maldonado's term of cultivated capital, I have used 'Grown and Cultivated' as one of the terms to group ingredient types together in the guide and game. The other categories I have delineated are 'Mineral', 'Catalyst', 'Hybrid', and 'Reclaimed'.

> **Organism** is an ingredient that is currently alive e.g. enzymes, fungus and bacteria.
>
> **Grown and Cultivated** describes a once alive natural resource that is grown, harvested, or refined by humans.
>
> **Mineral** is a material harvested and refined by humans, with a base resource that has never been living or growing.
>
> **Hybrid** is an ingredient that is made up of a combinations of Mineral, Grown and Cultivated and Organism categories.
>
> **Reclaimed** describes found artefacts that are part of the process of making Material Kin, e.g. string, saucepans.

An outworking from the theory of vibrant matter is the acknowledgement of the vibrancy of matter which means that rubbish is not an inert material but it is active, and continues to act even while it is classified as a discarded commodity (Bennett 2010). Bennett argues that the sheer volume of commodities and hyperconsumption, which drives the need to junk and upgrade, conceal the vitality

of matter. By categorising materials through aliveness, discarding materials becomes harder, and we can start to move to a quality economy rather than a quantity economy.

Considering Material Kin through levels of aliveness requires us to work with concern and care as we consider the ingredients' past, present and future. Through considering the aliveness of ingredients we are forced to consider the ingredients' history and this knowledge should inform how the ingredient is used.

I have not given rules about which particular ingredients can or cannot be used to create Material Kin, but rather I rely on the maker's situated knowledge and discernment to make decisions in their context. For me, I chose to stop working with Bycol as an ingredient as I didn't know its chemical makeup, which meant I could not evaluate its impact to Material Kin.

Reconsidering categorisations of materials causes change, and likewise working in a relational ontology system also causes change. This is evident in the connections between Indigenous Australians, Country and its human and non-human inhabitants, which are 'reflexive and recursive. To be in connection is to take care and to be cared for' (Rose 2013, p. 71). The use of kinship relations results in inclusion, responsibility, accountability and security and therefore has a role in decolonisation. By framing materials in a relational system, I am working towards these same values which are encapsulated by the term care. Care entails more than selecting ingredients to use, it also informs how the Material Kin might be used or applied. However, this aspect requires further exploration as the focus of this project is to discover and make Material Kin rather than finding an application for the Material Kin.

Post-Natural design principles.

2. ***Substitutions have already occurred, will continue to happen and should be encouraged. In addition, creating multi-faceted substitutions should be the aim of designers.***

3.3.2 Substitutions and Ingredient Properties

Substitutions are a core aspect in Haraway's multispecies SF and also feature in the making of Material Kin. Artist Patricia Piccinini works and explores multispecies hybrids in her sculptures. In her exhibition, *In another life (2006)*, Piccinini creates multispecies sculptures which are simultaneously uncanny, discomforting and cute. She writes 'there is no question of whether there will be undesired outcomes [of multispecies hybridity]; my interest is in whether we will be able to love them' (Piccinini 2006). Kinship framing helps answer Piccinini's question as kinship provides a way of not only accommodating the strange and the different but also caring for them. Working from a relational ontology system allows for substitutions to be tested and experimented in a supportive environment.

To expand the concept of substitutions for Material Kin, I created types of properties for the different ingredients I was using. I created the properties groups of Transform, Mixer, Catalyst, and Additive. Different colours were then used in the map to indicate ingredient properties.

Material Kin ingredient properties

Transform Plaster, gelatine, agar all have transformative properties as they can transition between states of liquid and solid. Generally, proteins are transform ingredients. Transform ingredients are indicated by the purple ingredient cards.

Mixer Water, glycerine, and gums all aid in the mixing of ingredients. Plasticisers also are considered as a mixer ingredient. Mixer ingredients are indicated by the aqua ingredient cards.

Catalyst Meat glue and yeast cultures have catalyst properties as they cause reactions in other ingredients. Catalyst ingredients are indicated by the dark grey ingredient cards.

Additive Food colouring and oxides are additives that change the colour of the Material Kin. Perlite is also an additive as it adds voluminous, lightweight properties, while sago balls add texture. Additive ingredients are indicated by the green ingredient cards.

New Material Kin can be generated through the process of substitution. Substitutions between ingredients with the same type of properties can be made in the recipes for Material Kin. The recipes will need tweaking to account for the different ingredients. Like the term care, substitutions is a more expansive term than the examples of substitutions demonstrated in Material Kin. Substitutions inform the making process, as it requires openness to new ideas, the trying of new combinations and the experimentation with processes.

Post-Natural design principles.

3. ***The ownership of knowledge and substitution rights should lie with the community or people, not corporations.***

3.3.3 Sharing Material Kin

This principle adds weight to the DIY way of making, creating and retaining knowledge. Highly specialised processes and machinery are not used to create Material Kin so that the knowledge can be easily replicated and adapted. The recipes that I have generated for Material Kin are freely shared and customisable.

In this stage of my practice I developed another three examples of Material Kin. The recipes for the following five Material Kin that I created can be found in the maker's guide:

Biobubble Lace
Collagenated Plaster
Protein Foam Filler
Stretch Cord
Plaster Tubes

I have also used this design principle to further develop the process of making Material Kin into a game. The creation of a game is intended to be a tool to create communities who can develop Material Kin and share their material knowledge. Haraway talks about using SF as a tool that she and Latour 'play' (Terranova 2016). While Haraway has not produced a literal game, I was inspired by this idea and decided to develop my map into a game proposition. This game is intended to help explore and generate connections between ingredients and processes with the goal of making Material Kin.

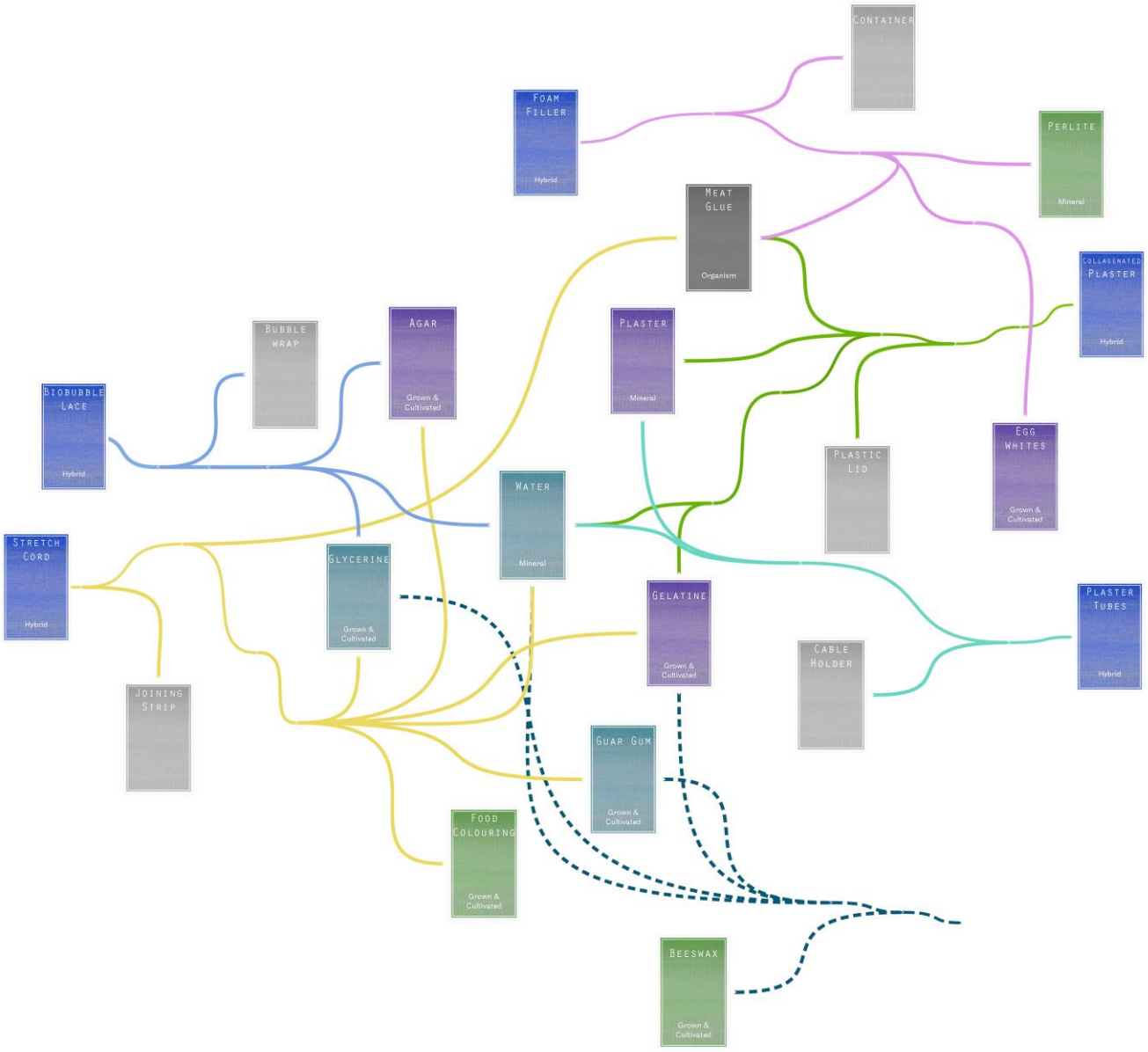


Figure 28: Relational map of ingredients and processes

3.4 Stage 3: Designing a Game

3.4.1 Games and Design

Games can be played for enjoyment but they can also be used for learning and education, to share information, and as a research tool in design. In this section I will look at precedents of games used for design research and critical thinking, I will examine some of the theories of storytelling, narratives and play in game design. Firstly I will look at how games and play can impact and change culture, along with the recent growth of 'serious games'. Lastly, I will look at some survival type games and then articulate how the Maker's Guide and game fit in this context of a designed game.

Play is one of the primary elements in games and in culture. Johan Huizinga, who is considered to be the father of modern game theory wrote 'that culture arises in the form of play' (Huizinga 1938). Artefacts and examples of play and games are found in many ancient cultures, and these games have an evolutionary background as instruments for survival training (Breuer & Bente 2010).

Games have found their way into contemporary design education, with 'serious games' denoting games that involve pedagogy. Colleen Macklin runs PETLab (Prototyping, Evaluating, Teaching and Learning), a lab focused on developing games for experimental learning and social engagement. She builds upon Huizinga's premise that play drives and develops culture by arguing that play and seriousness are not mutually exclusive and that playing games about serious subjects does not diminish the seriousness of the subject. Macklin has developed many games for social change including *Re:Activism*, an analogue game where instructions are sent from the game organisers to the players through SMS. It is designed as a scavenger hunt, in which:

> *players race through neighbourhoods to trace the history of riots, protests and other political episodes in the history of New York City. Teams pit themselves against the clock and test their puzzle-solving skills to locate important sites representing acts of civic engagement and*

> *struggles for greater social justice… It has since been documented online and adapted into a downloadable kit to encourage redesign for use in other cities.* (PETLab 2018)

Games for Change is another organisation that promotes and connects different communities, companies and organisations to develop and implement 'serious games' as well as holding yearly meetings (Games For Change 2018). Serious games in their elevated form can be used to communicate information across language and cultures. They are 'more than story, art, software they involve pedagogy, activities that educate or instruct, thereby imparting knowledge or skill' (Zyda 2005).

Another example of a serious game is the card game, *Global Futures: The Game* (Tsing & Pollman 2005), in which a player is dealt three cards with symbols or icons on it representing disparate groups, institutions and places. The player is tasked with forming a coalescence or a story that links these various cards together which creates a historical force for society. The game is designed to reward creative linking of strange and various combinations and to encourage the consideration of possible new connections, identities and political visions. Players are provided with a space for the exploration of potential futures as well as space for debate and dialogue about different theories of culture and globalisation. As with Re:Activism, Global Futures is used in a pedagogical context, such as at the Environmental Humanities department of University of New South Wales, where students were required to document themselves playing the game and upload their videos as part of an assessment (FutureLearn 2018).

The fictional worlds of Atwood and Bacigalupi create rich, compelling speculative futures. Games such as *Dungeons and Dragons* (D&D) similarly create detailed speculative environments where action takes place. D&D has an accompanying dungeon master's guide, which shows the dungeon master how to build their own world, invent magic spells, tinker with the rules of the game, and write their own D&D adventures (Wizards of the Coast 2014). It is envisaged that through playing Material Kin players will physically create materials in response to their imagined environment. This

mode of playing is intended to immerse the players in a speculative world, similar to speculative fiction novels, however it is through playing the game and creating Material Kin that players participate in the imagined environment.

Stewart Brand devised a number of physical games as an antiwar protest and as part of the countercultural new game movement in the 1970s. The objective behind the games was to shift the players attitude of winning at all costs and instead sought to promote cooperation and collaboration between players and teams. Brand's game *Slaughter* was an expanded version of *Tug of War* with two teams trying to roll a large ball painted to look like the earth towards their goal. However, individuals in the teams were instructed to change sides midway through the game to keep a balance between the teams. The aim was to shift cultural norms from competition to cooperation in game playing.

A contemporary example of game designers taking a similar activist approach is the #resistJam collective. Rather than playing physical games like Brand, #resistJam look at ways of resisting through interactive media. The collective state:

> *The global political climate grows increasingly terrifying by the day … Not everyone can march, or be a figurehead of a movement, but we can all find ways to resist the oppressive hegemonic authoritarianism that pervades modern society. This is one of them (itch.io 2017).*

Paolo Pedercini is part of the #resistJam movement, and develops satirical games as a way of shaping opinions by subverting the tropes of a computer game. In *Tuboflex,* the player assumes the role of different production line workers. There is only one outcome for the worker at the end of the game; begging for money on the street. The higher the skill of the player, the longer the player can stay playing or working in the game but the outcome is the same. The game is a critique of society and by playing games as an active participant, players make sense of the complexity of systems (Macklin 2013).

In *Oiligarch*, another game developed by Pedercini, players take the role of an oil tycoon who has to balance supply and demand, bribe politicians for favourable exploration licenses, and initiate foreign interventions to gain access to new oil fields. The result of satisfying the growing demands for oil eventually leads to nuclear fallout. To create an alternative ending which is not so dire, the player must actively choose to defy the wishes of the game narrator. Pedercini uses this game to highlight the proactive and countercultural stances that need to be taken in real life for the betterment of society (Ferri 2013).

Pedercini has developed a game called *Dogness* inspired by the theory of eugenics, the current political climate in the US and Haraway's book *When Species Meet* (2008). In this game, the goal is to create a homogenous pack of dogs that all have desirable 'dog traits'. This is achieved through immigration (of dogs), selective breeding and expelling less desirable dogs from the park. This importance of this game is that it shows a precedent of a game being created from Haraway's writing and theories.

Australian artist group, pvi collective's *Blackmarket* is an example of a performative participatory game (pvi collective 2018), in which players act out a future scenario in the city's streets and alleyways. The game is set in the near future after the collapse of today's society and economy. As money has no value in this future, players bring items with them to trade for survival. A phone is given to the players, which helps them navigate and connect with other traders to exchange goods and services. This game challenges the value of goods and considers a future where current values have changed. The Material Kin guide and game similarly questions the value of materials in a range of futures.

There are many card games developed for a similar survival context, either survival in the outback (Bob Cooper Outback Survival 2018) or urban environments (Urban Survival Playing Cards 2016). The survival information outlined on these cards do not change the function or gameplay and they can be used in place of a regular pack of cards. Through use and playing with the cards, the tips and

tricks on each of the cards might be conveyed to the player and be helpful in different situations. In the case of the outback survival cards, each suit in the deck of cards deals with a different theme, such as harvesting water, building shelter, creating fire and warmth, and sourcing food. While these packs of cards deal with aspects of survival in a foreign environment, they do not impart knowledge in an integrated manner with the game.

The playing board for the game *backcountry* (Trailside Games 2018), uses a topographical map as a playing surface, where the map features, such as tracks and landmarks shape the gameplay. The game that I have developed is similar to the board of *backcountry* where the Material Kin map is made by showing the relations between ingredients and processes. The gameplay is openended and influenced by the map. The results are unknown, with possible dead ends and failures. However, it will hopefully educate and instruct, impart knowledge and skill.

The Material Kin guide and game are less overtly activist than #ResistJam and Pedercini's games. Instead they are designed to create space for imagining and making materials under a different value system. The guide and game are developed for both present and possible futures. The first mode is designed to explore and imagine potential collaborations between ingredients. The other survival mode of playing allows for a possible future where necessity rather than inquisitiveness drives material creation process. I imagine that the game will be useful in this survivalist context as it shows how a way of making can be transferred to a new set of ingredients and contexts.

3.4.2 Creating the Game Prototype

I started out with the idea of using cards to create a trading card game, which has similarities to *Pokémon* trading cards in the way that cards are traded and can be added to upgrade different characters. *Pokémon* originated in Japan in 1996 and was designed with two levels (PokéPlayer 2014). For most people, collecting and trading cards to create a complete set was the goal. The second level was to play a card game with the Pokémon cards. During the game, players or trainers

can choose character cards to battle opposition players. Trainers can also use additional cards to evolve their characters to higher levels with greater attack or defence capabilities. I imagined that Material Kin would operate on two levels like *Pokémon.* The first would encourage the exchange and the swapping of cards, which would lead to further collection or trading of knowledge and ingredients. During the second level of Material Kin game time, I imagined that players of the Material Kin game could use their ingredient cards to try to build and create Material Kin by adding different ingredients.

Developing the game prototype

In each of the Material Kin that I created in the studio, there was at least one ingredient with the properties of 'transform' and one the properties of 'mixer'. The only Material Kin that did not use a mixer ingredient was the Protein Foam Filler. As such I devised a game where one of four different properties where attributed to each ingredient card. These cards are then sorted into groups by property and the players then randomly draw one card from each group. The game is to then create Material Kin from the resulting hand of drawn ingredient cards.

A map of previously made Material Kin, shows the ingredients and combinations used to develop them. The map is useful to compare with the drawn ingredient cards. The map helps to highlight past relations between ingredients as well as offer variations to developed Material Kin through substitution of ingredients with the same property. Like in *poker* you can discard unwanted cards and draw different ingredient cards to replace them.

I then tested the game by playing it, while I did not succeed in creating another Material Kin I was able to better articulate the specific roles of the guide and the map. I also discovered that unresolved combinations and dead ends still contribute to knowledge that is useful for other players or other rounds of the game. This knowledge of unresolved combinations is just as important as the recipes for Material Kin.

In the test round of the game I played, I tried to combine aerated wax with eggwhites. This combination did not combine well, so I substituted the egg whites for gelatine, however the mixture separated during this process. Faced with this roadblock, I decided to pause this material experimentation at this stage and pick it up again at a later date. When I returned to it I discovered I could make whipped wax, a new material kin; by aerating the wax as it is cooling the wax was able to be scooped up and spread around, with a possible utility as a waterproof gap filler. After playing the game, I was able to refine and formalise the rules.

Developing the Guide

The guide needs to contain all the knowledge from past testing, as well as Material Kin recipes. The guide can then be used as a reference manual when playing the game and considering combinations of ingredients. The guide is designed to be modular and can be added to and amended by the material maker. The first module gives an overview of the game, and rules for playing. The following modules are the developed Material Kin recipes, there is space to add notes and variations to the recipe for the maker's specific context. Two modules (Biobubble Lace and the Collagenated Plaster) are in this thesis (section 3.2.3 Discovering Material Kin). Each module has been stitched as a booklet so it can be removed, tested, copied and shared. Two holes have been punched through each booklet, so that they can be collated all together. Notes from past tests and new Material Kin recipes can be easily added to this guide.

Developing the Map

I have translated the relational map (Figure 28) onto a fabric game board. The hessian fabric was chosen as it was a reclaimed material which links back into DIY approach of this project. Furthermore this particular hessian was also woven with an alternating plastic and hessian yarn, the combination of the plastic with the hessian provides the foundation for further Material Kin to be developed in a Post-Natural environment. String is used to show the relationship between ingredients, the string also links back to Haraway's String Figures and the Cat's Cradle game. Loop

junctions that connect the string together indicate a process or action that is required to link the ingredients together. Examples of a process could be: heat, mix, cool, layer. The ingredients are represented by the ingredient name written on top of a colour rectangle, the colours indicate the ingredient property. The map is used to give an overview of the ingredient relationships, for more specific details regarding ratios and processes the guide should be consulted.

All the elements of the map have been stitched down onto the hessian, this is to create a stable and clear map. The map is customisable by the maker and ideally the ingredients could be changed and moved around on the board. In an attempt to remedy this problem a clear slip has been sewn over the coloured rectangles to create a pocket in which to house different ingredient cards of the same property. For example if I had the ingredient card Agar – which has the property of transform - I could substitute Agar into any other ingredient with the property of Transform. This feature aims to provide a simple way to consider substituting ingredients in existing Material Kin recipes, and can start to add another temporary layer to the base map. If after testing the substitution creates a different Material Kin, this new recipe could be stitched onto the map.

Similar to the guide, the map is intended for customisation, further development and additions by the Maker are encouraged. An overview of the game and rules are explained in the Appendix and printed in the guide.

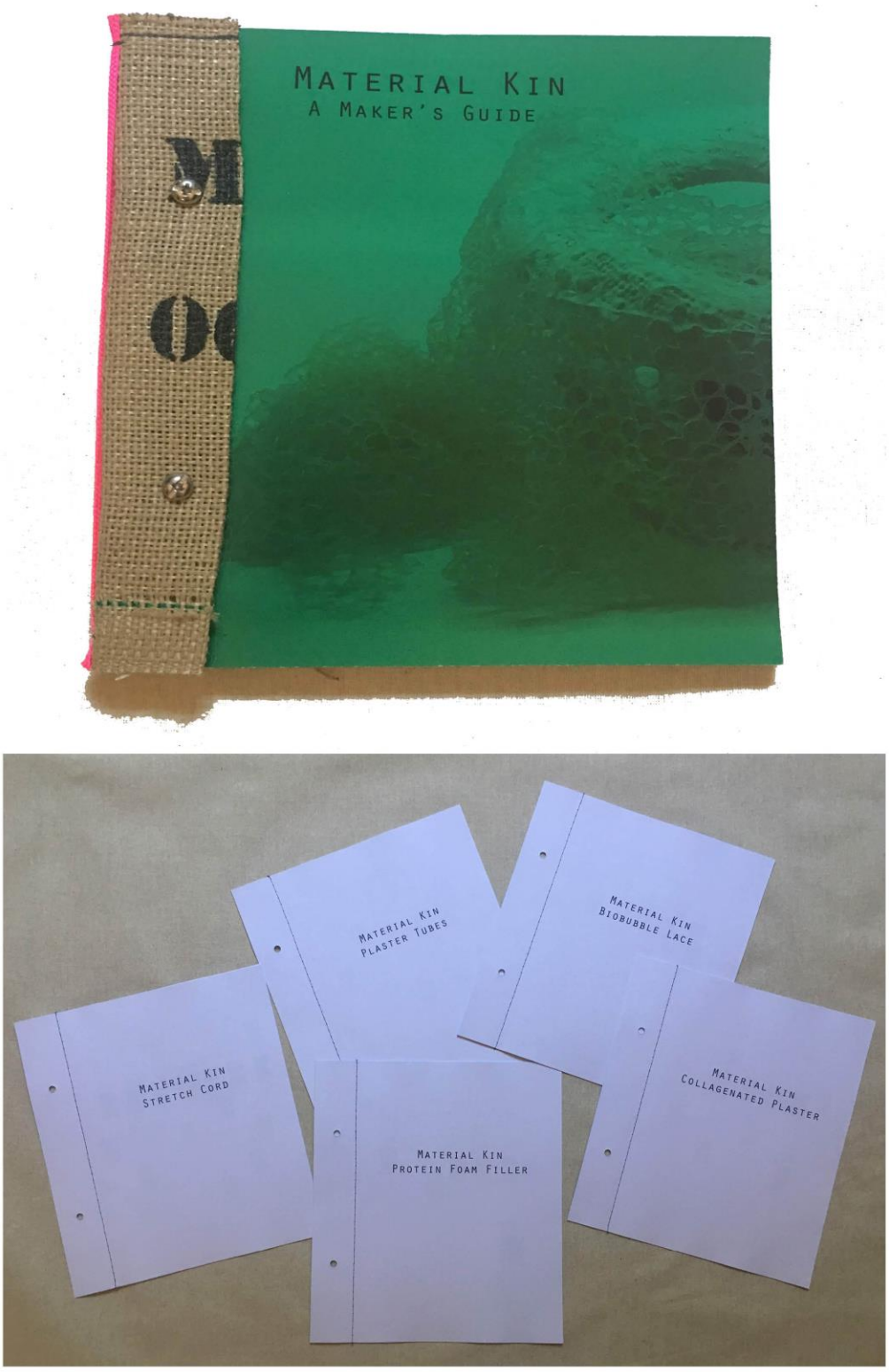


Figure 29: Guide with Material Kin modules

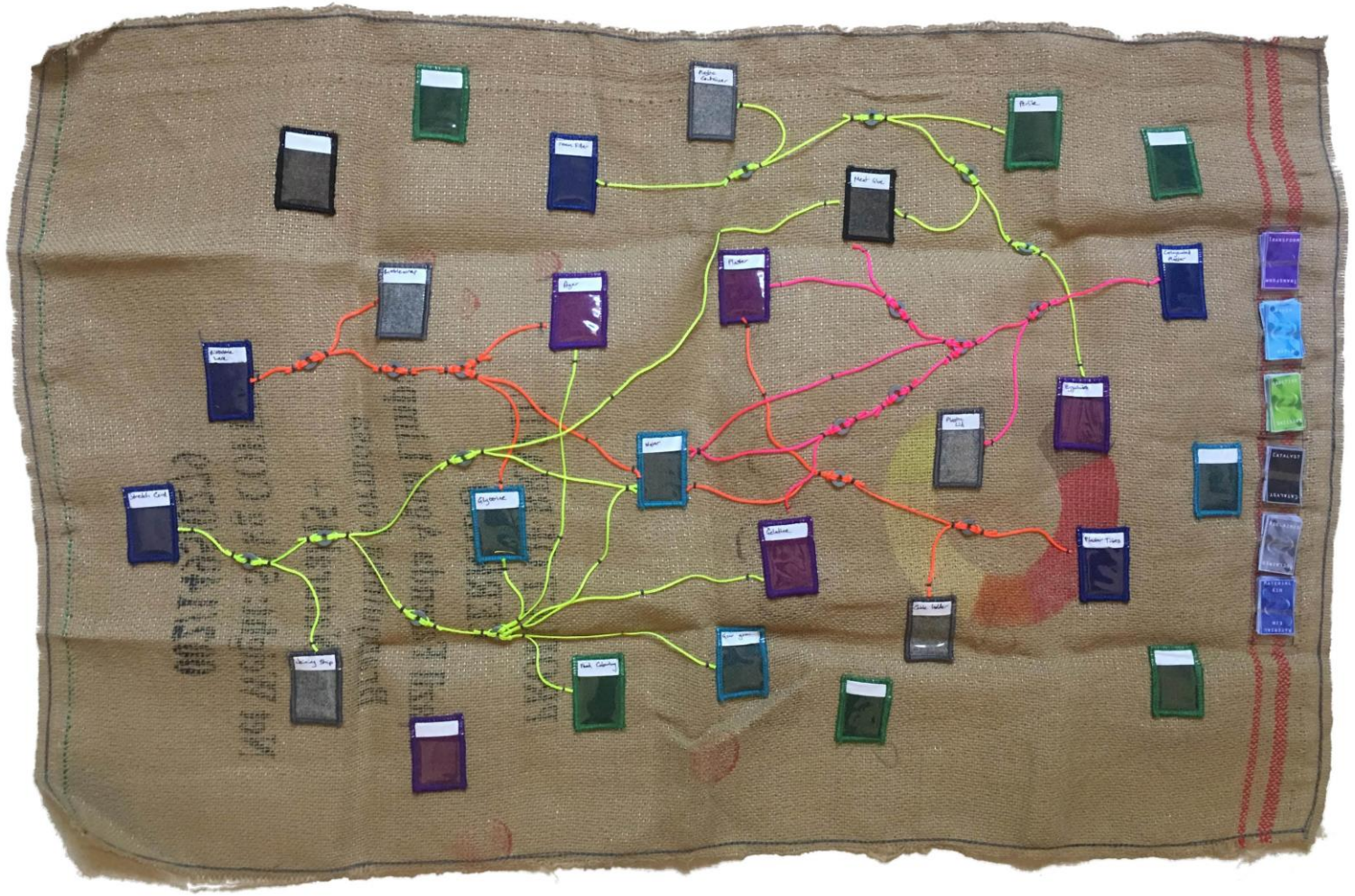


Figure 30: Map prototype for the game

4 Conclusion

Originally I started this project with the aim of developing a single, sustainable material from which I could build shelter. I did not make the exact material that I envisaged, but through tinkering I did find a variety of interesting combinations and materials. Instead of continuing to develop a single purpose material, I shifted my focus to *how* individuals can create materials rather than *what* these materials are and what can they be used for. In other words, the utility of my project is its method, not its end product. With method as its purpose, this project's goal demonstrates a way for DIY makers to combine readily-available ingredients with each other to develop sustainable materials for a range of possible futures. Drawing on Haraway's concepts of kinship, I considered ingredients and materials in kinship relations. Through this framework, I worked on shifting my role as a designer from a master and author of materials, to a collaborator and curator of materials.

This thesis has documented the journey in answering the following research questions:

Using readily available ingredients and processes, how can sustainable materials be developed in preparation for a range of possible futures?

- How does the value of readily available ingredients change, as they combine together to create materials?
- How does a relational ontology approach shift the role of the designer from the master, manipulator and author of materials, to a collaborator and curator of materials?
- How can this approach to material making be shared?

The literature review canvassed widely the various approaches to sustainability and adopted the Anthropocene term as the context for today's environmental crisis. In that chapter, I came to terms with the collapsing of boundaries between the natural and the human, and defined a post natural sustainability framework from which to base my design ideas. Theorists such as Haraway and Latour have informed my own sustainability position within this literature. I have also adapted Fry's theory

of sustainment and a quality economy, linking this theory to Haraway's String Figures in which a relational system changes values over time. In the second part of the literature review, I analysed different types of relationships that designers of furniture, buildings, fabrics and artists have to nature in order to ground my practice in historical and contemporary examples.

Having established a theoretical framework through the literature review, the thesis moves into the terrain of my practice as a designer and maker. Using DIY as a design approach I present a process of experimentation which develops Material Kin and also design an accompanying game and guide. Some precedents of DIY material experimentation and game design are highlighted in this part of the thesis, with the aim of further contextualising my design work within an ongoing conversation about the relationship between designers, what they make, and what they imagine for the future. Material Kin shows that through hybridity and DIY processes, sustainable material can be developed. Hybridity is encouraged through substituting various ingredients and processes. Multi-faceted substitutions where waste, by-products or other ingredients can be used should be the aim of designers, so that we are prepared for a future, resource-limited world. No longer can we use the justification of the 'natural' to validate our design decision making, rather we must operate with care and concern towards others with the intention of contributing to a quality economy rather than a quantity economy.

Material investigations in the studio led to unexpected discoveries of Material Kin. As a designer I know that play, experimentation and testing are a valuable ways of gaining experiential material knowledge. Kinship relationships and the process of making the materials by hand infer responsibility to the Material Kin and the maker.

The method of creating Material Kin is articulated through the rubric of a game whereas the specific Material Kin remain speculative, ambiguous and contingent on possible futures. In addition to articulating the process of creating the materials, I wanted to be able to share this knowledge easily

with other DIY material makers both now and in the future, finding an aesthetic and design that was appropriate for DIY maker communities.

While this project has outlined methods, guides, experience and theoretical possibilities that help answer the research questions, it has also raised many possibilities for further exploration and development of the idea of Material Kin. For example, in Stage 1 I focused on Material Kin experiments and generated Collagenated Plaster, which is particularly interesting, as the ingredients come from building and gastronomy fields, and are rarely combined together. By expanding the pool of ingredients and utilising ingredients from other interdisciplinary sources, further unusual collaborations could be formed and have great potential to develop in different directions. Another way of extending this project would be to develop structures and objects using Material Kin. Extending the project in this direction would move the focus of study from the process to the materials. How can these materials create large shelters? How can we collaborate with non-human partners and processes to build structures or garments?

Stage 2 focused on how to share the process and knowledge through the game. In this project the game is a proposition. Whilst I tested the game prototype, qualitative testing is required to evaluate the game in use by other material makers and to ask questions about how non-humans have agency in a game designed and played by humans. Specific functions of the gameplay could also be tweaked, remixed and redesigned. The way that the cards and the map interact could also be developed further. I would consider these ideas for development after evaluating the game in its current form. Creating a map that could be easily modified with the capability to connect to another maker's map to create a multiplayer game board is an exciting possibility. Presently the game has only been developed in a physical format. The game could also be digitised by creating an online iteration as well as creating an archive of Material Kin, to be used as an evolving and growing resource for DIY communities.

Material Kin: A Maker's Guide outlines the process of uncovering and forming Material Kin through experimental design processes. It is envisaged to be a possible aide in forming refuge and shelter in a post natural sustainable future where the role and responsibilities of designers is expanded. The ingredients that are used in the game are found in my immediate environment and speculated to still be available in the environments of different futures. Basic DIY techniques and processes have been employed so that these materials can be created with minimal equipment and knowledge. The guide is designed to change how humans consider our relationships as designers to materials, and to break down categories of the natural, non-natural and the human. The game strives to open up possibilities and potential for collaboration between ingredients, processes and communities of makers.

5 Appendix

Material Kin

Welcome to the Material Kin game and guidebook. You may have found this kit, or been given it, or sought it out.

This game and guide is intended to help the discovery and development of sustainable materials in preparation for a range of futures, as well as the present. Material Kin are the DIY materials that you will be creating from different ingredients from your environment. This guide and game can be used individually but it is recommended to be used in a group context. The game is intended to provide a mode for discovering and sharing new materials, processes, ingredient relations and knowledge with others.

First up you will need to find your ingredients. Trading ingredients with other makers will increase the pool of available ingredients to work with. Experiment with combining these ingredients, creating Material Kin, and finally complete missions and objectives using your Material Kin.

This game is designed to be played out over a number of material making sessions. Each material making session normally lasts for a couple of hours, and a gap of at least a week between each session is recommended. As such, this is not a game that is completed in one afternoon but requires an investment of time and resources to play this game. If you intend to play this game with a group of DIY makers, parts of the game can be played individually between sessions.

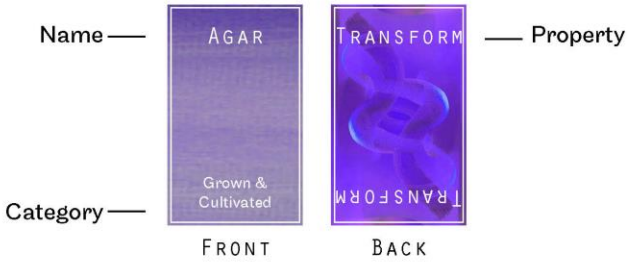
Now it is time to play.

Material Kin
Guide

Ingredient cards

48 ingredient cards have been provided in the game. These ingredient cards can be customised to tailor the game to your specific environment.

There are two sides to each ingredient card. The front of the card has the ingredient name and the category the ingredient belongs to, while the back of the card has its property. The property is also indicated by the colour of the card.



MATERIAL KIN
GUIDE

Ingredient Properties

Each ingredient has a property of either Transform, Mixer, Additive, or Catalyst. You will need to determine what property fits your ingredient best.

The purple cards indicate **Transform** ingredients. This is a property where the ingredient transforms for one state to another.

The aqua cards indicate **Mixer** ingredients. Mixers are ingredients that help other ingredients combine with each other.

The green cards are **Additive** ingredients. Additive is a property where the ingredient adds properties to a material such as colour, texture or smell.

The dark grey cards are **Catalyst** ingredients. Catalyst is a property where the ingredient sparks a change in other ingredients.

MATERIAL KIN
GUIDE

Ingredient Categories

Each ingredient also belongs to a category that indicates its 'aliveness'. The category is listed below the name on the ingredient card.

Organism is a category of ingredients that are currently alive; e.g. enzymes, fungus and bacteria.

Grown and Cultivated describes a once-living natural resource that is grown, harvested, or refined by humans.

Mineral is a material harvested and refined by humans, with a base resource has never been living or growing.

Hybrid is a category that includes the ingredients that are combinations of the above categories.

Reclaimed material cards

These cards are to guide you to find objects and artefacts in your environment which can be used as moulds, mixers or containers in the making process. These cards are useful to bring in at the later stages of development to make the materials more compelling. The Material Kin Plaster tubes is an example of a recipe that uses plaster, but it is the combination with a repurposed cable holder that gives it unexpected utility. These cards represent found artefacts that can be used in the process of making Material Kin e.g. string, saucepans. Reclaimed material cards are light grey.

Material Kin cards

Once a Material Kin has been created, a Material Kin card can then be made. The Material Kin can then be treated as an ingredient for further explorations. Material Kin cards are blue.

MATERIAL KIN
GUIDE

Map

The map shows the various ingredients, Material Kin and processes in relation to each other. There is plenty of room to unearth more ingredients, processes and Material Kin. Written on this map are the ingredients that have been used to develop the sample Material Kin, you can add to this or turn the map over and start your own map from scratch.

Guide

The purpose of the guide is to help you to collect and store recipes and knowledge of material explorations. The guide explains how to play the game, and it has Material Kin recipes as well as extra room for future discoveries, simply unscrew and add in your new recipes.

There are five Material Kin examples already on the map and outlined in the guidebook to help you get started and to help navigate through the map and guidebook layout. Familiarise yourself with the existing Material Kin recipes, create some or all of the Material Kin to develop your skills and to gain knowledge about the ingredients through the making process.

That's all the components of the guide explained; so you can now start to make Material Kin!

MATERIAL KIN
GUIDE

Before the game

First up create a list of potential ingredients and processes available to you.
Sort your ingredients by property and create cards for each ingredient.
Trade ingredients.

Setup

Find yourself a space to work in and store your experiments while they are drying.
Organise your equipment, tools and ingredients. Lay out your moulds ready for the material.
Make sure you have several hours for your experiments.
Consider your safety when using ingredients and processes. A dust mask, eye protection, and oven mitts might be necessory.

Game environment

Devise the constraints of your speculative environment, consider what ingredients and processes are readily available or not available. Construct a mission for your group.

Some ideas for your mission might be:

> Develop Material Kin that can be used for _____ with the following properties _____.
> Develop a shelter for _____ from _____.
> Develop novel ways to use an abundant ingredient for trade with a neighbouring community.

MATERIAL KIN
GUIDE

Instructions to develop Material Kin

1. Sort the available ingredient cards into their different properties. Shuffle the cards in each property group and place face down on the map.

2. Select one card from each of the different property types.

3. Place the four cards in their positions on the map.

4. If, after placing the cards onto the map, it becomes apparent that Material Kin has already been generated from these cards, or that numerous unsuccessful attempts have been made. You can opt to return the cards to the decks and redraw.

5. If you come up with an idea for a potential Material Kin recipe but one or two cards do not feature in your recipe. You may either remove, substitute, or add another ingredient card.

6. Once you are happy with your combination of ingredient cards, look at the Material Kin recipes in the guide for ideas on ratios and processes. The map can help identify what past Material Kin use the same ingredients.

7. Sketch out a map for the way you will combine the ingredients. The sketch will help to formalise the processes you will employ.

8. Add ratios for the different ingredients to your map.

MATERIAL KIN
GUIDE

9. Test sections from the map you have drawn. Test by combining small quantities of ingredients and document the results. These experiments should inform you about what ratios of ingredients are required and knowledge about different processes.

10. Refine your ingredients, processes or ratios if needed and update the map.

11. Draft Material Kin recipe.

12. Make the Material Kin.

13. Wait for at least 24 hours before evaluating the Material Kin and making conclusions about the recipe. It is recommended that you create two samples of the Material Kin and leave one to dry for a shorter amount of time (24-48hrs) and another for a week to document what happens to the material over a longer time frame.

14. Refine again to alter or tweak the recipe. It will generally take 3-4 iterations to produce Material Kin. If you need to alter the recipe, go back to steps 9 - 13.

15. Congratulations you have made Material Kin! Now document your process in the guidebook, update the map and develop a Material Kin card. You can now move onto the mission stage of the game.

MATERIAL KIN
GUIDE

Mission Stage

The mission stage of the game is where you use the Material Kin you have generated to complete your mission that was constructed at the beginning of the game.

It is important to always test and refine, be open to other materials that you might create along the way that do not have the properties you desired, make records and either develop further or return to this material later. Remember these instructions are made to be broken, tweaked and ignored.

6 Bibliography

Anderson, J. 2009, 'Transient convergence and relational sensibility: Beyond the modern constitution of nature', *Emotion, Space and Society*, vol. 2, no. 2, pp. 120-7.
ArchDaily 2010, *AD Classics: Fallingwater House / Frank Lloyd Wright*, viewed 30/07/2018, <http://www.archdaily.com/60022/ad-classics-fallingwater-frank-lloyd-wright/>.
ArchDaily 2013, *AD Classics: La Sagrada Familia / Antoni Gaudi*, viewed 11/05/2018, <http://www.archdaily.com/438992/ad-classics-la-sagrada-familia-antoni-gaudi/>.
Arias-Maldonado, M. 2013, 'Rethinking Sustainability in the Anthropocene', *Environmental Politics*, vol. 22, no. 3, pp. 428-46.
Arias-Maldonado, M. 2016, 'The Anthropocenic Turn: Theorizing Sustainability in a Postnatural Age', *Sustainability*, vol. 8, no. 1, p. 10.
Atwood, M. 2008, *Oryx and Crake*, Virago, London.
Atwood, M. 2009, *The Year of the Flood*, Nan A. Talese/Doubleday, New York.
Ayala Garcia, C., Rognoli, V. & Karana, E. 2017, *Five Kingdoms of DIY-Materials for Design*, TU Delft Open.
Bacigalupi, P. 2009, *The Windup Girl*, Hachette Digital, London.
Bellamy, B.R., LeMenager, S. & Szeman, I. 2016, 'When Energy is the Focus: Methodology, Politics, and Pedagogy', *Postmodern Culture*, vol. 26, no. 2.
Bennett, J. 2010, *Vibrant Matter: A Political Ecology of Things*, Duke University Press, North Carolina.
Benyus, J.M. 1997, *Biomimicry: Innovation inspired by Nature*, Morrow, New York.
Bhatnagar, S. & Hanna, M.A. 1996, 'Starch-based plastic foams from various starch sources', *Cereal Chemistry*, vol. 73, no. 5, pp. 601-4.
Bob Cooper Outback Survival 2018, *Play your cards to survive*, viewed 07/07/2018, <https://www.bobcoopersurvival.com/2009/07/01/play-your-cards-to-survive/>.
Bowker, G. & Star, S.L. 1999, *Sorting Things Out: Classification and its Consequences*, MIT, Massachusetts.
Breuer, J. & Bente, G. 2010, 'Why so serious? On the relation of serious games and learning', *Journal for Computer Game Culture*, vol. 4, pp. 7-24.
Burton, J. 2014, *Understanding Gelatin: Sheets V. Powder Pt 1 of 3*, viewed 14/06/2018, <https://www.youtube.com/watch?v=iUsbA6BMQ6A>.
Carson, R. 1962, *Silent Spring*, Houghton Mifflin, Boston.
Chakrabarty, D. 2009, 'The climate of history: Four theses', *Critical inquiry*, vol. 35, no. 2, pp. 197-222.
Corcoran, P.L., Moore, C.J. & Jazvac, K. 2014, 'An anthropogenic marker horizon in the future rock record', *GSA Today*, vol. 24, no. 6, pp. 4-8.
Crosby, A. & Seale, K. 2018, 'Counting On Carrington Road: Street Numbers As Metonyms Of The Urban', *Visual Communication*, vol. 17, no. 4.
Crosby, A.L., Lorber-Kasunic, J. & Accarigi, I.V. 2014, 'Value the edge: permaculture as counterculture in Australia', *M/C Journal*, vol. 17, no. 6.
Davis, H. 2015, 'Life & Death in the Anthropocene: A Short History of Plastic', *Art in the Anthropocene: Encounters Among Aesthetics, Politics, Environments and Epistemologies*, pp. 347-58.
Dawe, N.K. & Ryan, K.L. 2003, 'The Faulty Three-Legged-Stool Model of Sustainable Development', *Conservation Biology*, vol. 17, no. 5, pp. 1458-60.
Delmas, M.A. & Burbano, V.C. 2011, 'The drivers of greenwashing', *California Management Review*, vol. 54, no. 1, pp. 64-87.
Edinformatics 1999, *Chemical and Physical Properties of Agar used in Cooking*, viewed 27/06/2017, <http://www.scienceofcooking.com/chemical_physical_properties_agar.htm>.
Edwards, A.R. 2005, *The Sustainability Revolution: Portrait of a Paradigm Shift*, New Society Publishers, Gabriola.
European Bioplastics 2017, *Bioplastic Materials*, viewed 30/07/2018, <https://www.european-bioplastics.org/bioplastics/materials/>.

Farm, A., Shapiro, A.M., Lord, C. & Schreier, C. 1970, *Inflatocookbook: A Pneu-age Tech Book*, Ant Farm, Incorporated, San Francisco.
Félix, M., Romero, A., Martín-Alfonso, J.E. & Guerrero, A. 2015, 'Development of crayfish protein-PCL biocomposite material processed by injection moulding', *Composites Part B: Engineering*, vol. 78, pp. 291-7.
Ferri, G. 2013, 'Satire, propaganda, play, storytelling. notes on critical interactive digital narratives', *International Conference on Interactive Digital Storytelling*, Springer, pp. 174-9.
Fry, T. 2003a, 'An Other Economy: The Voice of Sustainment', *Design Philosophy Papers*, vol. 1, no. 6, pp. 371-80.
Fry, T. 2003b, 'The Voice of Sustainment: An Introduction', *Design Philosophy Papers*, vol. 1, no. 1, pp. 41-8.
Fry, T. 2016, *Simposio de Diseno A Tony Fry*, viewed 21/06/2018, <https://www.youtube.com/watch?v=7xayhp9muxI>.
Fujiwara, D. 2018, *21_21 DESIGN SIGHT | "COLOR-HUNTING" | About*, viewed 11 /05/2018, <http://www.2121designsight.jp/en/program/color_hunting/>.
FutureLearn, U. 2018, *How to play the Game of Global Futures - Environmental Humanities - UNSW Sydney*, @futurelearn, viewed 21/07/2018, <https://www.futurelearn.com/courses/remaking-nature/0/steps/16750>.
Games For Change 2018, *About Us*, viewed 08/07/2018, <http://www.gamesforchange.org/who-we-are/about-us/>.
Goodland, R. 1995, 'The concept of environmental sustainability', *Annual Review of Ecology and Systematics*, vol. 26, no. 1, pp. 1-24.
Green Plastics 2009, *Make your own bioplastic - YouTube*, viewed 15/06/2018 2018, <https://www.youtube.com/watch?v=5M_eDLyfzp8>.
Haraway, D. 1992, *The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others*, Routledge, New York.
Haraway, D. 2015, 'Anthropocene, capitalocene, plantationocene, chthulucene: Making kin', *Environmental Humanities*, vol. 6, no. 1, pp. 159-65.
Haraway, D.J. 2008, *When Species Meet*, vol. 224, University of Minnesota Press, Minneapolis.
Haraway, D.J. 2016, *Staying With the Trouble: Making Kin in the Chthulucene*, Duke University Press, Durham.
Hauser, J. 2016, 'Biomediality and Art', *Recomposing Art and Science*, Walter de Gruyter, pp. 201-19.
Hawkins, S. 2018, *Sky gardens and green cities*, viewed 11/05/2018, <http://www.australiangeographic.com.au/topics/science-environment/2015/06/sky-gardens-and-green-cities>.
Heise, U.K. 2011, 'Martian Ecologies and the Future of Nature', *Twentieth Century Literature*, vol. 57, no. 3/4, pp. 447-71.
Holtzman, B., Hughes, C. & Van Meter, K. 2007, 'Do it yourself and the movement beyond capitalism', *Constituent imagination: Militant Investigation//Collective theorization*, pp. 44-61.
Huizinga, J. 1938, *Homo Ludens: A Study of the Play-Element in Culture*, Routledge & Kegan Paul, London.
Humier, L. 2012, *Cooking Material. Could Molecular Gastronomy Help Discover New Matter*, Triennale Design Museum, Milan.
Illas, E. 2014, 'Gaudi Gehry Barcelona', *Cultural Critique*, pp. 144-61.
Institute of Making 2012, *Fish-Scale-Plastic*, viewed 03/04/2018, <http://www.instituteofmaking.org.uk/materials-library/material/fish-scale-plastic>.
itch.io 2017, *#ResistJam*, @itchio, viewed 08/07/2018, <https://itch.io/jam/resistjam>.
Jazvac, K. 2014, *Plastiglomerates*, viewed 11/07/2017, <http://www.kellyjazvac.com/Stones/Stones.html>.

Jonas, W. 2007, 'Research through DESIGN through research: A cybernetic model of designing design foundations', *Kybernetes*, vol. 36, no. 9/10, pp. 1362-80.
Jordan, C. 2011, *Midway: Message from the Gyre*, viewed 01/07/2018, <http://www.chrisjordan.com/gallery/midway/#CF000478%2019x25>.
Karafyllis, N.C. 2007, 'Ethical and epistemological problems of hybridizing living beings: Biofacts and body shopping', *The Ethics of Today's Science and Technology. A German-Chinese approach.*, pp. 185-98.
Karami, A., Golieskardi, A., Keong Choo, C., Larat, V., Galloway, T.S. & Salamatinia, B. 2017, 'The presence of microplastics in commercial salts from different countries', *Scientific Reports*, vol. 7.
Keeble, B.R. 1988, 'The Brundtland Report:'Our Common Future'', *Medicine and War*, vol. 4, no. 1, pp. 17-25.
Kellert, S. 2008, 'Dimensions, Elements, and Attributes of Biophilic Design', *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*, Wiley, New Jersey, pp. 3-20.
Knitting Industry Creative 2018, *In Conversation with Asta Skocir, Co-Founder of AlgiKnit | Knitting Industry Creative*, viewed 14/06/2018, <https://www.knittingindustry.com/creative/interview-with-asta-skocir-co-founder-of-algiknit/>.
Latour, B. 2012, *We Have Never Been Modern*, Harvard University Press, Cambridge.
Lee, J. 2014, *Material Alchemy: Redefining Materiality Within the 21st Century*, BIS Publishers, Amsterdam.
Leeds, A.J., Kudrowitz, B. & Kwon, J. 2018, 'Mapping associations: Exploring divergent thinking through mind mapping', *International Journal of Design Creativity and Innovation*, pp. 1-14.
Leopold, A. 1949, *A Sand County Almanac; and Sketches Here and There*, Oxford University Press, Oxford.
Lewis, M.W. 1994, *Green Delusions: An Environmentalist Critique of Radical Environmentalism*, Duke University Press, Durham.
Macklin, C. 2013, 'Games for a New Climate: A Game Design Case Study for Humanitarian Programs', The New School, New York City.
Maguire, S. & Hardy, C. 2009, 'Discourse and deinstitutionalization: The decline of DDT', *Academy of Management Journal*, vol. 52, no. 1, pp. 148-78.
McKibben, B. 2011, *Eaarth: Making a Life on a Tough New Planet*, St. Martin's Griffin, New York.
McNeill, J.R. 2001, *Something New Under the Sun: An Environmental History of the Twentieth-Century World*, WW Norton & Company, New York.
Mota, C. & Boyle, K. 2018, *openMaterials*, viewed 14/05/2018, <http://openmaterials.org/>.
Mueller, T. 2008, 'BIOMIMETICS design by nature', *National Geographic*, vol. 213, no. 4, pp. 68-91.
Munro, G. 2018, *Full Grown*, viewed 10/05/2018, <https://fullgrown.co.uk/about-full-grown/>.
New, M., Liverman, D., Schroder, H. & Anderson, K. 2011, 'Four degrees and beyond: The potential for a global temperature increase of four degrees and its implications', The Royal Society, pp. 6-19.
Nixon, R. 2013, *Slow Violence and the Environmentalism of the Poor*, Harvard University Press, Cambridge, MA.
open Materials 2018, *Molecular Gastronomy: Boric Acid Caramel*, viewed 03/04/2018, <http://openmaterials.org/boric-acid-caramel/>.
Orr, D.W. 2002, *Nature of Design: Ecology, Culture, and Human Intention*, Oxford University Press, Cary.
Pascoe, B. 2013, *Dark Emu: Black seeds agriculture or accident?*, Magabala Books, Broome.
PETLab 2018, *Re:Activism NYC*, viewed 08/07/2018, <http://petlab.parsons.edu/newWeb/index.php?content=none&project=reactivism>.
Piccinini, P. 2006, 'In another life', in City Gallery (ed.)vol. 19, Wellington.

PokéPlayer 2014, *History of Pokémon TCG*, viewed 05/08/2018, <http://pokeplayer.com/news/6-history_of_pokemon_tcg_-_base_set>.
pvi collective 2018, *blackmarket*, viewed 22/07/2018, <http://pvicollective.com/projects/blackmarket/>.
Recochem 2018, *MSDS Information*, viewed 15/06/2018, <http://www.recochem.com.au/index.php/msds/b/>.
Robinson, J. 2004, 'Squaring the circle? Some thoughts on the idea of sustainable development', *Ecological Economics*, vol. 48, no. 4, pp. 369-84.
Rognoli, V., Bianchini, M., Maffei, S. & Karana, E. 2015, 'DIY materials', *Materials & Design*, vol. 86, pp. 692-702.
Rolls, E.C. 1984, *A Million Wild Acres*, Penguin, Ringwood.
Rose, D. 2013, 'What if the Angel of History were a Dog?', *Cultural Studies Review*, vol. 12, no. 1, pp. 67-78.
Rosner, D.K. 2018, *Critical Fabulations: Reworking the Methods and Margins of Design*, MIT Press.
Schuh, R.T. 2003, 'The Linnaean system and its 250-year persistence', *The Botanical Review*, vol. 69, no. 1, p. 59.
Shiva, V. 2011, 'Equity: The Shortest Way to Global Sustainability', in C.C. Jaeger, J.D. Tàbara & J. Jaeger (eds), *European Research on Sustainable Development: Volume 1: Transformative Science Approaches for Sustainability*, Springer, Berlin, pp. 23-7.
Sisson, M. 2011, *Meat Glue: Separating Fact from Fiction*, viewed 30/07/2018 2018, <https://www.marksdailyapple.com/meat-glue-separating-fact-from-fiction/>.
Steffen, W., Grinevald, J., Crutzen, P. & McNeill, J. 2011, 'The Anthropocene: Conceptual and historical perspectives', *Philosophical Transactions of the Royal Society: Mathematical, Physical and Engineering Sciences*, vol. 369, no. 1938, p. 842.
Stelarc 2015, *STELARC | IMAGES*, viewed 30/07/2018, <http://stelarc.org/?catID=20290>.
Terranova, F. 2016, *Donna Haraway: Story Telling for Earthly Survival*, E. Meiresonne.
Trailside Games 2018, *The Story of Backcountry: The Game of Wilderness Survival*, viewed 07/07/2018, <http://trailsidegames.com/the-story/>.
Trainer, T. 1990, 'A rejection of the Brundtland Report', *IFDA dossier*, no. 77, pp. 71-84.
Trofe, D. 2016, *MushLume lighting*, viewed 10/05/2018, <http://danielletrofe.com/lighting/>.
Tsing, A. & Pollman, E. 2005, 'Global futures: The game', *Histories of the Future*, Duke University Press, pp. 105-22.
Urban Survival Playing Cards 2016, *Urban Survival Playing Cards*, viewed 07/07 2018, <http://urbansurvivalplayingcards.com/>.
UTS 2015, *Governance Support Unit*, University of Technology, Sydney, viewed 27/06/2018, <http://www.gsu.uts.edu.au/policies/sustainability-policy.html#statement>.
Van der Ryn, S. & Cowan, S. 2010, *Ecological Design*, Island Press, Washington.
Visionlearning 2018, *Science Glossary | Visionlearning*, viewed 05/08 2018, <https://www.visionlearning.com/en/glossary>.
White, D., Rudy, A. & Gareau, B. 2015, *Environments, Natures and Social Theory: Towards a Critical Hybridity*, Palgrave Macmillan, Basingstoke.
White, D. & Wilbert, C. 2006, 'Introduction: Technonatural time–spaces', *Science as Culture*, vol. 15, no. 2, pp. 95-104.
Wilson, E.O. 2009, *Biophilia*, Harvard University Press, Cambridge.
Wizards of the Coast 2014, *Dungeon Master's Guide (Dungeons & Dragons Core Rulebooks)*, Wizards of the Coast, Renton.
Yoldas, P. 2014, *Ecosystem of Excess*, viewed 11/07/2017, <http://www.pinaryoldas.info/WORK/Ecosystem-of-Excess-2014>.
Zalasiewicz, J., Waters, C.N., do Sul, J.A.I., Corcoran, P.L., Barnosky, A.D., Cearreta, A., Edgeworth, M., Gałuszka, A., Jeandel, C. & Leinfelder, R. 2016, 'The geological cycle of plastics and their use as a stratigraphic indicator of the Anthropocene', *Anthropocene*, vol. 13, pp. 4-17.

Zyda, M. 2005, 'From visual simulation to virtual reality to games', *Computer*, vol. 38, no. 9, pp. 25-32.