

‘LIBRETTISING’ SCIENCE: Using operatic narrative and performance to
re-present scientific thought in an investigation of new methods
towards developing contemporary opera.

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Abstract

This practice-based research investigates presenting scientific concepts and research on the operatic platform through an interdisciplinary and collaborative process. It focuses on libretti writing and performance, using tools such as anthropomorphism, archetype and mythological characters to engage participants and the audience with the subjects on stage. The work explores how to create an experience which enables a deeper sense of the reality of the science presented, and makes the audience, performers and creative practitioners complicit in the existence of the concepts, or objects, being performed. The performativity of the work is allowed to play a key role in shaping the final piece, as the researcher explores the embodiment of the characters during the process of production towards cyclical presentations of the work.

This investigation includes two major collaborative projects in which I participated as librettist, producer and performer:

1. *The Flowering Desert*. An opera about the discovery of the TRAPPIST-1 planetary system, written to be performed specifically in planetaria. This involves a collaboration with: composer Daniel Blanco Albert; designer Alexander Kaniewski; filmmaker Tadas Stalyga; projectionist Leon Trimble; and the ThinkTank Planetarium (led by Colin Hutcheson).
2. *Lipote: An Interconnected Journey*. An opera/musical about deforestation due to intensive agriculture. Set in the soil from the perspective of the roots of trees. This involves a collaboration with: composer Oliver Farrow; jewellery maker Wanshu Li; choreographer Jingya Peng; and sound artist Leon Trimble.

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1 Chapter 1

1.1 Introduction

This doctoral research seeks to make use of the subjects of recent scientific research in the creation of new operatic works, in particular using anthropomorphism with reference to the creation of libretti and performance. The scientific concepts and fields of research which inspired each case study manifest themselves in the various media that opera allows us to play with, through the characters and narrative, the music that leads these characters through their journey and the scenic elements such as venue, lighting, costume, and props. The subject can also be treated as a collaborator alongside the creative participants (composer, designer, choreographer) and performers. As such the PhD has required an interdisciplinary approach to each work, grounded in creative experimentation leading to live performance.

During this PhD when referring to 'science' I mean both the broader categories of the subject and the individual objects that are studied in the pursuit of knowledge via the scientific method of experimentation, observation and quantitative analysis. This involved looking to current trends in scientific research, searching out new findings through reading recent journal papers and discussing subjects with the scientific researchers in that field.

I am situated within this practice-based research as both librettist and performer. Starting from the science itself, and the scientists' experience, I construct narratives, characterisations and relationships that combine scientific ideas with typical human behaviours (e.g., love, anger, regret). Through an anthropomorphic transposition of the material, I aim to bring the audience closer to the subject. The production of the libretto acts as one of the central features of the research and is informed by

experimentation with multimedia digital artefacts, performance, and research into the fields of science, psychology, and opera. This is then extended into the production of the full theatrical work. All work is produced in cycles (a method described later in the Methodology), undergoing several stages. This is an ongoing process, meaning that the works presented will evolve still further through scrutiny and collaborative work.

My background means I am ideally positioned to carry out this research: I hold an undergraduate degree in Physics and Philosophy, a Masters in Environmental Technology and subsequently worked as a physics teacher, meaning that I have been trained in scientific thought and am experienced in the public's response to the way science is often presented. I am also a performer, with a Masters in Vocal Performance, and have worked as a performer and creator of new works, meaning that I am able to approach the creation of libretti from the perspective of a performer and producer as well as that of scientist and science disseminator. I am also co-founder of the opera company, *Infinite Opera*, along with composer Daniel Blanco Albert. Our approach to creating new work is always to embed the chosen subject in multiple ways within the construction of the libretto and music, whether that be through anthropomorphising, or as a way to generate narrative and character structures, or using data, concept or historical setting to inform the music. Our first piece *Entanglement! An Entropic Tale* (2018) told the story of an electron and a positron who fight against entropy to find a way to be together on a journey through the universe. This work uses the relationships and theories in physics to guide and dictate the relationships and fates of the characters on stage.

The present research comprises the production and performance of two new operas, used as case studies within the thesis. These are *The Flowering Desert* – an opera about the discovery of the TRAPPIST-1 planetary system – and *Lipote: An interconnected journey*; an opera about the root networks of trees in rainforests and plantations. The libretti and a filmed performance for each work are available

in each chapter in folders '2.5 The Flowering Desert Film and Libretto' and '3.5 Lipote An Interconnected Journey Film and Libretto'. This is supported by a commentary which explores the characterisations and creative process involved. Each work encompasses both creative and production phases, to fully explore the process of 'librettising': performing and carrying a subject to an audience through the medium of opera. In particular, the works seek to explore the following areas: how science can be embedded in operatic characters, form and performance and the role of collaboration in achieving this outcome. The aim of the research was to investigate the above through the creation of new interdisciplinary work leading to performance, the writing of libretti which embed and anthropomorphise scientific thought and the exploration of vocal and performance techniques to help develop a broader range of expression for embodying these abstract concepts. Even though the audience and their feedback are used as tools towards understanding the work during its developmental stages, an analysis and understanding of their response to the work is not a key aim. This research does not explore the use of opera as a pedagogical tool to teach an audience about a subject. Whilst it enables a different approach to science, using characters and stories which will strike a chord in order to generate a more empathetic experience of these topics is employed, this is not the focus of the research.

My approach has developed in the context of considering the more-than-human, specifically in reference to David Abram's text *The Spell of the Sensuous* (1996). This explores the way in which the non-human is manifested in our consciousness, and how we relate to the non-human in a contemporary and urbanised society. To Abram the concept of a story transmitted orally is key to the embodiment of knowledge about the more-than-human and the connection to the natural world. He says:

Stories, like rhymed poems or songs, readily incorporate themselves into our felt experience; the shifts of action echo and resonate our own encounters—in hearing or telling the story we vicariously live it, and the travails of its characters embed themselves into our own flesh. The

sensuous, breathing body is, as we have seen, a dynamic, ever-unfolding form, more a process than a fixed or unchanging object. As such, it cannot readily appropriate inert 'facts' or 'data' (static nuggets of 'information' abstracted from the lived situations in which they arise). Yet the living body can easily assimilate other dynamic or eventful processes, like the unfolding of a story, appropriating each episode or event as a variation of its own unfolding. (Abram, 1996: 76)

Writers such as McGilchrist (2021) have argued that the scientific and rationalist enlightenment paradigm to objectify and dissect the natural world, separating the scientist from the studied object (Magnat, 2020:125) and sanitising the experimental context to a point which no longer represents the real world, now has the potential to work against our development. The onset of pandemics, destruction of land, loss of biodiversity, growing economic inequalities both globally and at home may all be symptoms of an objectified and abstracted view of ourselves in our world. This research project explores through practice the use of theatre, and particularly opera and music theatre, to bring us closer to these objectified and abstracted worlds, giving them an emotional relevance and allowing an audience to see themselves fully reflected in the concepts and ideas we study (and not just see them as an external object, whose presence is proved through an empirical assessment). The more I have looked at science this way, the more I have found that even though our main focus in the development of knowledge has been to reframe the way we see the world through the scientific lens, the embodiment of knowledge may still be experiential and empathetic.

1.2 Research Background

1.2.a. Science, Story and Stage

As an analogy for the process undergone by the science-based subjects in this work, consider the Earth itself, its atmosphere and surface, and how it acts as a lens through which we experience what is both within and beyond it. The light from the sun is reflected, making the external world visible and connecting people to their surroundings by the path of a photon. The daylight, sent directly from the Sun, has undergone several transformations before being received by the retina. As it enters our atmosphere the light and radiation from the sun and more distant stars is scattered and refracted or reflected, making the sky blue, the sunsets red, and changing the perceived position of celestial objects in the sky. Continuing its now altered path it can either travel directly into the eye, become further refracted by some other material or partially absorbed, scattered or reflected by other objects. When I perceive my surroundings in daylight, I do not remember in every instant that this light came from, and was created by, the sun, and that in fact in these moments I am engaged in a direct relationship to the fiery star at the centre of our planetary system. The sun is mediated to me through the prism of the earth and its atmosphere and surface, yet the relationship is still there and reminding me that the sun really does exist. Beyond the limits of the Earth's atmosphere the sun emits radiation I do not see: X-rays and gamma rays which are shielded from me. The fundamental building blocks of life protect me from experiencing the fullness of what the sun is and creates, yet by experiencing the scattered refracted and reflected light I am able to know that this fullness and reality is there beyond our reach.

This work makes use of this mediated, scattered, refracted and transformative process. The sun acts as the idea or 'subject' and the Earth – its atmosphere and material makeup – as the human psyche, our

archetypal stories and transpersonal¹ experiences, and the operatic stage and performer. Through an anthropomorphic and dramaturgical refraction of the subject its every day, and even eternal, relationship to us as humans is transmitted to the audience, who become the receiver.

Opera is a prism which allows the audience to receive a subject in many ways, just as raindrops help us to receive all the refracted colours of light in a rainbow. They can receive the subject in opera refracted and scattered through stories and emotions (which in this work are created through properties of the science), the musical journey and the visual representation of it. In receiving the performance, the audience becomes a key player in the piece, engaging with the subject on stage, and becoming complicit in its existence.

By looking through my own human tinted glasses, and acknowledging the ways in which these lenses refract, distort and reflect what passes through them, I can start to imagine what exists beyond them and get to sense what that subject might really be in its fullness.² This work aims to first acknowledge through narrative and characterisation how we as humans see through the lens of our own species, in order to empower the participants and audience to centre their thoughts in the worlds and realities that exist outside of themselves (even if we cannot see them, touch or experience their existence ourselves).

¹ 'Transpersonal experiences may be defined as experience in which the sense of identity or self extends beyond (trans) the individual or personal to encompass wider aspects of humankind, life, psyche or cosmos.' (Walsh and Vaughan, 1993: 203)

² This is similar in some ways to Donna Haraway's metaphysical concept of diffraction. She prioritises diffraction over reflection or refraction saying that '[d]iffraction does not produce 'the same' displaced, as reflection and refraction do. Diffraction is a mapping of interference, not of replication, reflection or reproduction. A diffraction pattern does not map where differences appear, but rather maps where the effects of difference appear.' (1991: 300). In this research the multimodal elements of opera, and the concepts that determine the dramaturgical structuring of the narrative, are acting as a performative lens through which the subject is viewed. In this sense I am not only diffracting but also acknowledging the refraction, scattering and reflection of the subject, through the optical, man-made, world of story and stage.

It focuses on the abilities of anthropomorphism to disrupt typical views of these 'subjects' as being relegated to the realm of science and the interest of only scientific thinkers, re-presenting them in our human selves to refocus the way theatre makers and audiences think about them. Just as I see the sun in everything around me, I can also see all of these subjects, and my relationships to them in relationships with other individuals and our species.

In Iain McGilchrist's seminal text *The Master and his Emissary* he describes how important imitation has been in the development of human consciousness and intelligence, describing it as 'imagination's most powerful path into whatever is Other than ourselves' (McGilchrist, 2009: 248). In the same argument he goes on to explain that:

The enormous strength of the human capacity for mimesis is that our brains let us escape from the confines of our own experience and enter directly into the experience of another being: this is the way in which, through human consciousness, we bridge the gap, share in what another feels and does, in what it is like to be that person. This comes about through our ability to transform what we perceive into something we directly experience.

It is founded on empathy and grounded in the body. In fact, imitation is a marker of empathy. (McGilchrist, 2009: 248)

As a performer the imitation, assimilation and embodiment of what is often described as *the other* (the non-human in this case) enables the body to enact and explore the inherent drama that lies in the perceived existence of that *other*. This in turn can help to inform the creation of a narrative that can come out of the physical experience of the body performing the subject.

As a singer one can also consider how the voice engages with the subject through timbre, text and vocal communication. Virginie Magnat explores the ability of the voice and vocality to engage in the

experience of creativity. She cites Fox and Alldred's description of creativity as an 'open-ended flow of affect that produces innovative capacities to act, feel and desire in assembled human and non-human relations'. She suggests that an understanding of the:

ecology of other/more-than-human relations is key to the development of non-anthropocentric perspectives on the affectivity - understood as the transformative power - of the sensorially experienced, non-visual materiality of sonic/aural/phonic and vocal performativity. (2020: 145)

Here she acknowledges from the perspective of a singer and performer that vocal performativity can be a powerful tool to engage in this exploration of the *other* and our relationship with it. ³

1.2.b Anthropomorphism

Anthropomorphism has been used as a way of relating to all forms of art and language since the earliest traces of human activities. Converting more-than-human subjects and experiences into human language and expression has played a key role in the development of human culture. David Abram shows in *The*

³ This is further cemented in when she says:

vocality is an extension of movement, and [that] exploring the body-voice connection enables the performer to experience an interconnection between the organicity of the human body and the organicity of the natural world. This is reflected in the use of imagery evoking natural elements and the importance of connection to space/place, as well as in the fluidity of the notion of organicity encompassing all forms of life, human and other/more than human.

Within this relational understanding of ecology, performance may be considered as a continuous search for balance, or a deeply felt experience of life as 'precarious equilibrium' . . . From such a perspective, singing is experienced as a material practice striving to sustain ecosystem balance between all sources of life.' (2020: 40-41)

Spell of the Sensuous the extent to which our language and alphabet may have formed around images of animals, and experience of the land:

Writing, like human language, is engendered not only within the human community but between the human community and the animate landscape, born of the interplay and contact between the human and the more-than-human (Abram, 1996: p. 95)

Equally, jumping forward to the modern period, Caroline Van Eck says that:

In mediaeval and Renaissance architecture, it provided formal patterns for design and metaphors to understand architectural form. In the nineteenth century, a new variety of anthropomorphism arose in the aesthetics of empathy, or *Einfühlung*, which explained the artworks' effects on the mind by relating those effects to human shapes and to the physical or psychological processes they expressed. (Van Eck in King et al. 2012: 16-17)

In an exploration of the historical and cultural significance of anthropomorphism, Dario Gamboni references the social anthropologist Pascal Boyer and his description of anthropomorphism as the various different human domains (e.g., physical, intellectual, social etc.) projected onto another body (King et al., 2012: 20-22). Siân Ede also makes use of this definition of projection in her text *Art and Science* (2005) when describing how anthropomorphism may have given evolutionary benefits by supplying the hunter gatherer with a way to predict the behaviours of their prey and competitors. Yet when describing the history of anthropomorphism through the cave paintings of God-like half-human, half-animal figures, she fails to consider that these imagined creatures show both the animal being anthropomorphised and the human being zoomorphised. Gamboni does go on to reject this projection-based definition as old-fashioned, expressing the importance of interpretation over projection in the act of perception. He makes the clear point that the perceived anthropomorphised identity of any subject

must include values both from the human characteristics assigned to it and the characteristics of the subject itself, making this a two-way dialogue between the anthropo- and the subject. Despite this he is in agreement with Stewart Elliott Guthrie's account of anthropomorphism which Gamboni describes as:

an effect of the cognitive dimension of perception and 'our need to find whatever pattern is most important' (2012: 20)

This view of Guthrie's is highly anthropocentric, positing that anthropomorphism has been a way to endow other subjects with the most intelligent and 'important' patterns that pertain to human behaviour.

It is this view of anthropomorphism as something which only works to elevate the human, and blinds us from the reality of the subject, that has been argued against by scholars such as Karen Barad (2007) and Jane Bennett (2010). Lisa Woynarski expands on her own definition of 'ecological anthropomorphism' as such writing that 'is one way to recognize the similar agencies and vibrancy of the human and the more-than-human'. (2015: 32)

Through analysis of recent films and installation art she suggests that anthropomorphism can help us to see both the similarities and differences we hold with the more-than-human. Woynarski goes on to describe how Karen Barad argues directly against Pascal Boyer, stating that Barad's 'anthropomorphic moment' (Barad, 2012) has the ability to not entrench our narcissistic 'habits of projection' but to actually 'decent[er] the human by problematizing the binary distributions between human and more-than-human.' (Woynarski, 2015: 27). In addition to this Bruno Latour has argued that the etymology of the term itself implies a two-way relationship:

Anthropos and *morphos* together mean either that which has human shape or that which gives shape to humans. (2009: 160)

This gives agency to the subject to shape the human perception of it during the process of anthropomorphism. It becomes an 'actor'⁴ and is no longer a passive agent. If we are aware of the pitfall present in Guthrie's definition, we can mindfully ensure we shine a light on comparative differences between us and the non-human, and do not glorify the similarities, or give greater value to whatever seems most human out of the non-human world. In this seemingly paradoxical approach, I am seeking those qualities and narratives within human stories and archetypes that will most reflect the superficially non-human characteristics of my subjects. In this act I am not only turning the non-human to human, but I am also converting the performers and audience into the non-human subject.

Jane Bennett believes in the importance of anthropomorphism saying that:

We need to cultivate a bit of anthropomorphism – the idea that human agency has some echoes in non-human nature – to counter the narcissism of humans in charge of the world. (2010: xvi)

There is clearly a manner in which the use of anthropomorphism can become a disruptive force, reframing the way we see objects and our relationships to them. In my research anthropomorphism makes use of ideas of the collective unconscious and archetype, linking the audience to the transpersonal experiences of classic narratives and characters which have been encountered throughout civilisations in mythology and folk tales. I do this to pre-empt the initial shock and confusion at having to deal with concepts or objects which are normally distant and removed from our daily lives. Presenting them anthropomorphically in a classically defined and traditional format gives a structure through which the audience can receive and experience the subjects. Through a methodology involving methods which

⁴ Something that has the ability to affect the path of another object/subject through trauma and transformation (Latour, 2005: 46).

enable a detailed process of engaging with the subject myself, I attempt to allow it to speak, through this human lens, directly to the audience. In creating a relationship through which the audience can start to empathise with the subject, it has a broadened field of existence within the audience's experience as well as those on stage. This occurs, in a return to Latour's definition, as the audience also become anthropomorphised by the subject. They can allow their human selves to be shaped as much as I and the other creative participants have humanly shaped the subject. Perhaps through these experiences one can really decentre the human experience away from the self, as suggested by Woynarski. So long as it is possible to see everything through this lens, and find the archetypal human traits in *all* subjects, one can protect against the glorification of the most obviously human-like systems, in a realisation that all systems are human-like when seen through the human gaze. In fact, the similarities work to create an interface through which it is possible to allow the existence of those more-than-human subjects to leak more permanently into collective conscious and unconscious thoughts.

The present project takes science – a human pursuit of knowledge – as a basis for the dramaturgical structure of the operas developed, alongside other human representations of the natural world, such as mythology and psychology. This may encompass the laws and systems of scientific topic, the approaches taken to research by scientists, and even how our environments and upbringings shape the way we understand the natural world and phenomena around us. This engages with the way the subject is perceived via the human lens, self-consciously anthropomorphising to better understand our relationship with it, and enable greater self-awareness in how it impacts our realities, and how we also impact it.

1.2.c Archetypal Narratives, Models, Characters and Myth

Using myth and archetype to guide the development of characters and narratives aims to begin dissolving perceived barriers to scientific research and reframe it in a way which does not impose didactic demands on the audience and performers, but asks them to engage with the subject by physically experiencing it and the characters and archetypes involved.

There is already an extensive academic canon on the relationship between psychological archetypes, semiotics and narrative in myth. Liszka (1989) breaks down these narratives into the structures of 'rules', 'transgressions' and 'hierarchies'.⁵ Frye's (1957) four mythoi of comedy, romance, tragedy and satire define the key elements in each genre.⁶ Jung's archetypes (1980) present possibilities for characters which may be represented through science as well as art. Joseph Campbell (1978) has modelled the path of the hero in different cultural representations. Lacan's four discourses (Everett, 2015) on the interactions between the conscious and subconscious, discuss how characters can interact with different objects, whether these be real, lost or metaphorical. An understanding of all these different interactions, alongside research into contemporary scientific research, provides a foundation for embedding, and anthropomorphising, science within a mythological narrative.

⁵The narrative will start within a certain set of rules. These will be disrupted, perhaps through crisis, called the transgression. Finally, this will lead to a resolution of the crisis which will potentially destroy or enhance the hierarchy.

⁶ Each include 6 internal phases which will correspond with neighbouring categories. They can overlap via archetypal themes: agon (conflict), pathos (catastrophe), sparagmos (anarchy) and triumph. They include specific characters: comedy features senex iratus, romance features dream characters, satire features caricatures, irony features an unaware hero and tragedy features sacrifice.

The Flowering Desert makes use of the Jungian concept of the collective unconscious and archetypes which he claims are scattered throughout mythology from across all cultures. In Jung's text on archetypes, he states that '[t]he archetype in itself is empty and purely formal, nothing but a *facultas praeformandi*, a possibility of representation which is given a priori.' (Jung, 1954, vol 9i:155) His forms of the archetypes can take on any content and still have a strong resonance with the psyche. Gill (2006: 53-54) writes:

While myth is the primary cultural manifestation of the collective unconscious, Jung suggests that fields affording opportunities for free expression are the next most likely outlets of archetypal activity. Dreams, religion, literature and the arts, speculative philosophy, politics, sex and romance, and even science are just some of the human activities that Jung sees as being strongly influenced by the collective unconscious: all of which, he maintains, might be better illuminated by our understanding of archetypes.

In a paper by environmentalists F. R. Westley and C. Folke (2018: online) they stated that '[c]ollaboration in the art-science interface undoubtedly has the potential to reveal and explore the role of symbols in unlocking dimensions and elements of the human spirit, that correspond to the dimensions and elements of the biosphere'. This argues that the iconography and symbolism of history and society can provide a channel between scientific thought and the inner emotional life. When discussing the work of Jung on archetype and symbol, and how to understand the existence of such unknowable things as the divine, Edward C. Whitmont (1991: 79) tells us that '[t]he symbol, as Jung has defined it, always ranks below the level of the mystery it seeks to describe. And the objective psyche in

Jung's view, is far from a product of man's subjectivity'⁷. He goes on to describe the ways that religion has been experienced through the use of symbols and is, according to Jung, imposed on our subjective psyche as archetypal forms experienced not through individual choice but as a result of the culture we live in. In particular, the relevance of different mythologies emerges and dies away in relation to the prevailing objective psyche of a particular cultural period and setting. One of our prevailing cultural frameworks since the Enlightenment has been the rational and scientific approach to the world. The commonly held view of what this means often involves: the collection of data, the understanding of the world through numbers, and the subsequent separation that that creates from the scientists and the lay person. As non-scientists are distanced from scientific research through fear of ignorance, or lack of understanding, our contemporary objective psyche may be lost in the divide.

Mixed into these discussions on how to relate to these cultural pillars of the collective unconscious is the discussion of postmodernism and the compartmentalising and fragmentation of the individual. Roesler (2008: 424) expresses the view that '[p]ostmodern epistemology declares that 'out there' there are no fixed and independent truths that one could describe', and then goes on to explain the relationships between a postmodern constructivism of knowledge and identity and Jung's theories of the self. As in the metaphor of the Sun and the Earth's refraction I turn back to the question of whether, and how, I can know that the external reality exists beyond my perception of it, which can, in a Cartesian approach, intensify the importance of the existence of the individual and the self. However, as with the metaphor of the Earth's refraction, the lens through which I perceive does not negate the existence of the external, and the decentring of one's experiences outwards, towards the experiences of other humans

⁷ The objective psyche is another way of describing the collective unconscious. It was used as a term by Jung in his Collected Works, 7, paragraph 103n.

and the non-human is still something that is an important aspect in cultural development (especially in a more secular society). In creating large-scale, full length works featuring artists, performers and audience, this research seeks to elevate the seemingly mundane and obsolete objects and objectified elements of our natural world, engaging with them by understanding how they can excite and ignite the minds of those who focus their energies towards them, and through a type of romantic representation, bring them to a heightened centre stage in which the audience is confronted with both the absurdity of their human narratives and a reverence for their existence. By supplying the audience and participants with an over-the-top, dramatized version of the subject I acknowledge an attempt to share in its existence, finding the ways in which our cultural histories constructively interfere with our perception of it.

Neo-realist acceptance that there may be a type of reality to objects, which we cannot perceive, is an important part of my approach to the scientific subjects. It relies on the belief that I can empirically observe and learn from my surroundings, taking me closer to a knowledge of fact and truth as a basis of scientific pursuit. I am, however, open to phenomenological approaches, as it is also apparent from our own common sense, as well as the discoveries of quantum mechanics and relativity, that as we observe we have the ability to alter the world we see in a way that is relative to the observer. Karen Barad wrote of our relationship with the world that:

phenomena - whether lizards, electrons, or humans - exist only as a result of, and as part of, the world's ongoing intra-activity, its dynamic and contingent differentiation into specific relationalities. . . We have to meet the universe halfway, to move toward what may come to be in ways that are accountable for our part in the world's differential becoming. All real living is meeting. And each meeting matters. (2007: 371)

As discussed above, the use of anthropomorphism can have the potential to decentre the individual and focus our minds on the possibly unknowable or ungraspable ontology of things. If one can reclaim the culture of science through artistic and expressive practices this may open paths to be reconnected to inherited and ancestral transpersonal experiences of the various ways humans have described and *met with* nature.

When thinking about how Jung's archetypes of the collective unconscious are present in our lives Gill writes that:

In other words, potentially anywhere: the principle that the archetypes inform the essential human behaviours means that virtually any part of human life or culture may become archetypal, including those not conventionally associated with myth. (2006: 53)

Here he speculates that if mythological stories are an emergent property of the collective unconscious, it is possible that the activity of mythmaking could be happening in other fields far away from the theological or literary realm. As such, it is possible to draw a parallel, and an implied transpersonal experience, between the mythmaking of past cultures and the search for objective truths through scientific activities today.

The act of mythologising requires an openness of imagination, similar to the kind of lateral thought enacted by scientists in their research when developing hypotheses and theories. However, myth, unlike science, need not rely on empirical observations to create the base set of conditions from which to develop experiments and maths on the relationships and laws governing nature. The Egyptologist Emma Brunner-Traut suggests that:

in the myth the objects have their own inner relation to each other; they meet and interact in a world of their own, hidden and unmindful of the questioner. They are sufficient and attuned

unto themselves thus constituting their own truth in the dimension of the boundless. (Brunner-Traut, 1981: 268)

The myth provides a space in which to explore a fantastical world governed and ordered by rules and relations which do not exist on Earth. It may not be right to use the process of myth making to develop scientific theories, however the form of the myth is applicable to many scientific principles, laws and constructs. Successfully weaving archetypal characters and relationships into an exposition of scientific thought and research, provides a grounding in narrative, character and emotion through which to experience the science. The use of myth enables us to look into worlds beyond human anthropocentric existences. It provides an ideal backdrop through which to explore another type of living or non-living system.

Ultimately in the characters I create for stage, embedded with the meaning of the subject, I have attempted to use this integration of archetypal image to consciously realise the subject as a:

powerful impulse toward a meaningful activity or experience which has to be made real in terms of what is emotionally and ethically possible (Whitmont, 1991: 80).

1.2.d Opera as a Medium

Levi-Strauss wrote on myth and music in his book *The Raw and the Cooked*, stating that '[b]oth indeed are instruments for the obliteration of time' (1964: 15). He highlights that myths deal with fundamental truths which do not diffuse over time (just like physics). Vladimir Jankélévitch (2003) and Carolyn Abbate (2004) have also argued for the timelessness of musical experiences. This established connection between music, myth, truth and time is a fundamental part of the argument for embedding scientific thought within the libretti and performances I am producing. As stated by Samuel Taylor Coleridge,

poetics helps us to make use of a 'willing suspension of disbelief' (Tomko, 2015: 19). In further explanation of this Coleridge cites the example of a theatrical representation of a forest, posing the notion that on stage we are not being asked to view and engage with the picture of a forest but with a forest itself (Marshall, 2020: 24). There is a form of deception occurring in which our will to give faith to the sight that deceives us is fully accepted, as we also have the will to withdraw such belief. The audience willingly suspends, or places aside, their reliance on the expected environmental signals which imply the presence of a forest, and allows for an artistic interpretation of the forest to satisfy the phenomenology of what is presented on stage. In fact, often in theatre the audience will go beyond just willingly suspending disbelief, and willingly *believe* in the impossible or deceitful worlds created on stage. The sheer act of opera itself, as a sung through story, abstracts the audience from any expectation of a realistic representation of life.

Going further, contextualising contemporary opera within the genre of Music Theatre (not to be confused with Music-Theatre) opens the boundaries of the work we can produce. In *The New Music Theatre: Seeing the Voice and Hearing the Body* by Eric Salzman and Thomas Desi they suggest that:

The use of metaphoric performance roles, as told through a fairy-tale setting – and especially when sweetened or underlined by music – may stimulate an interest in a subject without resorting to mere voyeurism (2008: 86).

Tom Sutcliffe (2005: 339) states that opera has a 'much greater freedom in its staging precisely because it is not primarily a realistic or straightforwardly narrative form', and so is an excellent format through which to represent an abstract or complicated idea.

The multimodal nature of opera, which makes use of music, text, visual art, performance, dance, and now film and digital media, allows the producer to use multiple streams of communication with the

audience at the same time. Everett (2015) highlights how narrative may be subverted or enhanced through various different production elements. She describes how the various levels of pre-production (composer/librettist) and production (director/designer/choreographer) can work together in a multimodal way to convey the semiotics and underlying narrative elements of the work:

Each operatic production is unique in the sense that the multimedia elements – music, libretto, film, objects, lighting, mime and/or dance – operate as interdependent structural and semantic components that shape the narrative production of the whole. (2015: 2)

This creates an intermedial representation of a subject matter in which the different modal elements (text, music, visual) combine and interact to create a whole (Elleström, 2010). When working with abstract concepts, such as physics, this provides an opportunity to constantly reframe and emphasise elements and to effectively communicate them to the audience in several layers. Through the interference of these many different channels of communication the audience can grasp onto the subject being communicated to them, without having to comprehend the scientific jargon or technical language. As suggested by Salzman and Desi (2008: 83) ‘a good libretto offers the composer the possibility of combining gestures or expressions with musical motives, thus making a connection between what is heard and what is seen’. Unlike the reader of this PhD, who will be concerned with how the words combine towards the meaning of the sentence, and the sentences towards the meaning of each paragraph, the experience of an opera allows the audience to take on those individual parts as a coherent or destructive whole, and for the inputs towards the audience to be repeated, or forgotten as the dramaturgy of the production progresses.

Smith describes a trend in early and mid-twentieth-century libretti saying there has been a ‘development in the libretto (and in other arts) of a new approach to the traditional which is not a continuation but a revival. Conscious archaism has been one of the prime ingredients’ (1971: 385). He

particularly cites Auden's *The Rake's Progress* (1951) and Henze's *The Bassiards* (1966). From Rinuccini's first libretto of *Dafne* (1598 composed by Jacopo Peri), and the Florentine Camerata's revival of Greek drama and myth, through to Wagner's Nordic Gesamtkunstwerk, and the contemporary use of myth in works such as *The Minotaur* (composed in 2008 by Harrison Birtwistle and libretto by poet David Harsent), the relevance of myth and archetype to operatic narrative has never faded. Yayoi Uno Everett's recent publication on *Reconfiguring Myth in Contemporary Opera* (2015) also provides a thorough analysis of how the semiotic structure of myth might be applied to more contemporary works such as composer Osvaldo Golijov and librettist David Henry Hwang's *Ainadamar* (2003) and composer Kaaija Sariajo and librettist Amin Maloof's *Adriana Mater* (2015). My work as a librettist falls prey to this 'conscious archaism'. I actively make use of the typical structural forms such as recitative, aria, chorus, ensemble etc., making sure to highlight these as part of the libretti I pass on to my collaborators. Making use of archetypal characters (and creating them through research of mythology) also echoes the libretti of the past, referencing stories and characters that have been seen in opera many times before. I acknowledge and play with these influences to explore new ways in which to make use of the traditional form.

1.2.e A Brief Survey of Contemporary Related Works

In 2002 Lustig and Shepherd-Barr wrote about the use of physics and science to inspire playwrights. They cite several examples, including Frayn's *Copenhagen* (1998), which plays with the quantum concepts of uncertainty and the principle of complementarity, and Timberlake Wertenbaker's *After Darwin* (1998) where natural selection is played out through an increasingly tense relationship between two friends. Since this we have seen Nick Payne's *Constellations* (2012), Michael Chemers' *Birth of Stars* (2009) and Lucy Kirkwood's *Mosquitoes* (2017). The idea of using anthropomorphic scientific thoughts in a metaphorical or allegorical manner is also far from new. Blake (2015) argues that the mediaeval play

Nature by Henry Medwall (1495) is doing just this with Aristotelian physics through the use of characters such as Nature, Sensuality and Reason. The more recent works in this canon do explore science in many of the ways my work seeks to, by searching for human relationships that can be paralleled within the laws of nature. However, these are all explored through spoken word, and do not make use of the multimodal nature of opera.

Beyond this there have been some recent examples of opera making use of science to create new works. Science and physics are something that frequently makes the headlines and has an increasingly important and prevalent place in our world. As such it makes sense that there has been a rise in the number of operas created about physics. Philip Glass has created three works on physicists: *Einstein on the Beach* with libretto by Phillip Glass and Robert Wilson (1976), *Galileo Galilei* with libretto by Mary Zimmerman and Arnold Weinstein (2002) and *Keplar* with librettist Martina Winkel (2009). In *Einstein on the Beach* the libretto seeks to generate a sense of the various different periods of Einstein's life and discoveries or aspects of his character. Phillip Glass and Robert Wilson worked to embed these aspects of Einstein into every layer of the production. Lancaster (2000: online) describes this process in the direction by saying that '[U]nder Wilson's eyes the stage became a geometric space of scientific potentiality in embryonic process' and describing how each scene was dramatically engineered to represent different concepts or dreams of the scientist. The libretto for *Einstein on the Beach* is a non-narrative series of minimalist sketches and involves the use of 'knee-plays' which link the different main scenes together. This is also partly what inspired me to make use of a dual-linear form for *The Flowering Desert* (which I shall discuss further in chapter 2) with which one narrative is used as a series of thoughts between the scenes of the main dramatic story. This type of work is somewhat opposed to the types of stories and characters I am presenting, however. My work aims to explore an emotional journey extracted from the science, whereas Phillip Glass and Robert Wilson did not discuss the emotional content of their scenes (Broadhurst, 2012).

In 2005 John Adams and Peter Sellars created *Dr Atomic* based on the two central figures of the Manhattan Project: General Leslie Groves and scientist J. Robert Oppenheimer. This libretto makes use of found textual material from various sources including poetry by John Donne and Murial Rukeyser, the Bhagavad Gita and various extracts from declassified documents such as the Smyth Report, and Atomic Energy for Military Purposes (Herken, 2005). The chorus that sings the technical and scientific text from these documents act almost as a Greek chorus, explaining the physics and giving a moral commentary on the events unfolding on stage. There is focus on the relationship between Oppenheimer and his wife, making use of many biographical elements of the journey towards nuclear warfare at the end of the second world war. Although this deals with a scientific subject and involves many technical terms and concepts in the text, the style of the work remains distinct from the more formal elements of my libretti in this research.

In 2015 Giovanni Battistelli premiered *CO2* about global warming, inspired by Al Gore's *An Inconvenient Truth*. Battistelli's opera provides us with an allegorical approach to the issue and he has said himself 'It is a difficult love story, between man and earth.' (Schmid, 2015: online). During the creation of this work the librettist, Ian Bruton, took care to consider how to create a work which would inspire a sense of empathy in his audience. In the choice of name, he asked a group of university students to choose between three names, for which 'they felt greater empathy, imaginative solicitation' (Menichetti, 2015). During the work there are many key cultural figures represented e.g., Adam and Eve, the deity Shiva, archangels, the serpent and various scientists. Alongside these, the character of the Earth itself is represented in an anthropomorphised form as Gaia, with whom the other human characters frequently interact. This work makes use of many similar elements that I explore in this research by presenting trans-cultural elements, exploring a topic that is relevant to a global audience, and making use of anthropomorphised characters to generate a greater sense of empathy for the non-human subjects.

Hypermusic Prologue: A projective opera in seven planes has a libretto written by physicist Lisa Randall and music by Héctor Parra. This opera is based on Randall's extra-dimensional guide *Warped Passages: Unravelling the Mysteries of the Universe's Hidden Dimensions* which includes constant references to popular song lyrics. The opera tells the love story of a man and woman living in different dimensions. While the physics is embedded in the plot of the opera, it is not important to understanding it. Parra has said '[t]he audience isn't obligated to understand anything Lisa does. They will feel anguish, they will feel unification and accomplishment.' (Powell, 2009: online). The aims and outcomes of this work as described by both librettist and composer are similar to some of the outcomes from this research. Randall describes herself as trying to provide a 'forum to open up people's imagination, let them know there is more beyond what we can see', and that to her the most important outcome was that people do not necessarily learn from the work but that they are exposed to other ideas, dimensions and possibilities (Parra, 2010: online). For Parra an important outcome was that the work might provoke 'a catharsis that has to do with our inner relationship to the physical world.' (Parra, 2010: online).

Other science-based operas which explore anthropomorphising include *The Locust* by Jeffrey A. Lockwood, 2019 (Millius 2018) on entomology and *The Unsung Heroes of the Planet* by librettist/director Ruth Mariner (2017) on fungi and the environment. Both these works were written specifically for pedagogical goals. Their aim, in contrast to the aims of my research and the outcomes and aims of Randall's work as described above, is to help the audience to learn from the subjects on stage, imparting specific information directly through the text and performance. Lockwood himself published a paper on the results of the performances, and their abilities in science communication. He states in the introduction that:

As much as artistic expression might be an effective means of communicating science, it is important to recognize that art is not merely a way of making science pretty or digestible

(Dressler and Borrelli 2018). Art should be a full partner with science in efforts to understand the natural world. (Lockwood et al., 2020: online).

The use of anthropomorphism as a tool towards delivering the information to the audience is important in this work. However, the main scientific information in both pieces mentioned above is delivered through the character of a scientist, and is used to help the audience to solve a mystery (in the case of *The Locust*) or to make sense of the characterisations of fungus (in the case of *The Unsung Heroes of the Planet*). Ruth Mariner has continued to fuse operatic narrative with nature, anthropomorphising her subjects and searching for characteristic human traits. In 2020 she produced a 10-minute work called *Indus* on the story of whale evolution. During this piece a solo singer performs as a whale, singing both poetic text about the journey of their evolution towards this large creature and mimicking the sounds of whale calls. This work appears to be far closer to the research carried out in this thesis, although it only involves one singer and as such is closer formally to a cantata than opera. Therefore, there is no exploration of dramatic relationships between different characters in the piece, although the solo singer does embody the whole process of evolution from land mammal to water mammal. On her website Ruth Mariner describes this work as exploring:

the relationship between disability and environment through the unlikely story of whale evolution.

When a land-mammal begins to first explore the water, she finds a place where her differences become strengths, embarking on a journey of self-discovery towards an extraordinary future.

(Gestalt Arts, 2018: online)

This blending of a very human experience of disability, with the postulated story of whale evolution has many parallels to the experience and arcs of the characters I have created in this research.

In 2018 Infinite Opera (myself as librettist and composer Daniel Blanco Albert) produced *Entanglement! An Entropic Tale*. In this the characters are anthropomorphic versions of elements from physics (e.g., an electron, positron, entropy, gravity and a singularity). It connects common human interactions and emotions (love, greed, anger, etc.) with the interactions and forces of physics, providing an alternative and emotional metaphorical toolbox to connect with the complex concepts involved. This piece has laid the groundwork for the explorations and projects undergone in this PhD. In response to reading both *The Locust* and *The Unsung Heroes of the Planet*, I introduced a narrator in the form of a scientist to the most recent production of the opera in 2019, to see if this helped in the audience's comprehension of the work, and to consider the addition of a narrator to future works. Due to the nature of the research the narrator's role would never be to explain the science presented through the narratives, but rather to provide a sliding gradient between the audience and the non-human subjects presented on stage. I will discuss this further in subsequent chapters.

The work in this research builds on this growing world of science and theatre, which seeks out new ways to reframe, explore and represent the discoveries of our age. I can see through looking to related works that in my own practice I am part of a wider group of artists, writers and composers who are looking to integrate diverse disciplines into the theatre they create. Theatre, as an artform that is deeply connected to emotion and often grounded in philosophical or even ethical considerations of a subject, when blended with science can bring about new perspectives on our scientific goals and achievements, present them to wider audiences and give them greater relevance to our daily lives.

1.3 Methodology

The collaborative methodology can be seen through the lens of a post qualitative inquiry, that uses tools and methods from practice-based methodologies as a guide. The processes of embodiment and anthropomorphism can be explored from this viewpoint, as expressed by educational theorist St. Pierre:

[p]ost qualitative inquiry, “thinking without method’ (Jackson, 2017) and “minor inquiry” (Mazzei 2017) all require “a very lengthy preparation, yet no method, no rules, nor recipes” (Deleuze & Parnet, 2002, p.8). The *long preparation* for post qualitative inquiry is reading, thinking, writing and living with theory in “experimentation in contact with the real” (Deleuze & Guattari, 1980/1987, p. 12). (2018: 604)

Professor of education Lesley Le Grange (2018) has given a thorough account of how post qualitative methodologies can be understood and approached. He describes a main ethical driver of post qualitative research and inquiry to be in the dissolution of positions of subjectivity. To describe this, he refers to his previous work on ‘becoming-imperceptible’ stating that:

In becoming-imperceptible the cosmos or the earth is not reduced to human thought, but human thought is instead bent by the earth/cosmos. The ‘human’ does not simply inhabit the world/earth but is inhabited by it. (2012: 102, cited in Le Grange, 2018: 8-9)

The methodology which emerged around the practice in this research was founded on such principles (as described in sections 1.2.a and 1.2.b) that seek ways to decentre the experience of all humans involved, to move closer to the subject in both the creative process and the performances. This was done through a synthesis of different materials and disciplines in the process of creating the work.

There are three key elements which work together to form the context and structure of this research.

Firstly, the creation of the libretto through methods of collaborative theatre making with composers and other artists. Next the embedding of scientific concepts and thought into the work, through an extended period of research into subject matter, as a foundation for collaboration (a joint starting point), and scaffolding for dramaturgical structure, narrative, and character. Finally, a thorough exploration of the efficacy of the work through performance. Elements of opera, such as structural elements of recitative and aria, are used to inform the libretto. Ultimately the creation of libretti, exploration of characterisation and performance of the work is the form of the output from this practice-based research (Candy, 2006).

In particular, the mode of outcome is in line with Robin Nelson's suggestion of product, documentation and contextual writing (2013). The research is presented in two new operatic works (case studies), which were produced in collaboration with other practitioners and have followed a reflexive and developmental process. This thesis sees the performance of the work itself as an expression of the knowledge developed during the research. In Barrett's conception of the exegesis as meme she states that the output of research 'refers not only to the products of creative arts practices which may be judged by conventional criteria of artistic merit, but also to the experimental and material processes through which such products are externalised' (2010: 162). As such the output, although unique and dependent on the subject matter and collaborators, is achieved through a replicable and emergent process and methodology.

The works presented were developed in cycles of performances and collaborative composition. The first – *The Flowering Desert*, written 2020-2022 – had its most recent and final performance in January 2023 at the ThinkTank Planetarium, and the other *Lipote: An Interconnected Journey* had its final performances at the Edinburgh Fringe 2023. Other pieces worked on during the PhD will also be

referenced in relation to the research questions and further information on them can be found in Appendix 3. These are: *Entanglement! An Entropic Tale, In response to Naum Gabo's Linear Construction in Space No. 1, Autohoodening: The Rise of Captain Swing*, and *The Monk of the River/The Monster of Gao*. Some of the creative process during the PhD was documented in an online journal and the performances themselves were also documented through recording and film to help when reflecting on and evaluating the efficacy of the process. Some of the materials generated and recorded during the cycles can be found in appendices 2 and 3. Despite the documentation process it is important to note that these works are intended to be performed in front of, and watched by, a live audience, and that this should be taken into account when viewing the filmed material and libretto.

In order to develop a work that is representative of elements of opera, myth and science it was important when researching these three fields to narrow in on a specific subject matter and its related cultural representations. This process of research continued throughout the creation of the work, to the final cycle of stage production, keeping the topic alive in conversation and creation with my collaborators and for myself. The work produced from this knowledge can be described as an emergent property of a complex understanding of multiple fields (Goldstein, 1999). In a sense I have worked also as an interpreter, uncovering an understanding of the material and its dramatic sensibilities.

1.3.a Methods of Collaboration

There is a broad range of literature on the best approach towards collaborative working practice. Sawyer (2008) used jazz ensembles to study the effectiveness of improvisation on collaboration, finding that it is good for solving problems or developing new ideas. Alternatively, Simon (2015) has argued, through studying the example of Cirque du Soleil's practice, that strong leadership is necessary for successful collaborative outcomes. Mamykina, Candy and Edmonds (2002) have explored a mutualistic

approach to collaboration. They suggested three possible models for collaboration: the assistant model, the partnership model and finally the hybrid model. In the assistant model collaborators take on different phases depending on their skillset, the partnership model shows all participants working together on all areas, and the hybrid model combines the two. My research has been more in line with these models of Mamykina, Candy and Edmonds. It is close to a hybrid model, and also presents as an assistant model. By working with specialists each person is able to take on the responsibility of their own role, be that composer, librettist, designer etc.; however, the process of experimentation, reflexive consultation and conversation between practitioners meant that there was also a key use of partnership in which each participant was able to affect and direct the work of the others. In several cases I was pushed to take on roles which were not my own speciality, in the first case to express and communicate my ideas, and in the second out of necessity due to funding or time limitations. Perhaps the small nature of the team, in contrast to larger scale theatrical organisations such as Cirque du Soleil, made the need for strict leadership less important. There were moments in which clear leadership was taken by the members of the team who had been working with the subject for the longest time, such as myself and the composer, especially in relation to performance goals. In this case the team were able to draw on us as the most expert in the work, at that stage, for guidance and support.

Within my established practice as a librettist my role has always been to create characters and narrative about a subject matter and decide upon the philosophical themes of the work. Kerman suggested in his book *Opera as Drama* (1989) that the librettist provides a starting point and source of inspiration from which the composer will create an ideal. This has been partly true here; however, the chosen subject matter has always acted as inspiration for all creative participants with the mutual goal to embed the piece with the subject as far as possible. I have been very lucky to be able to work in collaboration with composers who are open and willing to explore the ideas and concepts we are researching together, in a constructive environment. I have found that it is important to ensure the development of a good

working relationship, in particular with the composer, in order to be able to serve the intricacies of the subject matter, and the future audience, as best as possible. The science, and chosen subject matter itself, is another important collaborator in this practice and must be given the depth of research and exploration necessary to be understood as an 'actor' in its own right (according to Latour's definition: Latour, 2005: 46) by all creative participants.

As a vocalist the act of singing and performing constitutes a large part of this research. I have allowed my exploration of different techniques within performance to affect how I construct text and operatic form. In sections 2.5.c and 3.5.e I shall discuss the choices surrounding the use of different types of voice technique, which range from classical to spoken word and to pop. The practice of singing is combined with the practice of writing libretti as the research develops through performance and practice, in turn to inform future works during the PhD. The performativity of the work is explored through collaborative and personal experimentation with voice, workshops, and open rehearsals, and is allowed to directly influence the development of the libretti and production towards the final cycles. In the initial stages this work is carried out mostly between myself and the rest of the creative team; however, it becomes something that is later workshopped and experimented with the other live performers. The work of practitioners such as Enrique Pardo and Linda Wise (techniques of disassociation, counterpoint and conversion (Pardo, 2003)), Jessica Aszodi (2018) (embodied vocal performance) and Jody Kreiman (2013) (on interdisciplinary voice studies) was a helpful starting point in this part of the research.

To engage with methods of collaboration effectively I began by using Lawrence and Ann Halprin's RSVP Cycles (1969). This provided a structure to manage the creation and research process towards the performed output. It also provided an ideological grounding in which all participants and collaborators were allowed to present and integrate their own individuality as part of the process, allowing for multiple components to be used as resources for the creative process towards performance. This is not

limited to the people I am working with but also the material and main subject matters of the works. The Halprin Cycle's method helps to begin the process of decentring from the individual's experience, towards that of the subject. Working in this iterative approach of development, experimentation, performance, and reflection is also similar to a scientific approach to research. It involves exploring hypotheses, or choices, within the text, performance and collaboration, analysis of the results and further experimentation or performance based on the results. It also provides the framework through which to engage with the subject as a stakeholder and make use of the creation of improvised and collaborative material and multimedia outputs, to develop a cohesive working relationship between collaborators. This process enters the realm of the posthuman, and therefore post qualitative practice, described in university settings by Braidotti as such:

[c]ritical posthuman scholars are collectively empowered to experiment with intensity, knowing that our political force lies in actualizing our "collective imaginings" (Gatens and Lloyd 1999).
(Braidotti, 2017: 46)

The Smith and Dean Iterative Cyclic Web (2010) is another initial tool which helped me to begin the journey of a practice-based researcher. With the use of critical reflections, involving collecting feedback from participants, audiences and myself, alongside analysing past performances or showcases, I developed my approach and working practices, which I could then test and develop along with the selection of a new subject matter and further productions. This also blends with Smith and Dean's research-led practice. My own method, as a result of developing the work in a series of cycles, begins in their realm of practice-led, making use of the research-led tools to repeatedly create new versions of the artistic output.

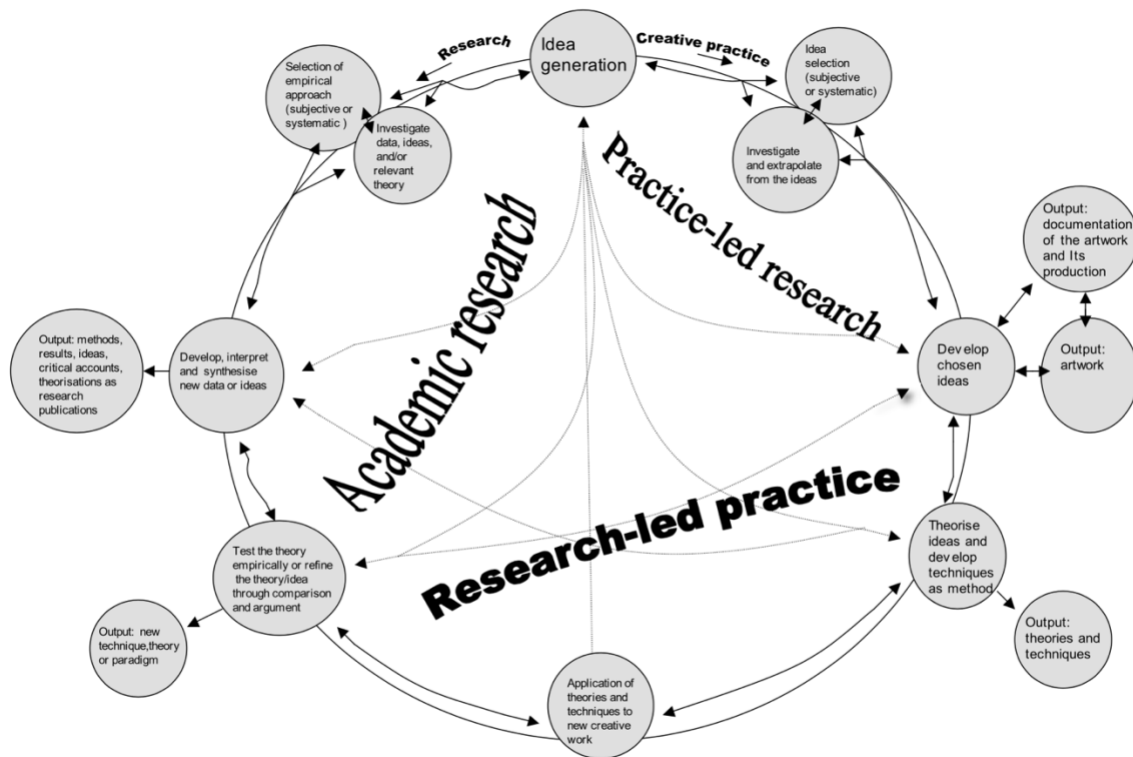


Figure 1 A model of creative arts and research processes: the iterative cyclic web of practice-led research and research-led practice. Source: Smith & Dean, 2010: 20

1.3.b The role of the librettist and the libretto in this work

In its most simplistic form, a libretto is the text used for an opera, musical, ballet or any music theatre piece. Classically it is presented as a script with soliloquy, dialogue and group scenes, alongside basic stage directions. It can also include some instructions which begin to dictate musical and dramaturgic structure such as recitative, duet, chorus, aria and ensemble (Macnutt, 2001). One commonly discussed, and accepted attribute of a good libretto is one in which as little text as possible is written (Strickson, 2014: 1), so as to provide maximum space for the composer and the music to also be able to speak and express the emotions, thoughts and characteristics of the players in the story. David Mitchell has described his experience as a librettist, saying that ‘the challenge of packing so much human luggage

into so few syllables with rhythm, rhyme, assonance and alliteration was addictive and gratifying—not unlike sudoku’ (Mitchell 2010, cited in Morra 2010: 125). The libretto can also include staging directions to help all collaborators process the initial vision of the piece.

The role of the librettist has changed throughout the history of opera. It ranges from the initial text-focused Florentine Camerata and the reign of Metastasio, to the composer-librettist teams such as Mozart-Da Ponte and Strauss-Hoffmannsthal, the Gesamtkunstwerk of Wagner to the detachment from text in the anti-operas of Cage (Smith, 1971). Fundamentally the librettist brings the element of text to the creation of an opera, ballet, musical or any music theatre piece. This may mean writing the full story and setting the scene, or a conceptually driven poetic and artistic form, but it could also be an interpretation of an existing story or text.

The libretto carries out its role through the use of poetics, characterization and text, while the music can do this more pragmatically through the generation of harmonic and structural material from the data collected in scientific research, although it can also respond to the poetics of the subject. Morra (2010: 122) has expressed the opinion that the role, or even expectation, of the composer is to provide a certain ‘established musical entertainment’ while the librettist ‘is expected to define the overall contemporary and dramatic relevance of the piece’. As text provides the most immediate source of information to the general audience it can feel as if it is the burden of the librettist to ensure that this conveys the aims of the piece as a whole. However, without the support and scaffolding of the music, design, drama, movement and space the text will struggle to be understood.

Adam Strickson (2014: x) wrote on his experience as a librettist that:

The ‘text’ is not the words on the page but a series of interlinked relationships. The ‘writer’ is concerned with the relationship of the breath to word and sound, with the

relationship between music and word/sound and with the body in action in a defined space.

The text itself must be generated as concisely as possible, to fit the nature of a mostly through-sung work. This means there is plenty of space for the music, performance, staging and design to illuminate the relationships implicit within the text. This in turn requires the text to be filled with layered meanings so that the creative collaborators have plenty of room to respond in different ways, and the fertile imagination of the performer can direct the delivery of the words.

1.3.c An Emergent Methodology and Methods for 'Librettising' Science

Having looked back on the PhD I can see that the creation of each work has undergone three clear stages. The first of these is that in which the core research and experimental material is gathered for the creation of a joint language between all collaborators. The next is the creation of the main body of the work (libretto and composer's score) involving reflective performance practice, and the third is the production of the first complete performance. This results in further developments towards future performances with a constant reflection, edit and adaptation of the work, whilst in conversation with collaborators. The overall outcome resulted in a methodology based in an interdisciplinary interaction over the various forms of knowledge we have about the subjects of scientific research. A conscientious and wide-ranging exploration of the chosen topic is necessary, uncovering and creating a broad range of sources to explore with collaborators and generate work in methods that involve cyclical patterns of creation and reflection. This approach seeks to engage with the complex assemblage of how the subject's experience of existence interacts with our experience of the subject's existence.

1.3.c.i Stage 1

During this first step I spent a large amount of time personally exploring and developing my connection to the chosen material. Due to the nature of the research questions, it was vital to do this to understand the various different representations of the topic. I found that exploring of the cultural, spiritual and artistic representation of a topic was necessary to not ignore the ways in which humans have understood, carried and related to this knowledge throughout history. This builds on the work and theories of 'anthropophagic' theatre:

anthropophagic theatricality is . . . a transformation that results in the meeting of two philosophical thinkings about life: the indigenous . . . and the European . . . Out of this encounter came the idea of mixing influences and 'devouring': taking over the properties of a source's arts or culture and making them your own. The theatre of anthropophagy is simultaneously both processes of an intercultural appropriation and collaborative creative creation. (Dundjerović & Ramos, 2019: 81-82)

The work above is exploring anthropophagic theatre in the context of Brazil, where there is a divide between the indigenous and Western cultural forces. The work involved in this research project does not explore such a cultural divide but looks to the different forms of knowledge generation. In particular, this work seeks to 'appropriate' knowledge systems based on scientific method (in particular work published in English), blending the cultures of scientific and artistic research. When talking about the role of practice as research, Barret explains that 'the exegesis' of practice as research 'illuminates particular knowledge and data derived from interacting with the environment (material and social) and then discusses it in relation to what is already presented in theory and general domains of knowledge' (2010: 163). In this practice research I 'interacted with my environment' by endeavouring to not only 'devour' a subject but devour and empathise with it at the same time. The aim of this was to create a

mutualistic relationship with the subject, allowing it to act as a collaborator which provides me with the fertile soils for creativity and imagination, whilst I as the practitioner give back by providing a space in which it may have a renewed existence through a new empathic representation. Through this process I and my collaborators could expose and explore more of the potential overlaps, interactions and entanglements experienced between the subject and the human experience, allowing us to get closer to the ontology and experienced existence of the subject. This process involved researching recent scientific publications and speaking with specialists (scientists) from the field to access knowledge and insight built up over lifetimes. Discussing the subject with scientists also gave insight into the emotional impact it has on the people who work with it. By sharing this stage with the other creative participants in the collaboration we generated a deepened perception of the subject's relevance, gaining insight not only into the factual levels of the topic but also into the history of its development and the way current research can shape the future.

Alongside these group discussions around the subject with the scientists, it was also explored through conversation, action, creative work and reflection with the creative collaborators. It was ideal to be working with multiple collaborators when doing this to help develop a language on the subject, and also to avoid an egocentric approach to the work. Creating an artistic ecosystem around the work, and letting the subject sit in the in-between space between the minds of myself and my collaborators helped me to let go of preconceptions and allow the subject to speak more for itself, seeing it both from the position of my relation to it and my independence from it. As we cannot physically ask these subjects to speak for themselves, and so have no access to the primary source, it was vital to allow for the input from as many secondary sources as possible in this initial stage. Through grappling with bolder, broader and more timeless ideas of the philosophy and methods which surround both the human understanding of the subject, and also an attempt to access the phenomenology of the more-than-human or non-human subject matter I found it easier to extract myself from my own positioning in relation to the

subject and build a narrative structure based around these other woven layers of knowledge that are encountered along the way.

This approach develops a stronger empathy towards, and understanding of, the subject from the participants and collaborators involved in the production stage. In order to successfully embody and engage with the text and music it was important for the performers to really understand the subject of the piece and get to grips with what they are representing

One performer from the second case study wrote the below testimony, expressing how working with the topic through performance encouraged them to explore the topic further:

Working on Lipote made me deeply curious about the science of trees and the communication that takes place under our feet through fungal networks and tree roots. I read books on the subject to learn more and it changed the way I think about not only communication between nature and myself but also within the opera as a performer interacting with my fellow musicians in a more interconnected way. (Performer testimony, 2023: personal communication)

Before writing anything I began by creating a word list related to the subject from which to begin accessing the contemporary literary sound-world surrounding the topic. This became a substrate from which I could build my own language and was a valuable resource from which I could draw on and return to whenever the writing became difficult or felt like it was steering off course or away from the topic.

The next step for myself as a librettist was to focus on generating the characters themselves. This occurs as an emergent property of the research and frequent conversations around the subject, alongside research into relevant archetypal models or myth. The development of the characters for libretti includes not only the archetypal qualities of each character, and the contexts that inform their particular

situations, but also the sound and voice of the character. I also attempted to allow the voice type of the characters to be informed by their discovered qualities. In doing so this stage of creation also becomes performative as it is through the use of recording and gathering feedback that the style of text, and voice type can begin to be generated.

Once this initial exploration of character had occurred it was then possible to begin building the story or narrative. Again, this was in relation to the other collaborators, including the scientists which have been interviewed during the initial stages. In order to ensure objectivity and keep the narrative in line with scientific facts, it was important to be in contact with the scientific collaborators as I developed the concept and narrative. I found during this research that their input at this stage helped to either steer me away from previously decided narratives, or to deeper understand the purpose and trajectory of the narratives I was creating. Initially I had long discussions with my creative collaborators about how to reconcile the problem that the work we are doing is not purely experimental. It does not simply take the data or science and translate it directly into text and music but uses the science as a structure or voice through which to make choices, and offers a joint language, goal or entry point to the work. In this respect there is a point at which the work can stop being just a representation of the science and becomes a more creative endeavour. Science is merely one of the tools, not the only tool, and it is likely to be more personal creative choices which will define how the work emerges.

In order to develop a personal understanding of the narrative of the piece prior to writing the script I wrote it out as a short story first. This generated larger descriptive sections of text which could be referred back to later in the process. I shared it with my collaborators, including the scientists, and even asked potential performers to read it. The feedback received at this stage helped to guide the work in the right direction before the text was set as a script for music.

Once the characters, and part of the story, had been uncovered it was also important to work with the artistic collaborators to produce some initial materials which expressed my understanding of these things and can also provide inspiration for the future of the work. These included short compositions, films, paintings, texts, performances etc. Much of this stage occurred during the pandemic, so for this project the artefacts created at this stage were of digital form. I do not know what difference it would have made had I been able to gather 4 or 5 different artists into the same space to create at this point. However, as soon as restrictions were lifted, we made sure to collaborate together in the same space and not just on Zoom or Teams calls.

In all works the collaborative creative processes engaged with at this stage helped to build a functioning artistic understanding between all creative roles in the project. In practice this has had different outcomes, leading to very different sounding, looking and feeling productions. This really highlights how much the personal creative choices of the collaborators will shape the final work. It was however vital that, as a librettist who is seeking to embed their chosen subject wholly in the work produced, I spent time with my collaborators building this joint understanding and language.

1.3.c.ii Stage 2

This next step was to produce the main bulk of the creative work, through solitary work and group workshops. As a librettist it involved a process of writing and reflective collaborative practice. Maintaining the process of the first stage was important, regularly checking in with my different collaborators, and continuing to draw inspiration from the source material and its surrounding scientific and artistic representations.

The early drafts of the libretto had detailed accounts of musical inspiration, reflections on the science, descriptive imagery of the scene and concept. These did not need be adhered to by the composer,

designer or director, but they were helpful to provide this foundation of concept in order to successfully communicate and have detailed discussions about the work. This text and background were removed from the final libretto after further discussions with the collaborators.

In relation to the Halprin cycles, I used the materials generated in step one as the resource for the development of the score (the libretto) which underwent trial performances and evaluations. These trial performances were key to developing a further understanding of the subject with the fellow artists, and performers I was working with. They helped us to get to grips with the physical, musical and textual materials we were working with, how they respond to the subject (if they are successfully conveying it) and the ways in which they interface and interact with the subject matter. It is also a stage to gather some critical and vital feedback from audience and participants to edit, rework and develop the piece moving forwards.

These trial performances ranged from creating recordings of the music to develop an understanding of the efficacy of the sound-world, and ease of performance, again creating filmed versions of the work, or holding open rehearsals in which audience members are invited to comment on their understanding and appreciation of the work. During this research myself and my collaborators created full recordings of the works, experimental films of selected scenes with design and costume elements, held open rehearsals and gathered feedback from audiences, participants and each other. For a more detailed account of this stage see appendices AP 1.3.h, 1.4.b, 2.1, 2.2 and 2.3.

There are many elements being brought together in these kinds of creative projects: the subject, the style of the music, the design and the narrative. All of these will require testing and reworking in order to be moved to a point in which they are playing with each other harmoniously.

1.3.c.iii Stage 3

The last stage towards creating a completed work is that of the production itself. I found there are several key considerations which will go into this. Firstly, it was important to thoroughly consider the performance venue, especially in relation to my subject matter. The venue itself can act as a collaborator on the work, providing an atmosphere and scenery which is potentially connected to the subject matter, and making it site specific. This will allow for the audience to begin to feel immersed in the subject without having even experienced the performance itself. It may also be important that the venue is supportive of other key decisions made during the creation of the piece, such as design or lighting decisions which will help to promote conceptual and symbolic parts of the work.

The rehearsal process also occurs during this stage. In this PhD I worked with the performers to develop the collaborative language relating to the subject matter, describing the reflections and inspirations which led to the development of their characters, so that they might better embody the music and text. This was also to enable them to perform with an element of improvisation, especially in the earlier stages and performances. None of the directions were prescriptive, as we focused on developing movement through the creation of a joint language and knowledge between all participants. This involved rehearsals in which we discussed and explored the subject being presented through dramatic exercises and improvisations. With opera it is necessary allow sufficient time for the performers to become accustomed to the new sound world they are working within, and personal work on the music. I was also participating as a performer during this PhD in order to gain an understanding of the work of embodying scientific objects and concepts from within, experiencing the dramaturgy in order to better edit the final product.

The many threads left hanging in the production process are pulled together in this final stage. Through reflecting on the artefacts produced in step 1 and the results of the trial performances in step 2, the

movement, costume, scenery, and programme presentation are developed in a collaborative process of creation, rehearsal, feedback and editing. The performance of the work then becomes the outcome of the research.

1.3.c.iii.a The role of production and audience

Ultimately the aim is that in the development of the production process and bringing the work to stage, the subjects, having been initially anthropomorphised, are able to have an impact on the audience to complete the anthropomorphic cycle as the on-stage performers become 'astromorphised', or 'arboromorphised' in full view of the audience.

During each stage that involved some kind of audience I also distributed questionnaires so that I could gather feedback and understand whether or not the production elements we were working on were successful in conveying the subject and encouraging an empathetic engagement with it. This, alongside gathering reflections from the participants and creative team, was very useful in helping to understand the efficacy of our approach towards the work. The work towards the production itself also allowed me the opportunity to understand the ways in which the libretto worked with the music, performance and design of the production. It allowed me to make further changes, based on a fully realised exploration of the true performativity of the work, and meant that I could ensure that each piece presented in this research is able to be brought into reality and to some extent to fulfil the research aims and objectives.

The methodology which emerged during the PhD involved a process of integration in a collaboratively unfolding creative output, making use of methods of reflective and active performance practice, in order to test and understand the efficacy of the produced work in achieving its aims.

2 ‘Librettising’ Astrophysics to Create *The Flowering*

Desert

2.1 Introduction

The Flowering Desert is a multimedia, immersive opera about the TRAPPIST-1 planetary system. It follows two separate timelines, happening in parallel. One narrative is the timeline of an astrophysicist as they discover TRAPPIST-1, and the other the story of a planet within TRAPPIST-1 as it becomes hospitable for life. This particular system was discovered in 2016 by teams based at the University of Birmingham and Liege, and included as one of its leads the award-winning astrophysicist Dr Amaury Triaud.

This opera was written from January 2020-October 2021 and was performed in May 2022 and January 2023. An excerpt was also performed at the UK Astronomy Meeting in Warwick Arts Centre with the *See The Sun* installation in July 2022. It is composed by Daniel Blanco Albert with a libretto by myself. During the process we collaborated with filmmaker Tadas Stalyga, costume and movement designer Alexander Kaniewski, projectionist Leon Trimble and art students from the Birmingham School of Art. It was performed in the Birmingham ThinkTank Planetarium with the collaboration of the ThinkTank lead Colin Hutcheson. We were commissioned to perform the work as part of the Commonwealth Games Culture Programme for University of Birmingham, after having collaborated with the astrophysicist Dr Amaury Triaud. The performers were funded by the University of Birmingham as part of their Commonwealth Games programme for the performance in May 2022, and by M4C for the performance and recording in January 2023.

The choice to focus on the TRAPPIST-1 planetary system and the science behind its discovery was a natural progression from the previous work I had done on *Entanglement! An Entropic Tale*, prior to the PhD as mentioned above (see section 1.2.e and Appendix AP 3.1). I had been working a lot with physics due to my background studying Physics and Philosophy and working as a secondary school physics teacher. I wanted to find a topic which would be a bit more focused than the broad range of physics covered in my previous work, and so the easy accessibility of the scientists engaged in the discovery of TRAPPIST-1 provided an ideal focus for a new work. Daniel and I already had connections to the University of Birmingham physics department, having become part of their PhyArt hub.

2.2 Context of the Research

In creating the libretto, it was essential to understand how to create a representation of the topic, alongside the key humanistic and philosophical themes that surround the research. This included not only researching the TRAPPIST-1 planetary system and the process to its discovery, but also understanding the scientists' experience of their work. This whole project was developed across three main collaborative cycles which involved creation and performance. The first creative cycle involved researching the subject and working with Dr Triaud, Daniel Blanco, Tadas Stalyga and Alexander Kaniewski to create short films (the overture, the triple study, and scene1 + mélodrame 1 + scene 2) which explored the initial performativity of the work. For this piece one of the most important moments that triggered the trajectory of the work was meeting and discussing TRAPPIST-1 and the experience of its discovery with Dr Amaury Triaud. The subsequent work had to take place mostly online due to the restrictions of the COVID-19 pandemic lockdowns, and so involved a series of online workshops, discussions, presentations and completion of small creative tasks. All work created by the team during the first cycle can be found in appendix AP 1.1-1.4. The second cycle involved working towards the first full performance in May 2022 at the Birmingham ThinkTank with Daniel Blanco Albert, Leon Trimble,

Alexander Kaniewski, the performers, and students from the Birmingham School of Art (BSA). Work created during this second cycle can also be found in appendix AP 1.5. The end of the second cycle made use of audience feedback as a resource for the next stage of the work. In order to see a fuller analysis and the results of the audience feedback please see appendix AP 1.5.d. The final cycle involved working further with Leon Trimble to update the projections, and further develop the costumes with a new group of students from BSA, towards our final performance at Birmingham ThinkTank in January 2023.

During this chapter I will be referring to various excerpts from the opera. Please find a full recording of the dress rehearsal of the opera on 16th January 2023 and full libretto in section 2.5. The pdf of the programme which includes libretto and further information on the show can be found in appendix AP 1.5.c.

2.2.a The TRAPPIST-1 planetary system

In this section, before exploring the creation of the work, I will outline some of the properties of the TRAPPIST-1 planetary system so that the reader can better understand the use of them in the creation of characters for the libretto.

The TRAPPIST-1 system is an alien and contrary landscape in comparison to our home, the Solar System. However, its beauty and symmetry has made it very attractive to artists, as can be seen by the number of collaborations made with artists by Dr Triaud on his website trappist.one (2019). It is one of the flattest systems ever documented, and the planets all orbit the star in a harmonic resonance. This means their orbital periods (the time it takes each planet to rotate the star once) can be described in a series of ratios that relate to one another. They do also have some minor perturbations among them, as the planets are so close to each other that the gravitational field of each one has the potential to affect

the orbit of those around it. This harmonic resonance would allow for the system to be converted into a musical form with an audible pattern, resonance or sensation.

The familiar, life-giving, star at the centre of our system, the Sun, is a G-type main sequence star, also often called a yellow dwarf. This category of star makes up roughly 7.7% of all the stars in our galaxy (Lada, 2006). It is by no means a large star, with the biggest red supergiants being measured to have a radius of up to 2,150 times the Sun's (Fok et al., 2012), however it is among the brightest, being brighter than roughly 85% of the stars in the Milky Way. Part of the reason for this is that the most common type of stars in our galaxy, the M and then K types, are also the least bright stars. The star at the centre of the TRAPPIST-1 system, called TRAPPIST-1a, is an M type star, also known as a red dwarf (Gillon et al., 2016). This type of star makes up roughly 79% of all stars in our galaxy. Its mass is approximately 9% that of the sun and its radius just larger than Jupiter's. It is particularly cool, even among other red dwarf stars, and is considered to be an ultracool red dwarf. It is in fact the coldest known star to host planets (from 2022) and is estimated to be 7.6 ± 2.2 billion years old, in comparison to our Sun's 4.6 billion years (Burgasser & Mamajek, 2017) (Delrez et al., 2022). Its full life expectancy is a very impressive 10 trillion years, whereas our Sun is only expected to be in the stable main sequence part of its life for another 10 billion years (Gesicki et al., 2018).

The artwork below shows, through a comparison with Jupiter and some of its moons, the proximity of the TRAPPIST-1a star to its 7 Earth-sized orbiting planets. We can see from this image that the two systems are comparable, with the TRAPPIST-1a star being just slightly larger than Jupiter itself.

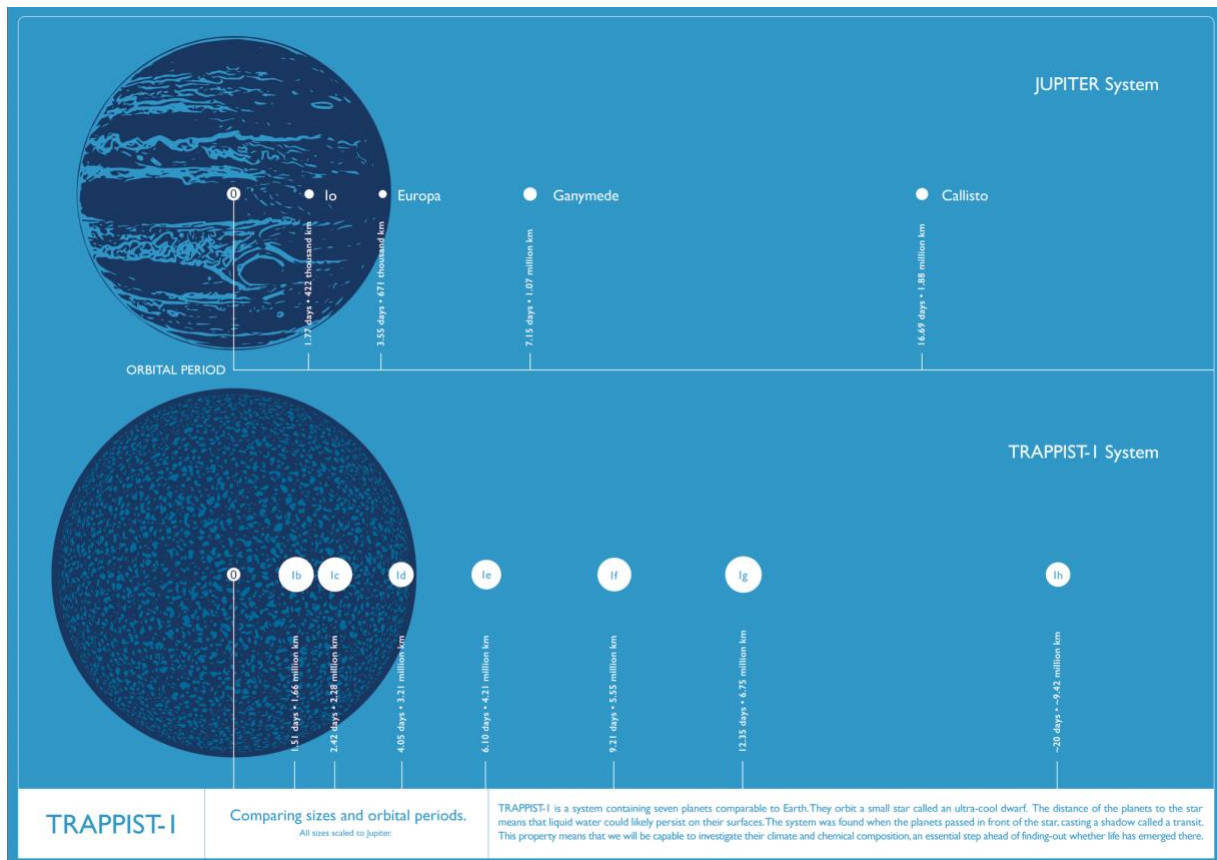


Figure 2 Comparing sizes and orbital periods. Source: IoA/Amanda Smith (Creative Commons)

2.2.a.i Detecting Exoplanetary Systems

These ultracool star systems are particularly valuable for astrophysicists as the transiting planets are quite visible and their light patterns are easy to pick up with a telescope. In order to measure the planets orbiting a star the telescope looks for dips in the brightness of the star. These will occur when something passes, or transits, in front of it, blocking some of the light emitted, and reducing the amount of light received by the telescope on earth. By analysing the magnitude and frequency of these dips in brightness, scientists can then make predictions about the number, size, orbital period and frequency of the planets orbiting the star. Figure 3 shows how these dips are represented graphically, and the orbits of planets that were constructed out of them. It is currently particularly easy to see the transit of planets around small and cool stars such as these Red Dwarfs. It will still be some time before we are able to

accurately gain information about the planets transiting brighter stars, such as the Sun, elsewhere in our galaxy. This means that these ultracool dwarf stars are an important place to begin studying planetary formation and planetary biology in our galaxy. Amazingly three of the TRAPPIST-1 planets (e, f and g) were found to be in the habitable zone, and at the time of discovery this system was the one with the most planets in the habitable zone.

One of the main goals of the field of astrophysics is to find out if there is life elsewhere, and how common it might be. The discovery that the type of star that TRAPPIST-1a is – an ultracool M dwarf – can have a multi-planetary system, with planets within a habitable zone, has expanded the way that scientists see this search for life. It provided a shift to the paradigm that habitable planets form around G type stars such as our Sun (an anthropocentric approach) and opened up the possibility of a galaxy teeming with life (Triaud & Gillon, 2017). In a comment related to an article on the discovery Dr Triaud offers his opinion in response to a question over the observation of Red Dwarfs by saying:

TRAPPIST-1 could have been discovered 10 years ago if anyone had dedicated some thoughts and a telescope to it. After all, TRAPPIST is a modest instrument, and several amateur astronomers have one in their backyard. (Triaud, 2017: online)

If we can understand the potential for life in these very common red dwarf systems, then we will be able to contextualise the formation of biological systems on earth and get much closer to understanding our place in the entire cosmos.

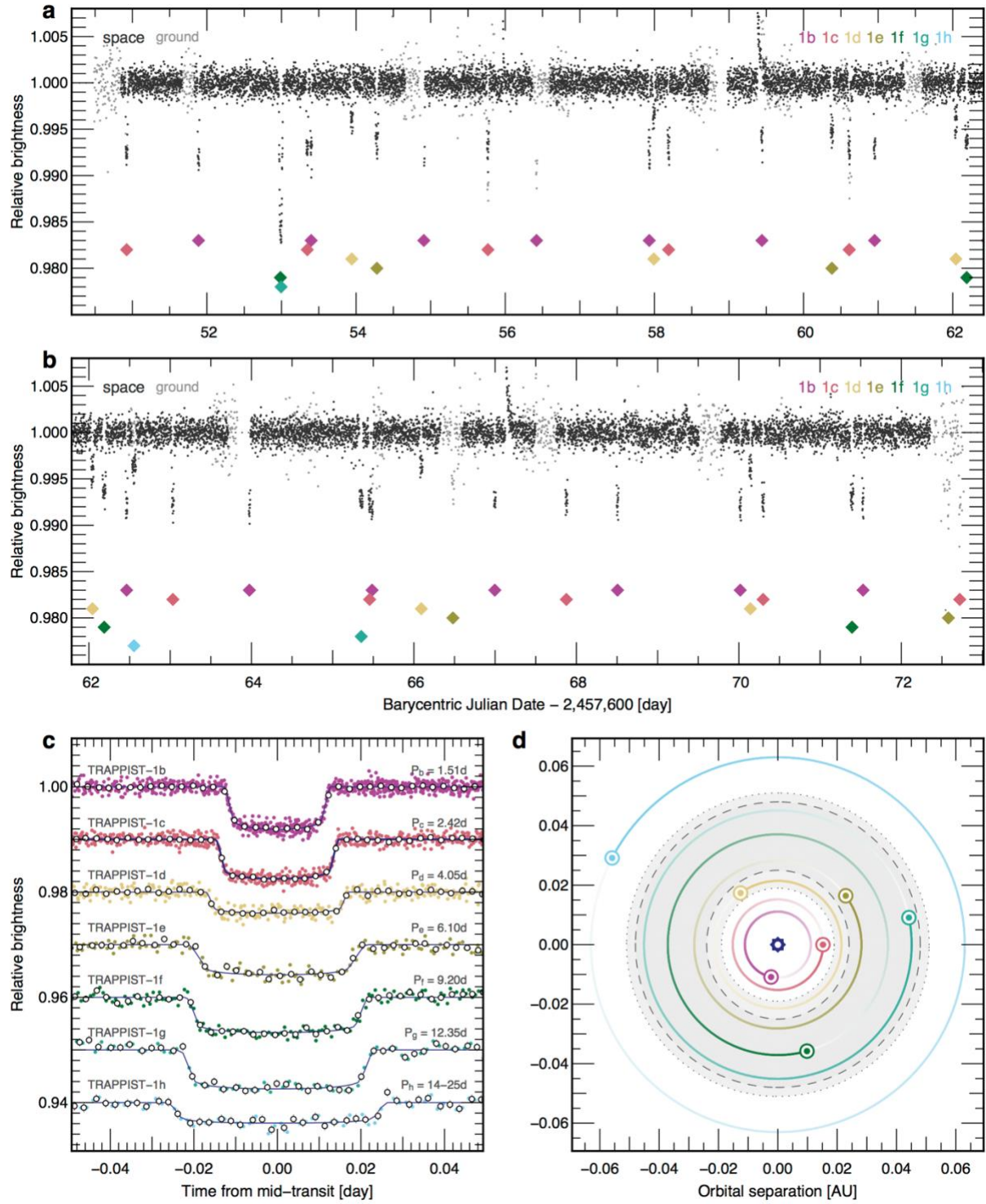


Figure 3 Graphical display of the TRAPPIST-1 transit data. Source: Gillon, M., Triaud, A. et al. (2017)

2.3 Synopsis

The narrative has two timelines which run in parallel during the opera. First, we have the overture and mélodrames which are the voice of the Measurer (an astrophysicist) before and during their experience of discovering the transits of TRAPPIST-1. Second there are scenes 1-4 which follow the development of the planet Pantele (a fictional planet from the TRAPPIST-1 system, mostly based on TRAPPIST-1e) as it becomes habitable. This involves the help and use of the comet Xoe (an exocomet from the TRAPPIST-1 system) and the Mother Star (star TRAPPIST-1a). To become a habitable environment, Pantele must first generate a magnetic field to shield the planet and its atmosphere from harmful radiations. This happens through a geological process called tidal heating, which causes the inner material of the planet to become molten and fluid. Next it must gain the elements required for life to form, which are delivered by Xoe in the process of panspermia – where an asteroid or comet collides with a planet bringing with it vital elements, and dispersing them with enough energy for them to form new compounds in the planet's atmosphere.

In order to see examples of the libretto and performance cited in the following sections please find both in the folder '2.5 The Flowering Desert Film and Libretto'.

2.4 The *Characterisation* of TRAPPIST-1

And as realism is an art of implicit simile, myth is an art of implicit metaphorical identity. (Frye, 1957: 136)

Looking at the night sky has been an activity of human existence for thousands of years. Before our knowledge of astronomy developed, the stars were used to tell stories and create myths. These myths were a way of interpreting the mysterious natural environment, and helped humans understand their

place within it (Helge, 2010). As such the night sky and mythology are already inextricably linked to an understanding of the workings of the universe. Key influences for this work were based on an exploration of mythologies which related to the various characters, objects and philosophies represented in the system and its discovery.

The various ontological approaches (some of which are touched on in chapter 1) to the world and other objects in it is tangentially related to the study of astrophysics, which depends on making observations of objects that before were not known to exist. This meant that one major element I wanted to tackle within the narrative for this opera was how our observation of something both changes the way it might exist, but also changes the way we conceive of other things outside of it: how the discovery of something new can alter our perceptions of the world in order to take up space in our constructed views of reality. As already described, the discovery of the TRAPPIST-1 system had a strong impact on the way we think of the origins of life in the universe.

After getting to grips with the physics and concepts behind this research, as well as researching traditional, mythical narrative, and archetypes to develop the characters and story within the piece I began sketching out the characters. The characters I chose to represent in this libretto are:

- The Measurer (an astrophysicist) - to incorporate the experience of the scientist and the shift away from a sun-centred approach to astrophysics. They are named Measurer in reference to their empirical role as a scientist.
- Pantele (mostly based on planet TRAPPIST-1e) - the most potentially habitable planet (Fauchez et al., 2020), to explore the dynamics of the system, and the conditions for life. The name Pantele is an anagram of Planet-e and also contains the Greek terms *pan* (whose etymology

stems from the Greek for 'whole' and was also the god of the wild), and *tele* (Greek for 'far away').

- Xoe (an exocomet in the TRAPPIST-1 system) - to explore the search for extra-terrestrial life. The name Xoe is an anagram of exo and is also a variation of Zoe which means life.
- Mother Star (the red dwarf star TRAPPIST-1a) - to explore the experience of a Red Dwarf Star. It is parental due to it being the centre of the system. It supports the position of each planet and acts like the controller of a stellar ecosystem, such as Mother Earth.

I focused the creation of characters for this piece on Jungian archetypes, so that all characters might reflect the postulated collective archetypes of the human psyche, the consciousness of the Measurer, and the objects within the TRAPPIST-1 system. The characters within the system (Pantele, Xoe and the Mother Star) are all part of an uprising of understanding from the Measurer's subconscious, and so present themselves as a narrative of thoughts, while the Measurer experiences the profound moment of discovering another planetary system. Jung's work has a deep relationship with the understanding of mythical archetypal figures, which is also a key element to the creation of many traditional operatic libretto. Using his archetypal forms helped me to embed both the science and the more traditional forms of opera in the work. I particularly focused my characters on the Jungian shadow, anima/animus, persona and self. During this process I made sure to keep aware of the original context of Jung's works. The society in which he was working was greatly different in many ways to how we live today therefore engaging with the meaning of his archetypes in relation to contemporary psychological studies was also an important part of the approach to his work.

The shadow is the representation of the subconscious, and specifically the darker parts of the personality. These may take the form of jealousy, repressed desires, or avarice, and can often be

represented through a villainous character or trickster. The anima/animus represent the life force within the psyche and are seen as the giver of creativity and ambition. They are contra-sexual inner organs: the Anima is the female projection in a male psyche and the Animus the male projection in a female psyche. It is also deemed highly important as it can carry messages between the conscious and the subconscious, represented also by the trickster. The persona is the outwards facing, social mask, of the psyche. This could be very different to the true Self. It is the go-between from the ego to the external world and is often represented by a hero character. The self is the embodiment of all the above parts. It is also important to note that even though I have described these archetypes as very separate, they will actually overlap and spill into each other within the individual's psyche.

A main reason I chose to have a human character in this opera was the great importance the discovery had on moving the focus of research in astrophysics forward, from an anthropocentric to biocentric outlook. Whereas life had been supposed to be most likely in planetary systems like our own it is now thought to be possible in those very different to ours. The anthropomorphism of the system in the Measurer's mind helps the character of the Measurer to shift their perspective of the value of the TRAPPIST-1 system itself. This shift in thinking is not only present in the work of astrophysicists but has been actively pursued by researchers in fields across disciplines such as law (De Lucia, 2014), theology (Hoffman & Sandelands, 2005) and philosophy.

2.4.a Using the Planetarium

From the start of the process, we knew we would be making use of the ThinkTank Planetarium in Birmingham, an unusual and subject-specific performance space. As such the space and the audience within it play a vital role in the conversion of the physics into an operatic performance.

The planetarium is an ideal space in which to present a work that seeks to enable the audience to deeply experience the subjects in this research. The performers rotate through the peripheral sightlines of the audience, making them a more elusive and supporting aspect of the piece, with the dome as the central focus. The musicians are also placed around the audience which, alongside the pre-recorded elements in the 5.1 speaker system, created a surround sound audio experience. As such the audience is a key feature of the space, becoming the point around which everything else rotates. This helped a lot in creating a deeper potentially hyper-immersive experience for the audience, and one that could attempt to go beyond merely putting the audience into the environment of the opera, instead making the audience's presence and cooperation a key part of that environment. The constant sensation of being in a rotating system from both a visual and auditory perspective, designing the music, placement of instruments, movement of the performers and projections to enhance this, aimed to help stimulate the audience's loss of distinction between fiction and reality, heightening the suspension of disbelief towards the fictional characters and scenarios presented. The more the audience accepts their environment and becomes part of the system the more they are allowing themselves to be shaped by the performance and anthropomorphised in the process. Just as through the discovery of the TRAPPIST-1 system the planets and star itself were actors in a network which affected and altered Dr Amaury Triaud's understanding of the world around him, and even further impacted the ways in which astrophysics is approached by scientists, the performance as a whole (that is, the sensory experience of the multimedia operatic performance) is an actor which has the ability to reshape the views and understandings of the audience perceiving it. Through the story, music and scenery, the audience can better or even hyper-immense themselves in the fictional (although built out of scientific research) worlds of the Measurer and the TRAPPIST-1 system.

One element we found to be vital to the audience's full engagement and enjoyment of the work in the dome was to implement subtitling throughout. This was done easily in the mélodrames and scene 2, as

they were performed to a click track. However, in the other scenes I condensed the sung text to the most important, or poetic, sections. These were then embedded into the projections at key moments where it would not make a difference if they were being sung at the same time by the performers. In a further performance of the work, I would suggest performing the whole piece to a click track to allow for all subtitles to be in line with the sung material.

In the following sections I will provide detail on some of the decisions made for the narrative and characters, explaining how they relate to the science, the archetypes and the collaborative process.

2.4.b The Flowering Desert as Comedy

Having read several creation stories and before writing the libretto itself, I wrote a short story which I would be able to use as source material (see Appendix AP 1.2). I wanted to make sure that this work was not a tragedy, as many of the themes of the work involve discovery and positive change. Ultimately the story is a mixture of comedy and romance which adheres to the comic principles of hierarchical change. To do this I sought to employ some of the traditional elements of comedy which are commonly present in opera buffa. Northrop Frye describes these principles as:

Thus, the movement from *pistis* to *gnosis*, from a society controlled by habit, ritual bondage, arbitrary law and the older characters to a society controlled by youth and pragmatic freedom is fundamentally, as the Greek words suggest, a movement from illusion to reality. Illusion is whatever is fixed or definable, and reality is best understood as its negation: whatever reality is, it's not that. Hence the importance of the theme of creating and dispelling illusion in comedy: the illusions caused by disguise, obsession, hypocrisy, or unknown parentage. (1957: 169)

The dispelling of the illusion through a youthful and rebellious transgression is reflected in the discovery of the TRAPPIST-1 system and experienced by both the characters of the Measurer and Pantele. In our first meeting, Amaury described to us how the discovery itself was a mistake. The team had not intended to focus the telescope towards this red dwarf star, however due to technical problems the data was collected 2 weeks later than expected. This delay is what enabled Amaury to be present to experience the *desierto florido* (the flowering desert), but is also the reason the telescope spotted the TRAPPIST-1 system. This disruption led to a huge change in the way the galaxy is studied and explored. I decided to make use of a dual timeline in the story, one being the thoughts of the scientist on Earth, and the other being the anthropomorphised representation of the TRAPPIST-1 system as the planet TRAPPIST-1e becomes habitable. The story itself takes on the form of comedy when the Measurer's attitudes shift from the illusory opinion that life is not possible in red dwarf systems, to an understanding that the reality could be far more complex. At this point the character of the habitable planet, Pantele, becomes independent from the system, no longer subsidiary to the star. Both the Measurer and Pantele take on a heroic role in the piece, and they would not have been able to overthrow the old hierarchy or assumptions were it not for the actions of the other characters. The flowering desert Dr Triaud experienced in the discovery of the system becomes a metaphor for the conversion of exoplanets around red dwarfs being seen as unimportant to now being viewed as potentially full of life.

The characters of Xoe and Parent Star can also be described through these further principles of the comedy mythos:

The total mythos of comedy, only a small part of which is ordinarily presented, has regularly what in music is called a ternary form: the hero's society rebels against the society of the senex and triumphs, but the hero's society is a Saturnalia, a reversal of social standards which recalls a

golden age in the past before the main action of the play begins. Thus, we have a stable and harmonious order disrupted by folly, obsession, forgetfulness, 'pride and prejudice,' or events not understood by the characters themselves, and then restored. Often there is a benevolent grandfather, so to speak, who overrules the action set up by the blocking humour and so links the first and third parts. (Frye, 1957: 171)

Xoe can be seen as this benevolent grandfather, who helps Pantele to overrule the forceful presence of the Mother Star. The Mother Star is initially viewed as the blocking entity, due to it being a seemingly inert Red Dwarf. However, we come to realise throughout the piece that it is also necessary for our heroine's (Pantele's) rebellion, the desire to host life, to succeed.

I workshopped the short story (see appendix AP 1.2) with colleagues and sent it for feedback to some friends, my supervisor Prof. Gerardo Adesso, and Dr Triaud. One piece of feedback which made me question the trajectory of the story was why we see Pantele before it has become habitable and not after, as this would probably have occurred early in the planet's formation. Indeed, if we think about the most likely moment that we as humans would be able to observe the planet, it is probable that we would be observing it long after it had become habitable. However, through the use of archetype and myth it is of great importance that this is the point at which we encounter this planet and the story.

Mircea Eliade has written on the topic of time, and timelessness in mythological tales:

This mythic or sacred time is qualitatively different from profane time, from the continuous and irreversible time of our everyday, de-sacralised existence. In narrating a myth, one reactualizes, in some sort, the sacred time in which the events narrated took place. [A myth may not be told by everybody and at any time, but only under the proper ceremonies] . . . In a word the myth is supposed to happen- if one may so – in a non-temporal time, in an instant without duration, as certain mystics and philosophers conceived of eternity. (1991: 34, 57)

This also connects us to the arc of the Measurer's thoughts and the role of the fictional system in the Measurer's subconscious thoughts. It reflects the timelessness that exists in the instant moment of understanding, as described in the short story below:

With pricking eyes, I blinked. Within that blink I had seen it all. I suddenly knew how life could work in a world so different to ours. How life could be so full and strange in another world. 'Thank you Xoe' I whispered out loud. You have reminded me I believe in life after all.

The workshops on the short story gave me more insight into the characters. These involved reading the story, discussing initial responses and reactions to the characters and narrative, and then re-reading whilst exploring new characterisations. They prompted me to convert the Mother Star into a speaking and singing role, as it had previously appeared almost as a prop or object. The responses to the story also showed me I needed to make sure the character's intentions and psychological states were clarified from earlier on in the libretto, especially to clarify and justify the use of the dual narrative timeline.

Knowing how an audience might respond to the tale allowed me to decide in which moments the language could become more poetical including more unknown scientific terms, and when it was important to make sure the narrative is very clear.

2.4.c The Measurer

In this work one of the two timelines is entirely dedicated to the voice and thoughts of The Measurer, or the astrophysicist. For this element I focused largely on the conversation Daniel and I had with Dr Amaury Triaud in January 2020, before we began work on the whole piece. One key theme that emerged from this discussion, and researching the practice of astrophysics before and after the discovery of TRAPPIST-1, was the conscious shift away from thinking about the universe in

anthropocentric terms. The discovery of this system encouraged astrophysicists to interrogate the development and structure of planetary systems different to that of our solar system, and to imagine worlds that might exist with a very different kind of physics guiding them. Dr Amaury Triaud was particularly excited about this change in perspective in our search for life. Throughout the *mélodrames* and overture the Measurer makes frequent references to vision and eyes. This was to highlight the change in perception across the piece, alongside referencing the tools we use to observe exoplanetary systems.

Another element I was keen to explore in these sections was the spoken voice of a narrator as a result of the production of *Entanglement! An Entropic Tale*⁸ in Leicester 2019 with an added narrator (see appendix AP 3.1). I learnt from this production that including a narrator-type figure helps to break the barrier between the audience and the physics even further. It can put them at ease with their fears or prejudices around the subject matter, providing an ally through which to experience the world of physics. After learning more about historical trends in writing libretti, I decided to make use of the French concept of *mélodrames* to develop this use of the narrator. *Mélodrame* itself (as opposed to the Victorian style of ‘melodrama’) has been defined by Anne Dhu McLucas as:

The technique of using short passages of music in alternation with or accompanying the spoken word to heighten its dramatic effect, often found within opera, or as an independent genre, or as a sporadic effect in spoken drama. (1992: online)

⁸ A previous operatic work by myself and composer Daniel Blanco Albert, which explores the key themes in twentieth century physics, from quantum mechanics, to general relativity, to thermodynamics to particle physics. This work was premiered in April 2018.

In particular this would be the added voice of the Measurer (the only directly human character in this work). It would be a mostly descriptive voice: the drama in this narrative coming through the dramatically shifting mindset as the Measurer moves between opposing thoughts towards a mindset that is transformed through experiencing the discovery of the TRAPPIST-1 system. I decided to name the sections of this narrative the *mélodrames* to provide the composer with a clear direction towards a different type of vocal and dramatic sound world.

Mélodrames were most commonly used in French theatre in the nineteenth century and subsequently became notably enhanced and adapted towards a *sprechgesang* by composers such as Berg and Schoenberg in *Wozzeck* and the cycle *Pierrot Lunaire*. As you can see in the final work the direction of vocal style was blended and extended beyond the purely operatic or spoken voice, to make better use of the technical potential of the planetarium, and also represent the text as an internal dialogue based on thoughts rather than recited language. *Mélodrame* is used in this sense in its formal and structural capacity, and less as a tool towards the melodrama. It is distinctly different from the operatic voices of the anthropomorphised elements of the TRAPPIST-1 system, yet not fully spoken. The half-whispered sound aims to bring the audience into the mind of the Measurer, to experience their fleeting thoughts, the subconscious and personal world, rather than the outward persona of the character. The vocal character for the Measurer was developed through an exchange of recordings between myself and Daniel, with freedom then being given to Daniel to refine the exact use of the different vocal techniques at certain points in the script.

Readings around Hindu mythology also played a key role in my archetypal exploration of this character, in particular Prajapati, whose origin has been interpreted as a Thought and as Form. These gods provide a deep connection between thought and creation, showing that this is an archetypal association. The name Prajapati was initially applied to many gods associated with creation. Later it was used to signify

one deity. The collective deities given the title Prajapati are the ‘mind born’ children of Brahma (Graves & Guirand, 1968).⁹

If we look at the Measurer through the lens of these gods, we can see that their subconscious thought, which has been embodied in the timeline of the TRAPPIST-1 system and the creation of the characters of Pantele, Xoe and the Mother Star, has undergone the kind of anthropomorphic process referred to by Latour, where not only has the subject been converted into human but the subject itself has also converted the human into its form (2009). The Measurer’s subconscious holds clues to the possible reality of the TRAPPIST-1 system and the discovery of the TRAPPIST-1 system changes the mindset of the Measurer. The Measurer is a conduit between the TRAPPIST-1 system, the scientific research around its discovery, and the audience. Through the Measurer’s thoughts the audience is also shaped by the existence of the TRAPPIST-1 system, just as our projected human grounded presumptions shape it in our minds.

⁹ Another god of note is Brihaspati, the master of magical power, is described as priesthood himself and the ‘Master of formula’ or ‘Master of created things’. Through this he has acquired a cosmological characteristic. Spati of Briha literally means spirit of the universe. He is described as a sage in the Rigveda. His wives are Shubatreyi and Tara – the goddess who personifies the stars in the sky. He is also based on the planet Jupiter (Graves & Guirand, 1968). This links to the TRAPPIST-1 system as TRAPPIST-1 is very similar in form and size to Jupiter and its moons (Bourrier et al., 2017).

2.4.c.i The Arc of the Measurer

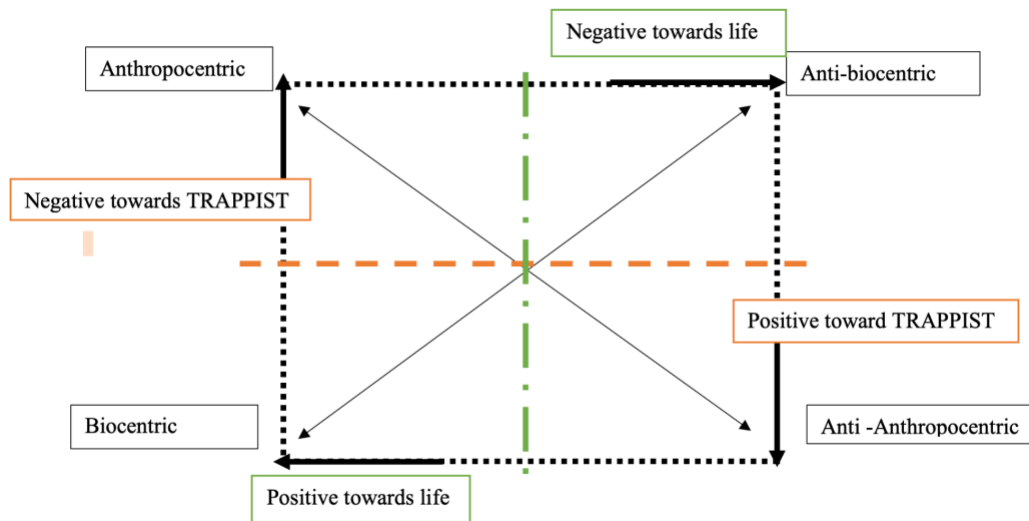


Figure 4 Semiotic square for the arc of the Measurer

The Measurer's journey was designed by the semiotic square¹⁰ above, to take them through a series of nuanced ponderings which begin with an anthropocentric tendency which is highly negative in the way it views the importance of the TRAPPIST-1 system. The voice here veers between a gentler whisper to a pompous sprechgesang, as the arrogance of this positionality is portrayed through performance. This can be seen in this excerpt from the libretto in the overture: Please go to timecode 00:07:10 to view the Overture (below p. 1, lines 14-20).

It is
Nothing like our sun.

¹⁰ This feature of Greimassian narrative analysis (Herbert, 2006) is a tool used to analyse archetypal narratives as Campbell's Hero's Journey, and can be applied to many mythological stories.

Turbulent and destructive enough
To create an active world - the *desierto florido* I lie on.
A red dwarf could never make a world like ours.
There is little hope for life.

The next Mélodrame (1) sees the Measurer begin to lose faith in the importance and meaning of life on Earth. This is the negative, anti-biocentric, state. They begin with their eyes closed, not even acknowledging their environment and mentioning the material non-natural objects around them. As they breathe in they open their eyes in a kind of frustrated nihilism and despondency. Please go to timecode 00:21:45 to view this Mélodrame (below p. 4-5 lines 93-100).

My eyes now closed
Covered by an atacameñan blanket
.
.
.
Why do we search for life at all?
Is that all the universe is there for?

Then, as the Measurer becomes aware that there is an excitement and activity coming from the observatory, they start to feel more optimistic about TRAPPIST-1. They lose the anthropocentrism of their first statements, as they begin to focus on the beauty of the flowers and the earth around them. In acknowledging the beauty of the flora and landscape the Measurer is pulled out of their anti-biocentric state to a merely anti-anthropocentric one. The very earth and ground itself is able to remind the Measurer that the search for life is not so futile. We decided to embed this idea in the projections by having a representation of the earth throughout this mélodrame. Please go to 00:37:38 to view this Mélodrame (below p. 7, lines 157-159).

This desert smells nostalgic.
Millennia of worlds who stood here before.

We humans are small - the flowers showed me that.

The following Mélodrame (3) is part of the journey to complete the arc of the Measurer but does not directly reference any of the anthropocentric or biocentric ideas. It is about the moment of discovery of the TRAPPIST-1a system. All the planets were not discovered in one reading, as suggested by the libretto; however, it provides the audience with more information and greater drama to describe the whole system at this point. Later with Daniel we decided to add in extra lines where the Measurer sings the names of the three planets which were discovered in this initial reading (c, e and f). The Measurer also mentions blinking in Mélodrame 3 which leads directly into the start of Mélodrame 4, despite the scene which occurs in between. Please go to timecode 00:54:04 to view this Mélodrame (below p. 9, lines 211-213).

Transits

I don't dare to blink

A system and planets b to g

In Mélodrame 4 we pick up at the moment we had left the Measurer, transitioning to a viewpoint which is biocentric, positive about life and positive about TRAPPIST-1. In the blink they realise the potential for life and the importance of the discovery. They see the story that the audience has also experienced unfolding before their eyes in the parallel timeline. At this point the Measurer represents the whole self, and the TRAPPIST-1 system in the story represents the different parts of the Measurer's self which are then able to contextualise the importance of this discovery. Please go to timecode 01:09:00 view this Mélodrame (below p. 11, lines 248-254).

Through smarting eyes, I have to blink

I think I've seen it all.

My mind has found how life could be so strange and full in other worlds.

Thank you Xoe

You reminded me - I believe

In life after all.

2.4.c.ii Reflections and Response to Performance and Feedback

In respect to the Measurer and the mélodrames, our main feedback after the first performances from the audience, Alexander Kaniewski and Leon Trimble, was that the projections for the overture did not work, it was hard to understand what was being said sometimes, and the projections created for the mélodrames in the second cycle were a bit repetitive (See appendix AP 1.5.d for further details).

In our recreation of the overture, we decided to present the visual motifs of all the characters in the system, alongside their dictated poems. The Mother Star would be generated using the text from the first libretto that had not made it into the final score. Xoe had been represented using various tools in the previous production and for this one we decided to focus on just using the animation I had created, but playing with it through Leon's synthesiser to develop and present it in various forms throughout the work. We also decided to develop the image of Pantele by including the video of the desert that Tadas had taken in the first cycle as a textural layer for the surface of the planet. All of this served to deeply enhance the projections for the overture, and the rest of the piece, giving them a more cohesive progression during the opera. We also developed the projections in the Mélodrames.

Initially the Mélodrames projections had been very sparse, allowing the audience to focus on the music; however, with the lack of subtitling this probably became tiresome as they would have been aware they were missing out on some key elements of the story due to the vocal techniques used for the Measurer. Therefore, we added subtitles which worked well as these sections are performed to a click track. We also updated the projections to better reflect the mood of the Measurer in each moment.

2.4.d Developing the Character of Planet-e: Pantele

In response to reading about the anima and animus, alongside TRAPPIST-1, I made narrative and character choices which focused a large amount on the concept of life, exploring themes around both its creation and discovery. Jung's description of the anima is related to the trajectory of the two heroes in this piece (the Measurer and Pantele) as well as search for life in astrophysics:

Although she may be the chaotic urge to life something strangely meaningful clings to her, a secret knowledge or hidden wisdom which contrasts most curiously with her hidden elfin nature. (Jung, 1954: 30).¹¹

For Jung the presence of the anima and animus can lead to a union of opposites (masculine in woman, and feminine in man), that will bring us to the point of individuation, which he named the 'syzygy'. The syzygy traditionally signifies a masculine-feminine pairing, or a conscious acceptance of the anima in men, and the animus in women. However, more recent work by scholars such as Mario Saiz et. al. (2023) has highlighted the importance of including androgyny in the development of theoretical and clinical practices around the psychology of the anima/animus, as well as considering feminine-feminine and masculine-masculine pairings (TePaske, 2017). This development of the archetype is valuable in maintaining its use and relevance in a contemporary setting.

Interestingly the term 'syzygy' also has a meaning in astronomy, as it refers to the alignment of three or more celestial bodies. In the search for exoplanets the use of transits requires another type of syzygy as

¹¹ It is important to acknowledge that the Jungian anima/animus distinction on the surface presents a highly binary view in gender representation. However in a fuller understanding of Jung's exploration of these so called 'inner organs' we see that an important part of their use is in the movement towards an androgynous psyche. Jung's psychology suggests that regardless of our sex, we all have the masculine/feminine within us, and that our path towards a greater consciousness is also a pursuit of a wholeness, in which we have wrestled with the contrasting and opposing parts of ourselves.

the earth must be lined up with the distant star and its orbiting planet, for us to notice the planet as it transits the star.



*Figure 5
Astronomical
Syzygy. Jupiter
(top), Venus (lower
left), and Mercury
(lower right)
above La Silla
Observatory
where the
TRAPPIST-1 system
was discovered
(May 26, 2013).
Source: ESO
(European
Southern
Observatory)*

2.4.d.i Pantele's shadow and self

The planet Pantele (or our fictional TRAPPIST-1e) is on a process of self-discovery throughout the opera, and is also moving towards becoming more conscious of their own existence, developing an identity of interest outside of the TRAPPIST-1 system, and separate from the control and influence of the Mother Star. It is on a journey of individuation that is unlocked by physical traumas (tidal heating and panspermia) which lead it to becoming habitable. These will be explored further in the next section.

Pantele's physical property of being tidally locked to the star TRAPPIST-1a (like the Moon to the Earth) causes its surface to be made up of two faces of contrasting extremes. One side of the planet experiences extreme heat and radiation facing the Mother Star, while the other always faces away from the Mother Star and is extremely cold and dark. There is a circumference of the planet's surface which

experiences a constant sunrise or sunset, named the terminator. It is predicted that the tidal locking would generate extreme weather systems, taking dust and material in strong winds from one side of the planet to the other (Grimm et al., 2018). The duality of climates on the planet is reminiscent of the connection between the conscious and subconscious archetypes of the Shadow and the Persona/Ego as well as the conflicting parts of oneself that are referenced in the process of individuation. To express these dichotomies that lie within Pantele, the character introduces themselves through a poem which makes use of both the discovered facts of planet TRAPPIST-1e and also introduces the terms shadow and self, in reference to the psyche of the Measurer. This poem was not read in the dress rehearsal but during the performance we read each of the characters' introductory poems during the overture (below p. 1-2, lines 24-37).

Pantele:

(self) I the planet Pantele

(self) One side never night

(shadow) One side never bright

(shadow) With a shadow as strong as my self

(shadow) Formed just as my mother star

(self) From the rubble of her welding parts

(shadow) With a shadow as strong as myself

(shadow) Every three years I see my neighbour twice

(self) Every two years I see my neighbour thrice

(self) I the planet Pantele

(shadow) With a shadow as strong as my self

(self) A dusky cage of persistent sunrise

(shadow) The terminator where light dies

(self) I the planet Pantele

Here we can see clearly the battle between the shadow and the self (persona/ego). The self begins with a strong declaration of identity, but the shadow soon takes control leading the recitation for a short while. The self takes back control as the shadow starts to think of the other planets in the system, and move away from thoughts of the star. Both the shadow and self speak for 7 lines, embodying the total amount of planets in the system (b, c, d, e, f, g and h).

Pantele's main aria occurs in scene 1 when it discovers from Xoe that it may have a purpose outside of the system. Pantele becomes aware of the human's gaze, and becomes excited by what new identity and meaning it may have when seen through these new eyes. Here the dark side of the planet (the shadow and the outward facing side) is more hopeful and able to inspire the light side of the planet, the self, to be awakened to the possibilities for transformation. The extreme winds that would likely exist on planet TRAPPIST-1e's surface carry the messages from the shadow to the self, awakening the merging archetypes of the subconscious (the anima/animus and the shadow) with the conscious self to begin the process of individuation of Pantele, and change the mindset of the Measurer. Please go to timecode 01:13:26 (below p. 3-4, lines 70-83).

'Aria for two halves of the self

Pantele:

(self) What does Xoe mean?

(shadow) What does Xoe mean?

(shadow) I can see the world outside

Kaleidoscopic distant eyes

I spied to them and now it seems

That one is spying back on me

Dark winds blow to wake my soul

And carry thoughts to make me whole

(self) These smarting Coriolis winds

Whip up the sands, make thoughts spin

I never dreamt I'd ever be

Known out there in the galaxy

Another star-bound family?

Someone there is watching ME!'

Pantele's process of syzygy or individuation is bound up in their journey to becoming habitable. The other characters of the system play vital roles in this task. The events necessary to develop the conditions for life (tidal heating and panspermia) signpost key moments in Pantele's narrative, as it

changes from uninhabitable –and so uninteresting to the human gaze – to habitable, and so of greater relevance to humans. At the start of scene 4 Pantele comments on changes to herself saying (below p. 10, lines 217-219):

'Pantele:

(self) You've made me so afraid

(shadow) But this coloured peripheral vortex

Is soothing all my scars.'

Then in her final moments, once her individuation is completed with the help of the Mother Star and Xoe (who also represent various parts of the psyche whose alignment has led to this process) she responds with a simple gratitude. Please go to timecode 01:06:45 (below p. 11, lines 248-254).

'Hymn

Pantele:

The airs I blow have hope

A field protects my face

Thank you Mother

Thank you Xoe'

This is then reflected by the Measurer's last thoughts in the subsequent mélodrame (4). The projections in this moment convert into a stop-motion of flowers created by myself and Birmingham School of Art student Niambi Robinson. It is at this moment that Pantele, a previously barren planet, is fully connected to the flowering of the Atacaman desert. We decided in the final cycle to remove the cut in

projections between scene 4 and mélodrame 4 to signify this moment in which the fictional world of the system and the experiential world of the Measurer combine.



Figure 6 A still from the stop motion of paper flowers. Flower props created by Niambi Robinson, stop motion created by Roxanne Korda. Source: Roxanne Korda

2.4.d.ii Pantele's traumas

As already mentioned, the two processes that lead to the development of Pantele's psyche and the transition towards habitability are tidal heating and panspermia. Tidal heating is the internal geological activity of a planet caused by the various gravitational forces affecting it (Breuer et al., 2022). This could lead to both the outcropping of gases to the planet's surface, the heating of the planet and the formation of a small magnetic field (Tsang et al., 2016; Kerswell & Malkus, 1998; Bland et al., 2008; Turbet et al., 2020). Tidal heating is represented and explored poetically in scene 3. The Mother Star provides the gravitational force, alongside the other orbiting planets, to create an effect of tidal heating, which would provide a constant geothermal heat source inside the planet. The interaction between

these inner convection currents, and the planet's own rotation also has potential to contribute to a magnetic field around a planet. Planet-e spins once on its axis every 9.21 days (TRAPPIST-1. 2019) meaning that it is not likely to have as strong a magnetic field as Earth (which spins once every 24 hours), however other planets in our Solar System with much slower spins (such as Mercury's 59 days (NASA, 2023)) do still have weak magnetic fields, so it may have the ability to form some kind of protective magnetic shield. The reason this would be helpful is that it would help to deflect the harmful protonic bombardment ejected by the star (Struminsky, 2018).¹²

As Pantele is the character upon which the creation of life can occur, and it is Pantele's goal to set about creating the right environment for life, it has a clear connection to the Prometheus creation story. The stealing of the fire from the gods could be equated to both the use of the parent star's tidal heating and radiating forces, to generate a magnetic field, and also to the fundamental particles for life carried by the comet Xoe (Graves & Guirand, 1968). When Xoe explains to Pantele her necessary destiny for habitability Xoe tells Pantele to steal from her mother's gravitational energy (grasp) which may at first appear to be a weapon against Pantele, but if used in the right way could also protect Pantele from her mother's bombardment (through the process of generating a magnetic field with tidal heating) (below p. 8, lines 166-170):

'First -
Your mother's grasp is strong
She holds and governs you.
But you can start to tame her-

¹² Otherwise, the hope for habitability would be dependent on life existing below the surface of the planet, perhaps under ice or a thin crust (Turbet et al., 2020; Fauchez et al., 2020).

Turn her weaponry to armour!’

In the libretto it is Xoe who first describes the process of tidal heating. In the below section from scene 3, I structured the rhyme scheme so that it is vertically symmetrical, in order to reflect the internal movement of geological fluid from the centre outwards and back again. Please go to timecode 00:48:22 (below p. 8, lines 178-183).

‘Xoe:

Your mother has been tugging
Within you is a friction
The outward eccentricity
Now dissipates internally
And caused a deformation
While underneath a bubbling’

Later in the scene Pantele herself refers directly to the process saying: Please go to timecode 00:50:00 (p. 8-9, lines 190-193).

‘Pantele:

(Self)
As I let my mother pull me
My skins crack to release a moan
Active and sore to my core
A heated tidal bulge’

The scene ends with the process of tidal heating fulfilling its role to help Pantele generate the magnetic field it needs, which can be seen to exist through the presence of an aurora.



Figure 7 Taking footage of wood cutting made by art student Yuan Wang to embed in visuals created with Leon Trimble.

At this point in the projections the aurora is created from a wood cut-out designed by both Yuan Wang and Amy Bradley, which imitates the flower design embroidered on Pantele's tabard. In order to create the image from the object we filmed its shadow (see fig 7). This was to explore and embed further the collection of data on exoplanets from witnessing their transits, and effectively becoming shadowed by them as they pass in front of their star.

In the next scene the comet Xoe collides with Pantele, fulfilling the theory of Panspermia which suggests that the elements to create life are carried throughout the universe by objects such as exocomets, which crash into planets (Wickramasinghe et al. 2018). I will discuss this process and its appearance in libretto further in the section on Xoe.

2.4.d.iii Collaborative development of Pantele

During the first cycle of collaborative work I discussed the myths that I felt best represented the characters. Many creation stories start with a being that exists before the rest of the world, and through whom the world is formed. These beings are often characterised as lonely, and their desire for having more, or for companionship, is what leads to the creation of the Earth as humans know it. The Finno-Ugric creation story features the character Luonnotar¹³, the daughter of nature, who has a deep sensation of longing and loneliness as they float alone on the sea. This helped to inform Pantele's isolation as a tidally locked planet around a star, and the desire for something greater than its current experience. The eagle in the Finno-Ugric story here is also similar to the comet character, as a flying celestial object looking for a home, that finally lands on Luonnotar, laying eggs which enable the creation of the earth (Graves & Guirand, 1968). This mirrors the process of Panspermia which occurs at the end of the opera.

¹³ **The Finno-Ugric story of Luonnotar** - Luonnotar (Daughter of Nature) tired of her isolation in the celestial landscape fell into the sea. She waves and wind caressed and tossed her, and gave her fertility. She floated for centuries, sad and lamenting, until at last an eagle landed on her knee. It built a nest there and filled it with eggs. When Luonnotar noticed a burning hotness on her knee she jerked it, knocking the eggs to the bottom of the sea. The remains of these eggs in the sea floor's slime became the world, the lowest parts forming the earth and the highest parts the heavens. The yolks became the sun, the whites the moon and the spotted shells the stars and clouds. (Graves & Guirand, 1968)



Figure 8 Still from the film of Scene 1 (focus on Pantele performed by Kinna Whitehead) created May 2021 with footage from Tadas Stalyga, costume by Alexander Kaniewski and edited by Roxanne Korda

The eagle in the Finno-Ugric story here is also similar to the comet character, as a flying celestial object looking for a home, that finally lands on Luonnotar, laying eggs which enable the creation of the earth. This mirrors the process of Panspermia which occurs at the end of the opera. Figure 8 from the film of scene 1, created in the first cycle towards developing the opera's performativity, shows Pantele layered on top of a film of a boat in water. We had decided to make use of the imagery of a lonely boat on a vast body of water in response to various creation myths, including the Finno-Ugric one described above. Even though this footage did not make it to the final projections in the dome, we still retained a sense of it by keeping a dark blue colour for one half of Pantele during her aria.

Alexander Kaniewski also created an initial costume for Pantele during this first cycle. After workshopping the character he decided to give her a white dress to signify her innocence and youthful attitude, a hat and red sash to show her submission and restriction from

the Mother Star. In the second cycle we added a tabard which would be turned over to display green painted and embroidered flowers when the collision happens in scene 4. In the final cycle we adapted this piece of costume in response to feedback from Alexander so that the green was more noticeable and it could be easily pulled down rather than turned over. This work was not completed until after the dress rehearsal shown in the video. See pictures of Pantele's costume below in figure 9.



Figure 9 Pantele's costume with tabard showing both sides of the tabard, before and after impact.

During the first collaborative cycle I also workshopped the vocal and musical characteristics of each character with Daniel. We decided that Pantele should be sung by a mezzo-soprano who could provide different vocal characteristics for the self and the shadow. For Pantele's music Daniel had decided to use the music developed for Planet-e. Initially Daniel had some fears that there might not be enough material to generate a score for the whole of the character's parts. However, upon further inspection of his study he realised that there are in fact 2 chords and 2 inversions (4 chords in total) of different modes. This provided the perfect accompaniment for Pantele's two halves. We both felt that the darker side should be associated with the major chord, as this side is more open and has a broader, brighter

experience of the universe. The light side took the minor chord as this side is constrained to always face the star and as such is almost a prisoner of it. As the music moves through these chords and inversions the audience can start to feel Pantele's internal psychological journey and growth. Only at the point of trauma or anagnorisis, where the collision occurs, does Pantele's harmonic material be combined with Xoe's, signalling a rebirth

In the final cycle of the work we decided to make use of make-up to further express the properties of the subjects. For Pantele we asked art student Vianna Mistry to develop the design shown in Figure 10 which literally displays the dark and light side of the planet, with the terminator in between. We also



Figure 10 Make-up design for Pantele by Vianna Mistry, December 2022

asked for the wind to be acknowledged within the design, which can be seen in the detailed swirls.

2.4.e Developing the Character of the Exocomet: Xoe

Astrophysics itself is a heavily data-driven field, with a deep reliance on information being conveyed, and then deciphered, across huge distances in order to bring knowledge of our universe to light. This is reflected by Jung in the role the anima/animus holds in carrying messages out from the subconscious, and so the inclusion of a messenger figure became an important element in the story. Ultimately this messenger was embodied in the exocomet Xoe, who carries the news to Pantele that something else has observed it elsewhere in the galaxy (the Measurer). It is also a conduit between the timeline of the Measurer and the timeline of the TRAPPIST-1 system. Ultimately in the final *Mélodrame* it is Xoe who the Measurer thanks, in showing them how to conceive of life in a red dwarf system (below at p.11, lines 252-254).

'Thank you Xoe
You reminded me - I believe
In life after all.'

The messenger archetype is often represented through the trickster, as a fluid character always in movement. The symbol of Mercury is highly relevant here. Mercury as a metal is known in both liquid and solid forms, moving between the two. In this piece whenever Xoe appears they are always on the move, either coming or going. For example, at the start of scene 3 (below at p. 7. Line 160):

Xoe :

Back I trot, out I pop.

As a mythological character it is a winged messenger of the gods, and as a planet it is part of our solar system. In the Homeric Hymn to Hermes, Hermes is described by Apollo as being a 'slayer of oxen, trickster, busy one, comrade of the feast' (*Homeric Hymns*, 1914: online, line 436). It is clear from the

tale of Apollo, Hermes and the theft of the cows, that Hermes is indeed the cunning trickster-god he came to be known as. This allows Xoe the scope of being representative of a trickster archetype, among other things. In Xoe's opening poem they describe themselves in relation to this archetype (below at p. 2-3, lines 46-59):

Xoe:

I am the comet Xoe.

I am the two tailed trickster,
Dropping via counter steered descent,
To a mother star skirt's brim.

Frozen stone exterior,
Radiate rays effervescent,
Excitement begin!

I am the comet Xoe.

I am the two tailed messenger.
Travelled far beyond this system's edge,
In an ever-wiser spin.

With a motion pendular,
Path perturbed by planetary dredge,
Secret's I've within.

The Homeric hymn also claims that Hermes 'first invented fire-sticks and fire' (*Homeric Hymn*, 1914: online, line 110), making this god a fundamental part of the creation of life and connecting it to the Prometheus story. Hermes was also often represented as a phallic symbol. The Herma or Herm is a sculpture made from an upright cuboid of terracotta or stone with the head of Hermes on top, and male



genitalia adorning the middle (see fig 11). Prior to Hermes being a protector of travellers, he also represented fertility and luck. As such the character of Xoe can also take on qualities relating to the animus, having their own hero's journey, particularly in relation to the theory of panspermia. For Jung the masculine is related to the first part of life through which the ego/hero rises out of the unconscious to find the maiden, helping to track Xoe's path towards transformation during collision with the more

Figure 11 An Ancient Greek Herm or Herma. Source: Creative Commons

feminine Pantele. As Xoe dives on their approach to Pantele, and to fulfil their role in the creation of life and habitability, they sing their triumphant aria. The presence of comets, and their potential to either destroy or create life has been studied in relation to the TRAPPIST-1 system (Kral et al., 2018), where it has been suggested that they might be vital in the replenishment of an atmosphere around the farthest planets in the system. The impact of comets has also been studied and shown to possibly produce hydrogen cyanide molecules, a component in the synthesis of amino acids, and important for prebiotic chemistry (Gersakines et al., 2004). Please go to timecode 00:01:14 (below is at p. 10, lines 220-237).

Mother Star:

Accelerate

Xoe's triumphant aria

Xoe:

Be brave Pantele.

You are seeing clearly.

At last you found your magnetism

I am so proud of how you listened

Xoe:

This final journey past Mother star

I noticed my tail burning out fast.

Mother Star:

Excel

Xoe:

I cannot brightly shine forever

There's more that we can do together.

And so it is with this last plunge

My adventures all will be expunged

Mother Star:

Plunge

Xoe:

All elements for life can form
Though first they may seem toxic
Embrace your star and be transformed
Once inert now biotic'

During this aria Xoe refers both to their own trauma for the first time (the burning of their tail) and to the event of panspermia which is about to occur. They reference the biological potential present in the coming together of Xoe and Pantele and the dissolution of their character and being in this last brave act (below at p. 11, lines 241-243).

'Xoe:

And now for the final wound
I'll meet you on your winds.
It's time for life to begin!

As it dives it breaks into many tiny pieces, some of which burn up on entry and some of which eventually smack into the surface of Pantele. When they do this, they cause huge plumes to rise from the surface of Pantele and spread across the surface from the bright side of the 'self' to the dark side of the 'shadow'. '

During the early stages of the work it was noted by several members of the short story workshops and two of my collaborators that this moment, and in fact the whole of Pantele's arc, could be seen as a loss of virginity. This reading of the story would mean the moment of Pantele's individuation would be related to the fecundation of the planet by the comet. In order to steer away from representing the planet and comet through these gendered stereotypes we chose to make the voice of Xoe a female, in

particular a high soprano, and we worked with the singer and director to think of this character more as an older sister or grandmother. The final collision was meant to appear not so much as a penetration but as a union. This helped us to shift the focus of anthropomorphism away from converting astrophysics into humans and closer to converting humans into astrophysics. The performers and characters can lose any reference to human categorisation such as male/female. As Jung himself acknowledges, the presence of masculine and feminine within the male and female psyche, as well as the importance of the syzygy and the confrontation of these opposing categories to an androgynous union, these character traits, drawn out of his archetypes, do not necessitate that the performer for any character be either male or female. It is exciting to be able to reframe these ideas of the masculine and feminine by applying them to such genderless objects as a comet. In such a moment we are allowing the properties of science to shape and question the way we see ourselves, alongside using human tropes to shape how we see the science.

At the moment of collision, despite Pantele's seeming lack of control over Xoe's actions, it was important that Pantele did not appear passive. In generating a magnetic field and surface temperature warm enough for life Pantele has already undergone a process of change which generated energy from within the planet itself. Reflecting on the movement and direction of the performance, were we to repeat the performance I would now revisit how Pantele is presented in the lead up to this moment, making her more active, perhaps even moving her from her central position, and showing how she is taking control of her destiny at this stage.

Being the same age as the system and the star Xoe also takes on elements of the archetype of the sage. It is wiser than Pantele due to both the distance it travels and the fact that it undergoes the trauma of being burnt and evaporated every time it comes near the star. It is able to guide Pantele through their journey of individuation, before becoming an active role in it at the end. This is particularly evident in

Scene 3 where Xoe informs Pantele that there are two conditions necessary for Pantele to become of interest and have an identity in relation to the observer beyond the system. Please go to timecode 00:44:30 (p. 7-8, lines 164-174):

'Xoe:

I'm so glad you asked
But it will be hard to do

Xoe's tone intensifies to signify an important message:

First -
Your mother's grasp is strong
She holds and governs you.
But you can start to tame her-
Turn her weaponry to armour!
Second -
Alone you cannot manage
You need some added magic
That only comes with luck

Returning to a lighter tone:

Habitability is hospitality and so far, you have
none.'

The meddling and ultimate demise of the trickster Xoe, a comet which collides with Pantele, reflects the commonly used reference to a cracked egg, for example in both the Finnu-Ugric and Hindhu creation stories. The use of an egg relates to a human understanding of the universe and creation in many ways. The energy and creative power that comes from within the egg links with panspermia and carrying the analogy towards reproduction. In the final cycle we returned to some elements of this idea as we directed Xoe to remove her hat and pass it on to Pantele. This would be both a shelling of Xoe's own exterior and a crowning to glory for Pantele in one gesture. Having played with the ideas around the use of the egg for the moment of collision in the projections, we finally settled on using the concept of flowering, in an explosion of colour and shape on the dome. This was created using an animation developed between myself and Amy Bradley to represent Xoe, and Leon Trimble's modular synthesisers, which distorted and refracted it as the

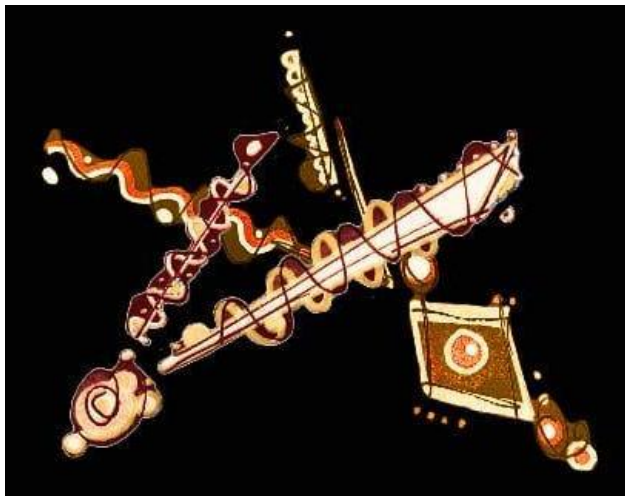


Figure 12 Design for Xoe created by art student Amy Bradley

comet breaks up in Pantele's atmosphere. The animation itself was designed to show both the shape of the comet and incorporate the idea of things splitting, breaking up and becoming something new. Please go to timecode 01:04:28-01:06:40 to see the moment of collision at the end

of scene 4.

2.4.e.i Developing Xoe through Collaboration and Performance

After initial vocal workshops in the first cycle we decided that Xoe should be light hearted, sung by a lyric coloratura soprano, and make use of the music generated from all the planets as it passes through

the whole system in the story. Daniel suggested that as Xoe was partly based on Hermes/Mercury it should use a lot of music from planet b (closest to the star) as well as material from planet h (the furthest away) to show the distance travelled.

In the first cycle of explorations through performance Xoe's movement was fluid and light, showing its freedom and agency in comparison to the servile and imprisoned existence of Pantele at this early stage in the story. However, as we progressed through the cycles we all agreed that this initial version did not match the music or research behind the character. We therefore changed the movement to become slower, more pained, and tired. Ultimately, we hoped to be able to combine the two by directing the singer to be quite bombastic in their vocal and physical expressions. Due to rehearsal limitations we had not yet reached the stage of this character being fully embodied by the performer, but with further work on future productions this is the direction we would bring the character towards.

In the final cycle we worked on the character of Xoe, giving her more presence by providing her with a stronger costume with a hat, makeup and a torch so she could light herself up from all around the space. This allowed her to sing from different points around the planetarium, and the use of the hat and makeup provided a different kind of characterisation which reflected the more fun and excitable parts of her character. We even had some giggles from the audience on a couple of her entrances, an encouraging sign which showed the audience were able to feel comfortable enough to not worry about taking the operatic elements of this quite jovial character too seriously. In the film of the dress rehearsal the hat was not yet complete, however you can see it below in figure 13.



Figure 13 Xoe's jacket, sash and hat.

2.4.f Characterising the TRAPPIST-1a star: The Mother Star

The Mother Star was not in the original short story as a character in the opera, as I had envisioned it more as a physical/musical object. This was to reflect the concept of sound itself (in particular the universal sound Ohm) as a source for the birth of the universe in Hindu tradition (Graves & Guirand,

1968).¹⁴ The idea of sound being a source of creation also connects with concepts which equate matter and energy in twentieth-century physics. Initially I had conceived of the Mother Star being present in the piece as this sound only; however, after initial workshops with students and discussions with Daniel we agreed to add the Mother Star as a sung character. The star exists as a causal object within the story. It lives in a different timeline to the other characters and so acts as an object they interact with, but does not have an arc itself. This is due to the properties of the star TRAPPIST-1a itself. As a red dwarf it has longevity. These stars could live for hundreds of billions of years. TRAPPIST-1a is a youthful example as the star has not yet reached its middle age (Burgasser & Mamajek, 2017). It is also very cool at a temperature of 2,511 K whereas the sun is 5,778 K. It has a limited visible light radiance but strong emission of other radiations (hidden in the shadows) and its luminosity is 0.05% of that of the Sun (TRAPPIST-1, 2019).

The Mother Star character is a vital part of the transformation of Pantele, constantly attacking and meddling with it. Being young itself it is not aware of the effect it has on Pantele, or even aware of Pantele's existence around it. It is much more concerned with itself. This can be seen in scene 2 when Pantele fails to get the Mother Star to listen during the Brutal Mother and Forgotten Child duet, and in scene 3 when the Mother Star attacks Pantele (with a protonic bombardment) for disturbing it. As described in the extract from scene 3 below, the more teenage-like age of the star in relation to its total life span is reflected in its spotted (acned) surface. Please go to timecode 00:49:03 (below at p. 8-9, lines 185-200).

'The Mother star like an irritated teenager is suffering a constant convection and burning. It laments its spot covered surface. This

¹⁴ The belief is that universal sound is a manifestation, or expression, of the breathing in and breathing out of the creator Brahma. It is such because the sound is fully open and then rounded. The 'O' is open at the back of the throat and then rounded to a contraction/closing with the 'mm' at the front of the mouth.

makes the cries and anxiety from Pantele, and the meddling of Xoe, even more frustrating. It lashes out by releasing a bombardment of protons on Pantele.

Mother Star:

Look there, and there and there -
Another spot!?
A darkish flare?
This mournful magnetic mass
In constant repair.

Pantele:

(Self)
As I let my mother pull me
My skins crack to release a moan
Active and sore to my core
A heated tidal bulge

Mother Star:

Now what is that I hear?
Something buzzing at my ear?
This proton punishment you'll see
For failing to just leave me be!

Mother Star choir the directs a painful bombardment at Pantele.

Pah ha ha ha
Poh ho ho ho
Pih hi hi hi

Ultimately it is a potential source of energy for life and also a source of inspiration for the astrophysicist. It is the backdrop to the transits and without it the planets would not be visible. As such it is almost a gateway to the external world. In this sense it is like the persona, as it is the façade of the system. When referring to mythology to understand the Mother Star I highlighted two stories. In the Chinkookan Sun's myth the sun is represented as an analogy for invading colonisers in the Americas (Hymes, 1975). This subversion of the traditional sun symbol makes it almost demonic when its power is not used correctly. This was a nice reflection of the kind of unloving mother it appears as in *The Flowering Desert*, whose radiation has the potential to destroy Pantele's hopes for life.

In Greek mythology Demeter was said to not have fed Demophon as a baby, but instead to have breathed on him softly, anointing him with ambrosia and at night hiding him in the fire (Graves & Guirand, 1968). Through this treatment he grew to be like a god. The harsh field of X-ray and UV radiation from TRAPPIST-1a is analogous to Demeter's breath, and the intense heat of the fire in the cold night is analogous to the tidally locked frozen and hot sides of the planets around TRAPPIST-a. This parental, but cold, treatment unwittingly led to the creation of a man of strength and honour, just as TRAPPIST-1a's brutal treatment of planet-e (due to the proximity to the star) may actually be part of what is required for planet-e to host life. Psychologically for the character of Pantele the cold detached nature of the Mother Star from Pantele provides further reason to look beyond the TRAPPIST-1 system for a sense of identity and purpose.

In scene 2 the Mother Star ignores the pleas of Pantele to listen to its exciting and life-changing news. The star's text is repetitive and process driven. As the character of the star is the least emotional, and lacking in narrative, the text for it was open to a more direct use of science. This scene in particular was based on the metallicity of the star as the process of fusion converts the hydrogen to heavier elements towards the star's core. The metallicity of TRAPPIST-1a in particular is not yet known so I used more

general information about the metallicity of similar stars of the same type (Mann et al., 2013)). At this moment the star is almost non-teleological, and is in a chemical, musical and lyrical rotation which seems infinite in comparison to the timeline of humans or even of the Earth. It is also comical in its presentation of the various different elements it is creating, using word play to deliver these elements with a sense of grandeur to the audience.

Through the process of workshopping and discussing this scene (alongside referencing some of the initial musical and performative explorations of the character) Daniel and I both decided that the Mother Star should not have any lyricism to it. It shifts harmony in blocks of rhythmic and melodic material, and involves the use of a pompous sprechgesang alongside hocketing to create a sensation of endless process, interference and bombardment. Daniel requested some extra dialogue in sections where the Mother Star would be speaking and not singing. It will be sung by a 4-part SATB chorus. Some elements of the vocal score would be recorded and played through the planetarium's 5.1 speaker system. This would both convey the character of the star as well as giving it a greater sense of size, beyond the performance space itself. The Mother Star's movement generated in the first cycle (which can be seen in the film of scene 2 in appendix AP 1.4.b) was also based on this sense of timelessness. The costumes are almost monk-like, reflecting the sempiternal nature of the performer's tasks within the star. Tadas's initial ideas had been to represent the Mother Star with images of quarries and stones, to reference the deep geological time of the Earth. With Leon and the restrictions of his tools, we chose to make use of a more mechanical looking design, which rotates in an industrial fashion, showing the endless burning of fuel and constant work that the star is undergoing. Please now go to timecode 00:27:10 to see a performance of this scene (p. 5-7, lines 101-151).

Scene 2

This section begins with focus on Mother Star slowly bringing focus to Pantele as it calls to Mother Star. Xoe will be moving, in its orbit, around Mother Star and begin returning to Pantele.

Pantele's 'self' cannot see Xoe very clearly, on its eventual return, due to the brightness of the Mother Star.

Mother Star sings but never answers. It exists in a different realm to Pantele and so struggles to understand or take notice of Pantele. However, Mother Star is always both giving to and attacking Pantele, through heat and radiation.

Brutal mother and forgotten child duet

Here the Mother Star chorus represents the fusion and metallicity of the star. It sings about the hydrogen fusion in a self-obsessed and conversational manner.

Mother star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

If they find their reflection

They flee in the other direction

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Oh, Iron I say

You look feral today

Pantele:

Mother, can you hear me?

Something happened to us.

Mother Star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Lithium is missing

Hydrogen is kissing

Pantele:

Mother I'm ecstatic

There's something so fantastic!

Mother Star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Out struts Titanium Oxide

The cool M Dwarf guide

Pantele:

Mother, can you listen?

I discovered my ambition

Mother Star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Vanadium Oxide - so amorphous

Rather dense and rather formless

Pantele:

Mother, can you hear me?

This might be momentous!

Mother Star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Good evening mistress silicon

You've almost reached the central dome

Pantele:

Mother listen to me!

You're being so unruly.

Mother Star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Such metals make a chill

Through round rouge ruddier fill

Mother star starts singing again and Pantele interrupts with increasing frustration

Mother Star:

Hydrogen 1 meet Hydrogen 1

Hydrogen 2 meet Hydrogen 1

Helium 3 can't meet Helium 3

Pantele:

Mother don't ignore me!

Your child has so much anxiety

Mother, for once - please hear me!

Pantele collapses with exhaustion over its attempts to communicate with Mother Star.



Figure 14 The Mother Star Teddy Woolgrove, Dalma Sinka, Megan Artemova and Ed Harrisson (left to right), January 2023

2.4.f.i Considering the direct use of data in creating Mother Star

In order to better understand the process of analysing the data from telescopes I spent some time researching the use of machine learning to process the data. This is not something that was required so

much for the TRAPPIST-1 discovery; however, it will be vital to unlocking knowledge of exoplanetary systems around all types of stars in the future. I found that the way telescopes capture information about transits can often produce an image that has a large amount of noise, and requires algorithms to find the transit patterns within it. The process of filtering the noise down to the useful information has philosophical resonances with constructivist thinking. Having just researched Naum Gabo and the use of constructivism for another piece, it seemed fitting for me to include this metaphor as a poetic layer within the libretto itself.

Initially I worked on developing a poetic metre based on the transit data as Daniel had let me know he was developing the score this way; however, after researching this aspect of astrophysics I decided against this approach to the work. I did not feel that creating a sense of rhythm based on the metre and emphasis of the text would help the audience to feel the processing of the data. As the data was so irregular and long it was unlikely it would even be noticed by the audience, especially once the text had been set to music. It seemed that it would be better to use this concept of form in some way to reveal the important parts of the text (as the important parts of the data also become revealed). I came up with several ideas for how to achieve this, but finally I decided that the Mother star should appear initially cacophonous, erratic and in parts unintelligible, until a climactic point at which we would finally realise what the star was saying. This would be aided by making the Mother Star a chorus, and so allowing for overlapping voices. In order to convey this I created a new text for the character, which can be seen and heard below. This is an example of a digital artefact created in Step 1 of the work with *The Flowering Desert* as referred to in section 1.3.c.i. After creating this work Daniel also sent me some scores to record and experiment with, finding ways of using the system's natural resonance in the music and sound of this character, replicating an ongoing and endless process. The exploration of this concept (see example 1 below) in the form of an initial libretto for collaboration with the composer, made up a large amount of the work done on the Mother Star in the first cycle. After having worked with this

material on the triple study we decided to let go of the musical material. However, we kept the text in part 2, using it as an element in the projections of the overture, and the poem in part 3 as a spoken element recited by the Mother Star during the overture. Below you can find the libretto and recording shared to express my thought process around the Mother Star character to my collaborators in the first cycle.

Example 1

Chorus of Mother Star

This is a chorus of at least 4 singers. Together this chorus is the character - Mother Star. The music will emulate the star. The sounds of the chorus are expressive of the coolness, radiation luminosity and heat of the star.

The libretto for this chorus has been written in 3 stages as there are the stages to the chorus itself. The first stage is representative of the sound of creation, the second stage represents the timeless processes of fusion occurring inside the star alongside the proton bombardment from the star (much of this longer text is an incomprehensible revolution of redness), and the final stage shows us the star itself.

Mother star:

- 1. **M-Dwarf** (could be hummed)*
- 2. Emulating proton bombardment and ultraviolet radiation through noise/sounds which break apart these words.*

Parent

Child

Kind

Endless

Eternal

Young

Common

During this section there can also be an ongoing long and overlapping reading of text such as:

Crimson wrinkles from cadmium candles.
Burnt with an umber flame and scorched in scarlet seas.
The yellowing fades to ochre.
Vermillion rivers burst beige damns
And furies of mauve turn scarlet to brown.
Spinning not through space, not through time.
Spinning knots through space, knots through time.
Energy that stretches space, energy that stretches time.
Time that whirls in disintegral space,
Disinterested space.
Trips of fancy, trips of minds.
Tripping over shadows, tripping over stones, tripping past oceans.
Oceans made of ignited dust.
Twirling dancing passing over.
Pause.
Go on.
It doesn't matter when you stop or start.
Twirling.
Dancing.
Pause.
Go on.
Did you just start or stop?
If you stopped then I'll start again.
If you start I might never end.
Twisted crimson candles and cadmium wrinkles.
Scorching umber burnt the scarlet sea.
Flooded vermillion beds drown the broken beige.

And all the furious purple faces will soften soon to
brown.
Keep on spinning, not a lot of knots in space.
Stretching and squashing transactions of energy.
Transactions of time.
Disintegral space and disinterested time.
Pause.
Go on.

3. *Dictation:*

I the Mother Star
Parent, child and carer
Kind and endless source
An axis of the eternal
Young but older than most
Common but barely observed
I the Mother Star

Listen to audio sample of this in the folder 'Appendix 1' under the title 00_Mother-Star-Experiment.

Despite the fact that the initial concept for the Mother Star was lost over the cycles, the work developed above for the first cycle was vital to help begin the process of creation among all participants. We used the material above, and recordings made by Daniel of his initial sketches, in several of the workshops during the first cycle. This allowed us to create a joint understanding of the character of the Mother Star leading to the creation of the costumes and movement, which would remain until the final performance in the third cycle.

2.5 Film and Libretto

See file '2.5 The Flowering Desert Film and Libretto' to watch the dress rehearsal in January 2023 alongside the final libretto.

2.6 Conclusion

This work explored embedding astrophysics in the creation of a libretto and production, through frequent contact with the creative collaborators (composer, designers and filmmakers), reflection on the subject matter, and a cyclical working pattern in which all artists were able to input their understanding and knowledge. This helped to generate a joint language between all of us working on the project, and to focus our creative outputs towards the same end goals, considering each other's own required outcomes. Through embracing traditional narrative, and making use of historical operatic forms and structures (such as *mélodrame*, *aria*, *recitative*, etc.) I was able to provide a text that clearly structures the scientific ideas into a narrative form ready to be applied to a theatrical setting. It also provided me with a scaffolding through which to unfold and construct the anthropomorphic characteristics of the science, and the archetypal dramatic story found within it, in collaboration with the other creative practitioners in the project. Having direct contact with Dr Triaud was a vital and catalytic moment for the work. It enabled me to have a greater sense of certainty when deciding on the characters, providing a joint starting position for myself and the composer, as well as reassurance over my understanding of the scientific and philosophical implications of this work. Ultimately it gave me the key with which to explore the emotional expression of this discovery and this system. It was also very important to be able to share this knowledge directly with Daniel as composer, and subsequently to relay it to all other creative participants. Dr Triaud was very generous with his time and met with us online during the pandemic as well as looking over the short story, and responding to further questions I had on the science itself.

This work displays the process and outcome of creating a hyper-immersive and emotional experience of the science for the audience through opera. I have been able to see from the feedback and responses that the cyclical process of working enabled us to get to a point at which the purpose, message and

intentions of the work were clear and understandable to an audience member who did not have much prior experience of either opera or astrophysics. This was evident in a message we received after our final production, and the feedback from audiences in both the second and third cycles (which can be found in appendices 1.5.d and 1.6.a). In this message the audience member stated that they had no prior interest in either opera or astrophysics, but that they had very much enjoyed the production and could now see themselves taking an interest in both. By the final production we had positive responses where the audience agreed that the show had increased their interest in both opera and physics, and that it had helped them to empathise with the science presented. However, it is important to note that we only had 5 questionnaires returned to us after this performance so it is not statistically reliable. However, I feel that the process undertaken by the creative team, to empathise with and embed the scientific research of TRAPPIST-1 within this piece has created a work which is able to communicate the principles which underpinned its creation to an audience.

Our subsequent review in the journal *Astronomy and Geology* by the Royal Astronomical Society (Bowler, 2023) expressed the view below:

Perhaps it's the combination of spectacular images and a comfortable, enclosed space, but there's something about a planetarium show that can open your mind to new ideas. Now add live action, musical performance and operatic storytelling and you have some idea of what *The Flowering Desert* offers. This immersive presentation . . . offers a strikingly stylised take on exoplanets.

3 ‘Librettising’ Ecology to Create *Lipote: An*

Interconnected Journey

3.1 Introduction

This piece researches the anthropomorphism of ecology through opera, using as a starting point the life of trees underground, in the soil, and through their roots. It is also based around research into the impact of intensive agriculture on forests, as this has become a reason through which much of the scientific work related to soil quality has recently been carried out. This is represented by the relationships of trees in the soil. I focused particularly on representing them from this underground perspective, as an exploration of a world we would not have so much access to were it not for the recent developments in science. The opera tackles an important issue which has a direct impact on our lives today, in particular trying to uncover and explore the problems surrounding the creation of monoculture palm oil plantations.

The work for *Lipote: An Interconnected Journey* began in summer 2020 and was completed in August 2023. It was composed by Oliver Farrow. We collaborated with jewellery designer and PhD student Wanshu Li, and choreographer Jingya Peng during its development towards an open rehearsal in August 2021 and the first full showcase in December 2022. At the showcase we also began collaborating with mixed media artist Leon Trimble to create incidental music for scene changes with his modular synthesiser connected to a living plant. After being tested in front of an audience at the showcase in Royal Birmingham Conservatoire in December 2022 it was performed at Nozstock Festival in July 2023 and in the Edinburgh Fringe Festival in August 2023. The development of the piece and work of the

collaborators was funded by Help Musicians UK, and the performances in Nozstock and Edinburgh were funded by the British Council's Connections Through Culture fund. It is performed to a soundtrack recorded by myself and Oliver Farrow. The style of music is mixed with multiple genres from contemporary classical to jazz, pop and dance.

The process underwent 4 clear cycles of co-creation. The first cycle involved myself and the composer and consisted of a process of understanding and connecting with the topic through research, discussions with scientists, the creation of digital artefacts and workshops. During the second cycle we began exploring the work with the designer, making use of her materials in relation to the outcomes of the first stage. This culminated in a week-long exploration and rehearsal in August 2021 with choreographer Jingya Peng, finishing with the open rehearsal of scenes 1-5 at RoguePlay theatre. The next cycle made use of the feedback and knowledge collected from this open rehearsal towards the development of the full piece. During summer 2022 we spent two weeks developing staging and scenery at an in-person research and development workshop. We then began working with two singers to bring this work to an audience in the showcase at LAB Theatre (Royal Birmingham Conservatoire) in December 2022. The final cycle involved reworking and editing the work based on reflections and feedback from that performance and ended with a run of 5 performances at the Edinburgh Fringe Festival, August 2023. For details of the work during these various stages please see appendix 2.

In order to make informed choices during the development of the libretto and story I spoke with Dr Leah Band (plant biologist), Dr Markus Eichhorn (forestry modeller and plant biologist) and Prof. Adrian Newton (professor of conservation ecology and experimental musician). In the creation of this work, just as I had used the Greimassian semiotic square to inform *The Flowering Desert*, I grounded the narrative in the panarchic cycle (see below). Towards the end of the creation of the work I attended a residency at, and began working with the Nature, Art and Habitat Residency. This is an organisation whose mission

is to find the intersections between nature and culture, and that is particularly interested in using art to explore embodied and participatory understandings of the environment. The residency for the year I attended, 2022, was focused entirely on soil.

3.2 Context of the Research and Influences

Through researching the science and different fields around tree biology I quickly found that there is a very alive and thriving world of eco-art which is deeply related to the ways in which I have started working for my PhD. During the pandemic and lockdowns I was able to attend conferences online whose main focus was to look for subjective representations of plants and forests, leading to many valuable interdisciplinary projects. In particular these were conferences held by Nature, Art and Habitat Residency (NAHR, 2021) and the Mind of Plants Symposium (Arts Front, 2021) and Be-Coming Tree (2021). I found that this subject has a long history in both scientific and traditional ecological knowledge (TEK). Having begun exploring other artworks in this field I was encouraged to make use of my work as well in this area, to expand the practice of anthropomorphism in science and opera beyond the realm of physics, and test out my processes and practices in another area of science.

I decided to focus this piece on the differences between various forest systems, such as rainforests and monocultures. I had been inspired to do so when researching deforestation occurring in Borneo during my Masters in Environmental Technology, specifically in the Malaysian regions of Sabah and Sarawak, in aid of reforesting for palm oil plantation.¹⁵ This is significant as these ‘forests’, or monocultures, are very

¹⁵ At that time Google Earth had just released photos of the ground and it had become clear from these images that when the Malaysian government was claiming to be reforesting under the UN Development Goals, they were in fact deforesting the rainforest and replacing it with palm oil plantations (Bryan, 2013) (Peterson et al., 2015).

different types of systems whose soils and networks vary greatly from those found in the Canadian forest soils by scientists such as Suzanne Simard. This lays the groundwork for 2 very different types of soil, which hold carbon (and organic matter/life), nitrates and phosphates in very different ways (Edy et al., 2022; Sahner et al., 2015)¹⁶. During the discussion with Dr Eichhorn the message he left me with was that ‘we need to not just learn to live with forests better but also to understand that all types of forests have a value and all have a place’ (Eichhorn, 2021). This also encouraged me to explore the various ways in which we interact with both natural and man influenced forests. In order to show the differences between these systems underground I used the characteristics of the trees themselves, and the ways in which they interact with their environments, including the soil, to provide a starting place for the characters and narrative to grow from.

3.3 Synopsis

The outcome of the narrative shows four very different plant-based communities: a rainforest, a palm plantation, a strangler fig and a forest garden/taungya. The story follows the journey of a single tree (a Lipote tree) which volunteers to go in search of help outside the rainforest. I was inspired to write a journey narrative having recently written a libretto for an adaption of *Journey to the West* (see appendix AP 3.4). This Chinese epic tale is lengthy – comprising 100 chapters – with many characters and trials faced by Xuanzang on his arduous journey to collect the scriptures from the Buddha, to save the many orphaned souls of the underworld. It would not be feasible for this piece to involve such a long and

¹⁶ These monocultures are nowhere near as carbon efficient as rainforest, and hugely lacking in biodiversity. In addition to this the trees in plantations, especially the palm trees in Borneo, have a limited ability to create substantial fungal networks. As these trees are not native species the mycorrhizae in the soils have not adapted to create partnerships with such trees (Edy et al., 2022). The soils are also much lower in nitrogen and phosphate pools, making the trees in plantations far more dependent on implementation of fertilisers (Sahner et al., 2015).

detailed journey in an opera of 1hr 20min, and I also had to limit the characters to the number of singers available, but it did encourage me to make use of a physical journey, with a protagonist in search of help for those suffering at home, as another example of a traditional and mythological narrative.

The trigger for Lipote's journey is when the Rainforest is wounded in a violent electrical storm losing many of its most important large trees. The Lipote tree volunteers to help and, along with the Rainforest's fungal network, grows its roots and mycorrhizae into the Palm Tree Plantation, the land of the Strangler Fig and the Forest Garden. When it reaches the Forest Garden, a land which is managed by human settlers who live in harmony with the forest, Lipote feels it has found somewhere which can help, but as it fuses with the fungus there the ground is dug up by machinery. The final scene sees Lipote with the Rainforest, discussing the knowledge it has gained. As they talk they realise, through a planted fruit tree (a durian tree), that the human settlers from the Forest Garden have been displaced and travelled to now live in the Rainforest. This may bring some help and support after the violent storm, but it will also mean that the Rainforest needs to accommodate human life. Ultimately it is a very simple story, which leaves room for each newly discovered world to be framed by the action and interactions between the characters in each scene.

In order to see examples of the libretto and performance cited in the following sections please see both in the folder '3.5 Lipote An Interconnected Journey Film and Libretto'.

3.4 Developing the Script

3.4.a Communication: Influence from the Science

Interestingly the science of plant biology and of trees in particular has recently been approaching an anthropomorphic threshold as discoveries have been made surrounding the lived experiences of plants

and trees. Famously Suzanne Simard's work has espoused the fungal and root networks which form the basis of underground communication between trees. She particularly highlights the importance of 'mother trees' which form major nodes in underground forest networks (2021). Both Stefano Mancuso (2007, 2008, 2009) and later Monica Gagliano (2018) are key scientists who promote plants as intelligent systems which have abilities such as memory and respond to changes in the environment.¹⁷ This has been a contentious debate in science, with many arguing against this conception of plants or trees as intelligent organisms or systems (Robinson et al., 2020).

In keeping with the methods and aims of this research I interviewed three UK-based tree/plant scientists and ecologists: Dr Leah Band, Dr Marcus Eichhorn and Prof. Adrian Newton. Dr Leah Band's work focuses on exploring the anatomical and mechanical elements within roots (including the influence of different hormones), which enable gravitropism: the ability to always grow downwards. Dr Markus Eichhorn's work encompasses both natural and managed forest systems, and the impact of these tree communities on the other species in the systems. Prof. Adrian Newton's work mostly focuses on biodiversity loss and the impact of humans on natural systems.

The conversations with Dr Eichhorn and Prof. Newton highlighted opposing opinions on the study of trees in forests, and also presented various representations of the potential experience of trees. Dr Eichhorn expressed the view that trees only ever act out of competition, explaining that this is why they have such large trunks and biomass above ground, and wanted to stress that he did not see trees as having communities. He did, however, mention later in the conversation that they can act in ways that

¹⁷ Mancuso's work, described as plant neurobiology, has shown that: plants can gather information; remember and respond to memory; have signals akin to those of neurotransmitters (hormones and chemicals which pass and induce electrical signals) which trigger physical biological responses; have access to multiple senses including hearing, tasting, feeling, responding to light, gravity and oxygen etc.; engage in play; have an awareness of their own shape and extension and can actively grow away from hostile soil or towards resources (Baluska & Mancuso, 2008).

appear supportive when they have been attacked or are under threat. Prof. Newton mentioned that there are many ecologists who view forests as purely competitive spaces but that it is possible to also see them as mutualistic. The science available today does not always support Dr Eichhorn's position. Suzanne Simard et al. have shown in their paper on Douglas fir trees and seedlings that proximity to a larger tree and access to the mycorrhizal (fungal) network meant that the seedlings grew better and became more efficient adult trees (2008).¹⁸ This suggests a supportive rather than competitive element in the role of trees in a forest.

Dr Eichhorn expressed dissatisfaction with the depiction and association of trees communicating, pointing out that we currently do not have a lot of evidence that the trees themselves are sharing resources, but rather that this process may be happening due to the activities of the fungal network.¹⁹ He described the transfer of nutrients to and from trees as a conveyor belt from which the trees simply take what is needed or discard what there is too much of. Prof. Newton also emphasised this to us which concerned me, given the need for communication during the story. I did not want to mislead or misrepresent the topic and its scientific basis in the pursuit of this work. However, when looking further to the research I found there have also been some results published that have shown that the roots of trees themselves can also graft together:

¹⁸ It was problematic when they were too close to the larger established trees, but it was also noted that it was better to be at a specific distance from them, rather than not near one at all.

¹⁹ His conception and representation of trees, analogising them to objects such as suitcases on a conveyor belt is starkly different to the anthropomorphic characterisations which I am seeking to employ in this work.

root grafting, i.e. the fusion of the vascular system of two or more roots generally from the same species but also rarely between different species, constitutes another underestimated pathway for resource exchanges (Quer et al., 2020: online)²⁰

Dr Eichhorn did also add that the types of questions he raises by worrying about the representation of trees as communities which collaborate and communicate, are questions and knowledge which has not yet been researched, and are also unlikely to receive a lot of traction in the search for funding of scientific research.

The libretto makes use of the idea of support, communication and interconnectivity as a driving element of the character's relationships. Ultimately the communication in the story is based around sending warnings and sharing resources, which have both been recorded as characteristics of trees in forests. In scene 1 (pp. 2-4) there are many warning messages of this sort: 'A colleague encounters a crisis', 'Interconnected humus standby', 'A living sick alarm', 'Give and take broadcast: Support! Support!', 'Mobilise bilious dispersal unit', 'Facilitate the mercy message'. In scene 4 the Whole Forest and Lipote describe the Palm Tree's inability to communicate (pp. 12 and 13, lines 275-280 and 301-305). I will discuss the representation of this on stage in further detail in the section 3.5.e:

Lipote: Their roots have no portal
 No way to pass a signal
 And now it's out of tune
 Dizzied and confused.

²⁰ In the above paper studying Balsam Fir in a forest in Quebec it was shown that 36% of the trees engaged in root grafting processes. Suzanne Simard's work has also shown that the conditions in which a tree develops over the first few years of its life also have a stronger impact on its future survival than its connection to a fungal network. This highlights the importance of a well-balanced natural environment to sustain a healthy and diverse forest system.

So fragile, so confined.
Imprisoned in its mind.

Lipote: What scabrous fronds!
 This is no use.
 I must move on even further,
 Search for someone -
 Who speaks the language of this land.

In scene 7 the Rainforest describe the connections they have made during Lipote's journey (p. 22 and 24, lines 542-544 and 571-573):

Lipote: Many voices touched my hairs
 Shared their experience
 I found traumas beyond the storm

Bus 1: We shared our worlds
 Forged new fungal pathways
 Densely matted and deep

Due to the contentious nature of the debate around tree communication and plant intelligence it is important to note the human characteristics performed and present in the story do not make direct scientific claims about the properties of the subjects. As already described the aim of this work is to bring the human closer to the subjects by empathising with them through the human lens. Just as the audience would not have to believe that planets sing when watching *The Flowering Desert*, the audience in this case will not believe that trees sing and communicate in words and sentences when watching this work. However, should the audience choose to look further into the topic of trees supporting, remembering and communicating they will find a wealth of developing scientific research available to them.

In order to represent the variety of views held on this topic mentioned above, and both the competitive and mutualistic nature of the forests, I chose to make it clear in the various systems represented in this work that not all trees are friendly or willing to share resources. The Palm Trees are unable to communicate effectively and ultimately see Lipote as a source of food. They repeat a mantra and are unable to constructively develop in response to the other trees. They only communicate with themselves and know of words and ideas related to their mission as part of a vast agricultural monoculture system. The Strangler Fig is parasitic in nature. Its text is deceitful and powerful, both involving the trauma of deforestation and of being a killer as in scene 5 (p. 15, lines 361-369).

Strangler Fig: I too have lost friends
I am the only one left here now.
I grew on them and hugged too tight.
Then came the humans.
Their touches of fire and blade,
They destroyed all around but they left me here.
They make their yearly pilgrimage, tie bands around my
branches
As I tied around my friends.

In the more mutualistic Rainforest there are even some trees who respond negatively or in fear to the idea of looking for help. You can see from this excerpt that some trees are untrusting of what might be beyond the edge of the rainforest, and cannot be sure that the Lipote will not act out of competition and consume all newly found resources itself. This shows the highly competitive nature of the Rainforest, alongside the potentially altruistic nature of actions, such as the growth of the Lipote, which might help the whole forest. This can be seen in scene 3 lines 189-192 (p.8):

Taking (solo): A volunteer from the fiery edge

Giving (solo): Will feel out the forgotten mud

Taking (solo): How can we be sure, what's there will not take more?

Giving (solo): Or trust this lonely soul?

3.4.b Exploring Different Worlds: Panarchy and Adaptive Systems as Narrative

Structure

In the conversation with Dr Eichhorn, he stressed that trees do not form communities and would only have 'awareness' of those in very close proximity. However, if we consider the forest as a whole system then we can see that it does also act as a larger group including the trees. Perhaps Dr Eichhorn was more concerned that we might associate human community group behaviours and agency to trees, almost over-romanticising their state of being where there is no evidence that they have such abilities, but in the context of this work I believe it is valid to characterise trees and their larger groups/systems in this way. It enables us to explore the emotional connections we might hold with the way these forest systems exist as a whole, as well as how the trees exist on an individual level. And it is important to encourage people to empathise and feel engaged with trees and forestry systems which exist all over the world, as our daily choices do impact their existence.

In a recent 2020 paper (Ibarra et. al) including Suzanne Simard as a named collaborator, it was suggested that forests can have a kind of system identity, or system state, which is able to mitigate against environmental alterations. This particular paper states there is a nest web, with a panarchy of adaptive nested cycles which will enable a forest system to maintain its equilibrium. This concept of panarchy has been used to describe processes which relate to the ecological resilience of systems, as well as how this type of organisation and process is seen in human systems (Garmestani et al., 2009). It was coined by Gunderson and Holling who expressed its meaning as follows:

Its essential focus is to rationalize the interplay between change and persistence, between the predictable and unpredictable. Thus, we drew upon the Greek god, Pan, to capture an image of unpredictable change and upon notions of hierarchies across scales to represent structures that sustain experiments, test results, and allow adaptive evolution. (2002: 5)

The connection between ecological and societal systems, when viewed through this approach, encouraged me to look further into panarchy and validated choices made during the creation of the narrative. In the Garmestani et al. paper they discuss different reasons for forests to engage in an adaptive cycle stating:

The interaction of variables, e.g., drought, lightning strikes, and fuel accumulations, leads to phases of release such as forest fires, followed by periods of reorganization and regrowth. It is at the stage of reorganization that the system can shift regimes into a new or different configuration. (2009: online)

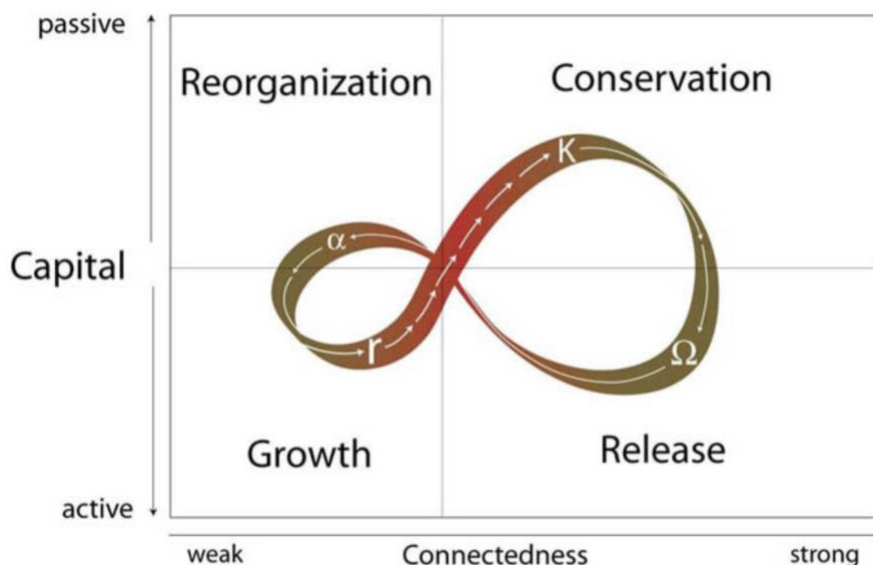


Figure 15 Process of Panarchy - Adaptive Cycle diagram (1986); temporal changes in a system proceed through phases of growth r , conservation (K), release (Ω) and reorganisation (α), The adaptive cycle is an

effective model for systems, the levels in a panarchy, and the dynamics of individual systems. Source: Garmestani et al. (2009)

Figure 15 taken from Garmestani et al. (2009) shows Holling's model of an adaptive cycle. The whole narrative can be described within the stages of release, reorganisation, growth and conservation seen in the cycle. The release occurs in scene 1 as the Rainforest is hit by a series of devastating lightning strikes. This is described by Lipote to the Strangler Fig in scene 5 (p. 15, lines 355-360):

Lipote: I have travelled carrying the voice of my home.
 The fire that rages in the skies,
 Strikes us
 A deadly snap.
 The wastes of the storm left scattered and burnt
 Searching for help in the soil.

The Rainforest actively seeks to reorganise in scene 3, sending out signals and alarms, passing resources through the mycorrhizal network, until the Lipote tree steps forward to help. The fungal network, and the Lipote tree, then grow outwards toward surrounding lands in scenes 4-6, prefaced by Lipote's declaration of their mission at the end of scene 3 (p. 9, lines 207-211):

Lipote: With intractable resolve,
 And the thrumming of my clan,
 I will push towards the white noise,
 Invade the shell-shocked land.
 Hairs erect, -

Lipote + Whole Forest:
 - ready to inspect!

In scene 6 and scene 7 the Rainforest conserves resources from the Forest Garden, and reflects on all of the information it has gathered in the Song of New Knowledge which I will discuss further in 3.5.h.

It is important to look at the environment and other systems surrounding a forest when considering its health and adaptive abilities, as the adaptive cycle will not be occurring in isolation. This encouraged me to look further afield to other types of systems for Lipote to encounter that might be surrounding a rainforest, and could have a strong impact on its health. For example, when considering the health of rainforests surrounded by plantation, it is of no surprise that the implementation of a monoculture on the border of a diverse system would have a deleterious effect on the resilience of that system (Fleiss et al., 2020). For this reason the Rainforest in this piece does not have the resources to recover on its own.

The two key panarchy transitions which can move a system forward and away from a state of collapse are revolt and remember (Greenlees & Cornelius, 2021). The revolt would account for a series of small fast actions which would overcome a larger slower action. This was the initial route the story would have taken, focusing on the idea of rebellion in the palm plantation. However, after having spoken to Prof. Newton and changing this narrative outcome (explained in 3.4.e), I dug deeper into exploring memory. An example of memory would be the tendency for a forest to put pressure on a burnt patch to return to the state it was in prior to burning, with the same ecological organisation and systems. Lipote's journey out into the Palm Tree Plantation, and the constant reference to memories lost in the soil during the script, are reflective of this push away from collapse in the Rainforest through the panarchic transitions of revolt and remember. The revolt is present in the action of growing outwards into the plantation and beyond. This action when repeated by many trees on the edge of the rainforest was suggested by Dr Eichhorn to be a likely outcome of creating an edge due to the potential for other nutrients in the deforested land and was a good confirmation of the decision for Lipote to reach for help outside of the Rainforest. This is referenced in the libretto in scene 3 when Lipote volunteers to help saying (p. 8, line 184): 'Yet, recently I felt enriched nourishment. / The other side has a source.'

This 'revolt' and 'remember' transition, enacted by the growth outwards to regain balance within the rainforest system. The peak of this growth occurs in scene 6 when the Lipote connects with the Forest Garden. In particular this occurs in direct revolt of the deforestation that happens in the second half of the scene, when the Lipote says (p. 20, line 509): 'We'll fuse further, / Our networks making matted earth. / Your wisdom shared with us, / We shall retain your worth'. It is also highlighted in the final chorus sung by the Rainforest (scene 7, p. 25, lines 611-621):

Our interconnected humus
Has penetrated the fiery edge
And shall always spread.

Track paths through stolen soils,
Make knowledge in the earth.
Reform destroyed memories.

In this moment we break the fourth wall and directly address the audience whilst also connecting ourselves to the other human participants in the production (Leon Trimble and Oliver Farrow). The Rainforest acknowledges the interconnection between them and the humans, now they are in need of help and management: 'We will offer you our help, / Make space in this home, / And marry our lives to yours.' (p. 25, lines 619-621). This final statement brings the natural and man-made systems together, and is intended to pull the audience closer to the story of Lipote's journey.

3.4.c Soil

As this piece is entirely set underground I wanted to engage the text in deeper explorations of soil itself. I also felt that it was important to convey information within the piece about the various properties of

soil, such as memory, an interface between worlds, the support for all life, a natural cleanser and a hugely biodiverse and bio rich landscape.

In particular the idea of soil as memory is very important within pedology, and is a recurrent theme in the libretto. Soil's value as an ecological memory is described by Carvalho Nunes et al here:

One of the most important functions of the soil is to be living memory because its definition is closely associated with living organisms. In addition, when a community or ecosystem that forms part of the soil ceases to exist, some of its parts or properties may remain, leaving behind an ecological memory such as spores, seeds, and structures created as aggregates that contribute to shaping the replacement community. Decreasing the ecological memory of an ecosystem reduces resilience, which in the soil would, for example, increase its susceptibility to the degradation, installation, or expansion of desertification processes. (Carvalho Nunes et al., 2020: 229)

Soils can exist as a kind of archaeological record of past environments, as this soil memory is held over long periods of time.²¹ Memory appears part of the opening narration: 'The ground itself holds an ancient knowledge, / permeating a memory longer than humans have known', (p.1, lines 15-16) and repeats as a trope through which to connect emotionally with the different types of soil in each location. After the storm in the rainforest and the destruction of the root and fungal system, the Rainforest describe their memories as 'now destroyed'.

²¹ The most mature soils have a 'lithomemory' which has developed from the degradation of the bedrock into topsoil, which can span 10^4 - 10^6 years, while younger soils can still hold memories (pedomemory) from the past hundreds of years (Targulian & Bronnikova, 2019: online).

The global state of soil is highly concerning. The recent reports show that we have lost a third of our arable land as a result of climate change and intensive agricultural practices (at the current trend all of the world's topsoil could be spoiled in 60) (Maximillian et al., 2019: 457). As mentioned in the quote above the process of soil degradation is often triggered from a reduction in 'ecological memory' which occurs when there is mass deforestation, forest fire, or the replacement of biodiverse regions with monocultures. One of the markers of a healthy and fertile soil is the heterogeneous texture, something which is destroyed in mass agricultural tilling processes. The homogeneity of the soil in the plantation, in relation to its texture and lack of diversity, is mentioned several times. It is mentioned by Lipote in the interlude (p. 17, lines 407-409): 'Our soil conquered, tilled / So evenly that now / There is nothing left to grip'. It is then again described by the King Durian in scene 6 (p. 19, lines 480-481): 'Rows and rows of replica trees / Rooted in lifeless soils', and the narrator in scene 7 (p. 23, line 548) 'Replacing memories with uniformity'.

In Targulian and Bronnikova's 2019 paper they gave a thorough account of the pedological descriptions that currently exist of soil as memory, with a focus on its importance as an interface between the atmosphere, hydrosphere, geosphere, biosphere and pedosphere:

Thus, soil is a result of the interaction of planetary spheres. It is one of the components of geosystems that have mechanisms for recording and preserving information about the state of the environment. Moreover, it is one of a few components, for which a terminological, theoretical, and methodological basis for studying the mechanisms of information recording, accumulation, transformation in time, and interpretation has been developed. (Targulian & Bronnikova, 2019: online)

The important role that soils play in maintaining our atmosphere (through holding carbon and fixing nitrogen) and our waters (through filtration towards the water table) is referenced in the song to soil in the interlude before scene 6. I decided that as a main home and source of nutrients for the trees they would themselves hold the soil in high regard. Lipote sings this when at their most desperate. This moment makes use of a traditional theatrical device, the entr'acte, a small scene which takes place in front of the curtain while the scene change happens. This is usually a monologue or short comedic double act. In opera there is also often an aria for deep reflection. In this case it is the moment in which Lipote prays to the soil for help on their journey. They describes the soil as life giver and builder of worlds of all sizes (p. 17, lines 410-417): 'Soily substrate / Which built the air / Crafted life / From earth to sky / Archived layers of time / We live among each other, / Micro to mighty, / In your damp and musty scent'. Go to timecode 00:55:00 for a performance of this scene. Targulian and Bronnikova also remind us that soil memory is often also referred to as 'soil archive' which you can see referred to in the libretto above.

The ability of the soil to store carbon, and the loss of that due to the impact of the storm in scene 1, is referenced by the Rainforest at the start of scene 3 (p. 7, line 153-154): Alert! Carbon crossing blocked- / Barricaded soil-' . The role of soil as this organising interface is again directly referenced by the narrator in the final chorus (p. 25, lines 608-610): 'The land which filters our waters and airs, / The soils which feed the trees, / And the fungus which connects it all'.

Soil is a determining factor on the health and resilience of the flora within it, but also the plants themselves have an impact on the soil as well. In a 2018 paper about the effect of tree root systems on soils, it was found that soils around both living tree roots, and tree stumps with empty or filled in root

channels, are significantly affected by these in both texture and chemical composition (Lukasz & Samonil), and that these impacts would remain in the soil indefinitely. They even stated that:

To sum up, the short-term effects . . . documented at the research sites developed and persisted for at least 100-300 years in relation to soil age (of magnitude of $>10^3$ years). These effects can be seen as progressive soil development (Johnson and Watson-Stegner 1987) that is probably irreversible until tree uprooting or serious human impact on the soil. (Lukasz & Samonil, 2018: online)

This kind of ‘serious human impact on the soil’ is therefore able to destroy hundreds or thousands of years of work which has led to balanced soils that support the plant and insect life, and many millions of microorganisms within it. Another 2019 paper by Kong et al. showed how the microbiota surrounding plant roots, which adds to the health of the soil and plants, is inherited by seeds and transferred to planting sites. This is partly why agricultural systems such as forest gardens, which foster plants from their growth as seedlings, are far more beneficial to the health of soils than monocultures with trees imported from nurseries. This type of forestry and the hugely bio rich landscape is described by the King Durian in the Forest Garden song (scene 6, p. 18, lines 431-446):

Forest Garden: Our multistoried paradise
 With walking caretakers

King Durian: They clear the ground
 Where saplings land
 Cared for and named
 Beneath their feet
 With music and fruits
 Among us they meet.

Forest Garden: Our multistoried paradise

With walking caretakers

King Durian: Worms work to feed
 The hungry earth
 Interfacing death to birth
 Fungal highways
 Bacterial trains
 Around each root - a cityscape

The immense ecological system in the soil is briefly described in a panic by the Forest Garden during the process of deforestation as below (p. 3, lines 493-497). These short lines reference the varied life forms and their systems as they are being destroyed.

Forest Garden: Alert Alert!
 Swinging branches - creatures flee.
 Insects burrow deep to hide.
 Fungal highways cut.
 Arcades uprooted fast.

In scene 6's Forest Garden Song the references to soil (and the fungal network) expand to the rhizome/rhizosphere of the trees, the roots and area surrounding them through which many chemicals and nutrients are exchanged: an interface between the many dimensions present in soil, e.g. hydrosphere, biosphere, atmosphere and lithosphere (Cianfrani et al., 2018) (p. 18, line 446): 'Around each root - a cityscape'. Some key phrases such as 'fungal highways' and 'bacterial trains' (p. 18, lines 444 and 445) are mentioned reference to recent research (Cowan et al., 2022) which examined the root microbiome in tropical rainforests.²² This paper found that the greater the

²² In particular they looked at the microbial activity in a planted garden in an area of selective logging.

diversity of species the more variation in microbial activity. At the end of scene 6 Lipote refers directly to the destroyed rhizome (p. 21, lines 516-519):

Lipote: Forest Garden? Durian?
 Fungal threads broken. Dug out.
 A flattened rhizome.
 No help to take home.

3.4.d The Fungal Network

After the discussions with Prof. Newton and Dr Eichhorn I decided to focus more attention on representing the mycorrhizae (fungal network) alongside the trees. This happened through two routes. Firstly, I made sure that the fungal network is mentioned alongside any mentions of communication. For example, at the end of scene 1 when the Rainforest is singing its message of help it says: ‘A decomposing irreparable fungal network / Mother node down.’ (p. 4, lines 94-95). The palm trees do not make any reference to fungal networks in scene 2 as they do not have and extensive amount of this form of communication with each other. In scene 4 the Lipote mentions the network just before they attempt to communicate with the Palm Trees: ‘I do not travel alone / My fungal friends travel upwards / Take my message to the fields of noise’ (pg. 11, lines 233-240). In scene 5 the Lipote references the decayed and useless networks of the lost rainforest: ‘There were friends here / not dug away. / Their networks rotten, / Their threads decayed.’ (pg. 15, lines 335-338). In scene 6 the King Durian declares ‘Let our fungal networks fuse / Build a highway from your land to ours’ (p. 19, lines 471-472) before they are able to share resources and information.

Secondly, Oliver and I decided to make an addition to the score of a ‘network audio’ which would represent the activity of the fungal network. Whilst on residency at Nature, Art and Habitat, I began a

project of recording the soil, transcribing and then composing from the recordings. Although this material did not make it to the final work it did inform our decision to include within the soundtrack the addition of the 'network audio', an ongoing responsive sound that would represent the fungal network and surrounding soil ecosystem. This sound appears most notably in the narrations (go to timecode 00:19:15 - scene 3), but is also present in the moments when there is communication occurring between the Lipote, the Rainforest and the surrounding systems. Initially we had used elements from the soil recordings, but later Oliver decided to replace these with sounds created from the audio of the music by designing midi patches (a network of transmitters and transformers) to generate random variations on the music in the Logic Environment. Despite the final product being far from the original work, these initial recordings of soil were very influential in creating this other sound world, guiding us in the type of noises and ambient sounds that are present in soil itself.

3.4.e The Narrator

Before discussing the development of the different systems and characters in the piece it is important to mention that this work makes use of a narrator. As a development of the test with the narrator for my previous work *Entanglement: An Entropic Tale* (see appendix AP 3.1) and the use of the Measurer and mélodrames in *The Flowering Desert* (see chapter 2) I used the narrator as a descriptive tool, rather than as a character in the story. I did not want to bring humans as characters into this story, as the issues surrounding rainforests, deforestation and plantations are often depicted from the human perspective. It was important for this research that I did not fall into the trap of this trope, but rather to completely focus on the world we cannot see, and so do not often consider: the world of the soil. The narrator is, however, an important tool to contextualise the way the characters behave in each of their worlds, putting the audience at ease during each scene, so that they do not feel they have misunderstood the science presented, or that the drama unfolding on stage does not make sense.

3.4.f The Humans

As humans are a part of many of the forest systems explored, I needed to acknowledge them within the libretto. In a 2020 research paper by Fleiss et al. the impact of palm tree oil production on deforestation, biodiversity and carbon sequestration is explored in Borneo. It found that in areas of plantation where 10% of the land remains as natural forest carbon storage increases by 20% more than land with no protected forest. They also found that higher levels of biodiversity were connected to the areas that stored the highest amounts of carbon. So protecting those forests which are very biodiverse is even more valuable than it was first understood to be. They also found, however, that when plantations are marked as sustainable due to the rules set out by the Roundtable on Sustainable Palm Oil (RPSO), which require a certain amount of natural forest to be protected within plantation land, these areas of natural forest had a low rate of new tree seedlings and so more must be done to conserve the biodiversity in these patches of forest. Fleiss suggests that human management of these areas of natural forest is now vital in order to allow them to flourish. When discussing the role of forests with members of Nature, Art and Habitat and the local inhabitants of the Taleggio Valley in the prealpine region, I also learned of the importance of forest management in the health of the forests in this valley. I discussed with local foresters and farmers how the systems of woodland and pastures required maintenance and monitoring as they were not part of the original landscape of the region but had been partly created by human settlement. Having already been altered and touched, even created, by man it is vital that humans continue to work to maintain the balance which keeps these very biodiverse ecosystems healthy and functioning well, not only for their own sake, but also to maintain the regenerative economies which exist in these areas. This information, alongside the readings on forest dwelling societies, encouraged me to include such a society in some way in the libretto. Both Dr Eichhorn and Prof. Newton had also pointed me in the direction of rainforests which are managed by humans in a way which does no harm,

and even protects elements of the environment. Prof. Newton referred to the taungya, otherwise known as a forest garden. In scene 6 the narrator directly references these types of systems saying (p. 17-18, lines 420-430):

Narrator: Lipote moves into new territories,

 Lands that have been touched and altered by man

 But that have also been left to grow

 A balanced land – a Forest Garden.

 This land is ancient too

 As old as Lipote and the rainforest can remember

 But man and woman have worked with it and among it

 Praying and protecting

 Thanking it for the fruits, nuts and grains it can
 bear.

As the research presented shows how important our active approach to the problem is, I wanted the work to leave the minds of the audience with a positive idea of their relationship with forests, not approaching the problem through fear and guilt, but as a story of which we are a vital part. This happens in the short recitative at the end of scene 7 and subsequent narration (see timecode 01:15:50) where the Baby Durian says: 'You were seeking help from us / Now we seek help from you / In partnership we grow together / Heal scars from fires and weather' (p. 25, lines 600-603), and the narrator goes on to say that the humans 'They will maintain and manage the land' (p. 25, line 607).

Humans are referenced in the three worlds which surround the Rainforest. In the Palm Tree Plantation, they are referred to as a kind of god. These lyrics from scene 2 (p. 5, lines 119-125) explain the relationship between the humans and the palm trees.

Our sacrificial fruits offered
To terrestrial controllers
Trusted victual providers
Who feed us with dogmatic drip,
Enough for all to be equipped
Trickling through the earth we grip
Without whom we could not exist

This representation of people is not one that I wanted the audience to feel connected to, in order to highlight the inhuman nature of a monoculture. The Strangler Fig refers to the humans who deforested the area around them (probably for the Palm Tree Plantation) but left them there as a sacred object which could not be removed. It has been rescued as cultural heritage. The final words of Lipote in this scene reference the legislation surrounding plantations from the RPSO which will not be effective at preserving biodiversity, despite their attempts to conserve plots of land, if effort is not put into boosting the life that would naturally occur in these plots (p. 16, lines 393-395):

Lipote: Bands of fear and death

 Conserving to consume

 You'll save us in order to destroy

In the Forest Garden there is a reversal of the roles in the plantation. The trees become kings being served by the humans. There is an enjoyed reciprocal relationship between these two communities. This

is reflected in the moment the King Durian realises the forest garden people are gone (p. 20, lines 490-492):

Durian Tree: Our walking caretakers have gone

 No laughter in my earth,

 No music through the soil.

3.4.g The Rainforest

3.4.g.i A Framework for the Rainforest

There are many ways in which trees and forests have been studied and understood by cultures throughout human history so it was important to approach this topic with an exploration of an understanding of forests and soil which goes beyond the scientific approach. Dr Eichhorn in particular, whose work is involved with the large-scale agricultural and forestry industry, had given me a very technocratic view of the ways in which trees exist and interact in forest systems (see appendix 2.1.f.iii). He himself acknowledged this and suggested that I might look to other cultures who engage with forests more spiritually to find a way into my story, such as the Cheq Wong, people indigenous to Peninsular Malaysia.²³ This was already an approach I had begun to take, and is also a key part of the methodology of the work, looking for ways in which non-scientific, TEK focused or historical interpretations of the

²³ He told us how they believe that each tree contains a spirit of their ancestors and as such give great importance to the health and life of the trees. They believe that the spirits are asleep in the daytime so no one is allowed to talk until night. At night the shamans sing a song which recounts everything that has been noted to have happened to all of the trees that day. The culture of this community is inextricably linked to the lives of the trees and the Cheq Wong and the rainforest they live in together are integrated into a greater whole. Further explanation can be found in Signe Howell's book *Society and Cosmos: Chewong of peninsular Malaysia* (2009).

natural world, such as mythologies or psychological models, can reflect the information gathered in scientific studies of natural phenomena. In order to achieve this, I looked into anthropological texts about cultures living in forests. A few key texts I looked at were Stuart A. Schlegel's *The Wisdom from a Rainforest* (1998), *Managing the Wild* (2018) by Charles M. Peters, *Society and cosmos: Chewong of Peninsular Malaysia* (2009) by Signe Howell, and *Don't Sleep There Are Snakes* (2008) by Daniel L. Everett. These books provide detailed anthropological accounts of living with forest dwelling communities in rainforests around the world. They are told from the perspective of the academics encountering them, who often have eye opening and mind changing experiences, as their world views and structures are confronted with a very different approach.

It was out of the research into anthropology and science around forests that I structured the Rainforest society's rules/commandments which would guide the actions of the characters in my piece. In particular, I was drawn to using the codes and conducts of the Teduray society (from the Philippines) as described by Stuart A. Schlegel in his text *Wisdom from the Rainforest: A Spiritual Journey of an Anthropologist* (1998). The commandments I created from this and the other texts are below:

1. You should never purposely make the world out of balance. The state of the Rainforest is either in balance or out of balance. All parts of the network should be working towards maintaining this balance.

Schlegel described the Teduray's system of balanced as being based on a healthy or unhealthy gallbladder:

The Teduray . . . put great emphasis on repairing gallbladders as quickly as possible, without violence through the legal system, and they put even more stress on never giving anyone a bad gallbladder in the first place. (1998: 171)

I also found that soil, and our coexistence with it, is of huge importance in Cree law. For this culture whatever is taken from the soil must also be returned. Joe Cardinal, a member of the Cree community, notes in his essay for the United Nations:

If we continue to abuse the land by taking without giving back, the situation will become chronic and irreversible. The consequences associated with this neglect and disrespect of the land has culminated in climate change. What Cree people have to offer to the world is shared with many other indigenous people--that interaction with the land must occur with deep respect and with recognition that what is taken, must be given back. (2010: online)

This idea of reciprocation with the soil was something that I found to be discussed over and over by environmentalists and anthropologists. I included the notion of balance within the commandments for the Rainforest so that the reciprocation of taking and giving (and the need for restoration) might be a strong part of the libretto. I made direct use of this concept in scene 3, where the Rainforest is struggling to maintain a balance after the storm. When we enter the scene we meet two types of trees in response to the ensuing crisis: the giving and taking trees. In the opening narration Lipote tells the audience 'The forest is out of balance' (p. 7, line 141) and the trees continue to express this imbalance throughout the panic. The giving trees offer help: 'Supplies here to repair / The charred bark, blitzed threads / darkened voices, broken cords / Take all we can give' (p. 7-8, lines 164-167) while the taking trees waste it: 'The more we take the more we leak. / Drained from tubes and tunnels to soil' (p. 8, lines 168-169).

This theme of balance is repeated throughout the opera in various different guises as the opera explores the different forest systems. For example, the growing imbalance is mentioned by the narrator at the start of the interlude (p. 17, lines 397-401): 'Lipote is lost / The Plantation cannot

listen / The Strangler Fig wants to take too much / Resources from
home are running out / Time trickles away'.

2. Memory is built into, and written upon, the soil. I took this from the many repeated descriptions I found of soil as memory. This idea that soil can hold memory ranged from indigenous belief systems to pedology (the Western scientific study of soil) and discussed above.

3. Cooperation over competition. Everyone in the same neighbourhood works together, sharing resources that would otherwise not be used.

Schlegel talks a lot about this quality in the Teduray tribe, but also this is a key element of a well-functioning ecosystem. The decomposers break down the waste and pass on nutrients to organisms in the soil, water is filtered and cleaned by the trees and soils before collected in the water table, plants efficiently convert the sun's energy and the gases in the air to glucose etc. Everything is exploited and made use of.

4. Each individual has a duty of care to the whole.

5. Time is measured only by how useful/resourceful the individual still is. One is only considered 'old' when one cannot give to the whole more than it needs to take. These elders must still be supported by the whole. Even though they no longer provide support in the form of water and nutrition, their knowledge and wisdom are valuable to the community.

This was inspired by the various studies which have shown that older trees can actually grow faster and sequester more carbon than younger trees in tropical forests (Köhl et al., 2017). It can be seen in the libretto in scene 3 (p. 7, lines 142-144): 'Many mother trees are almost lost. / Made old by the storm they need more than they can give.' Later in the song of

knowledge the Rainforest tell us: 'We felt the branches taken / Trees trimmed and used for tools / We learned it makes us young again / A rebalance of old and new' (p. 23, lines 565-568). This references silvicultural practices which trim and prune trees in order to promote more resilient regrowth (Ortega-Vargas et al., 2019).

6. Every member of the community has one or more specialisms which are respected and important to the whole.

As a complex and diverse ecosystem, everything has developed its own place within the natural rhythms and cycles of the Rainforest.

7. Gender and sexuality is irrelevant – such labels are never applied or even considered. These aspects are personal choices which only impact the individual. They do not affect the community.

Again this aspect of gender was drawn from Schlegel:

Not only were the genders unranked in forest Teduray society, but they were held to identical values as well (1998: 113)

3.4.g.ii Drama from the Rainforest

After reading a 2020 *New Scientist* article on the possibility of extreme damage being done to rainforests by the increased frequency of high energy storms in which lightning strikes are most likely to affect the oldest and largest trees (or 'mother trees'), I found I had a good place to start the drama for the Rainforest (Irwin, 2020) (Gora et al., 2020). Dr Eichhorn also confirmed that this has been postulated as a potential future harm.

In this work the Rainforest itself has been musically and lyrically characterised as a polyphonic world of many voices, passing important messages, and at times speaking together as a whole. During the first

cycle of workshops between myself and Oliver we had found that we wanted to use three levels to characterise the Rainforest. First the individual voice, second the cacophony of voices and third the Rainforest as a whole (for further discussion of the workshop see section 3.4.g.iii). This way of characterising the Rainforest from the individual to the greater whole worked well with the theories around panarchic systems, as well as indigenous science approaches to forests where individual trees are cared for as part of the greater system (Nair et al., 2021: Boakye et al., 2012: Björklund et al., 2019). As the Lipote journeys away from the Rainforest into other systems it remains connected and we frequently hear the voice of the whole forest reflecting Lipote's thoughts throughout its journey. This occurs less as Lipote travels further away but the connection back to the Rainforest is frequently referred to by Lipote in the journey. They often state that they do not travel alone and that they are part of a larger whole. In the final edit we removed many of these 'whole forest' sections so as to allow the narrative to feel less stunted and flow more smoothly from world to world.

In order to create the text for the first set of messages sent out by the trees in scene 1 I used words sourced from my reading on tree root and fungal networks. I rearranged these words into sentences which would work as alert messages to other local trees. The phrases generated through this process indicate an urgent passing of information and messaging, both asking for help from surrounding trees, and warning them of environmental factors above ground. The tone is more informative than emotional, in order to reflect the various conversations I had with scientists about their visions of how they see trees as acting largely out of competition, as well as working together to retain the ecosystem balance of the whole. As each message is sent out the sung melodic material is then repeated and filtered through the instrumental ensemble. The text in this scene was originally designed to build up and increase in a polyphonic density in line with the Fibonacci sequence so as to replicate a natural, rather than man-made, system. This structure was later changed in the workshops to understand the

dramaturgy and the performativity of the work. See timecode 00:00:00 to see the musical, lyrical and visual representation of the Rainforest from the final cycle of the work.

The musical nature of the Rainforest develops across the piece as its knowledge of different soils and lands increases. Once we have reached scene 7, and returned to the Rainforest, the music is very different to scene 1. Having experienced and learnt from various different types of forest cultures and systems, absorbing and conserving the knowledge and resources it could grasp from them, the music is more blended with other genres, and the form of the text is much more traditional and verse-like with areas of clear recitative. The worlds and music of the Rainforest and Forest Garden also begin to collide in the second half of this scene. This is all reflective of how the Rainforest has now become more integrated with humans, becoming home to the displaced people of the forest garden. The music and text become more managed and structured within human cultural, rather than natural, forms. (See timecode 01:16:53 for an example of the Rainforest music and text at the end of the opera). In this final chorus the voices are singing together in harmony (not polyphony) as they address the world beyond them. This signifies how the Rainforest has learnt the language of the surrounding systems, and is also now more integrated with the human world of the Forest Garden.

3.4.g.iii Exploring the Rainforest through cycles of collaboration and performativity

As composer and librettist, Oliver and I respectively felt it was important to generate a joint understanding of the topic in order to create a unified work. We both knew that we had started the process of creating and even recording the work too early, before really allowing the topic to sit with us, and so we were both open to reworking the material we already had in place. We worked from the initial piece of music and text (which we had recorded) and then carried out a series of creative tasks in relation to the drama, science and concept of the scene. These involved free drawing depictions of the underground root and fungal networks, dramatizing the experience of being a tree struck by lightning

through performative tasks, and writing lists of emotions and sensations related to both of these things. From these tasks we found a clearer dramaturgical structure for the scene, which involved zooming in and out of hearing individual voices, a cacophony of voices and the whole forest, as well as redefining the moment of the lightning strike and the sensation and recovery from it. A more detailed account of this work can be found in appendix AP 2.1 on the work generated in cycle 1 of *Lipote: An interconnected journey*.



Figure 16 Scene 1 at the Edinburgh Fringe (Image courtesy of Shaky crown collective)

The design for the Rainforest also underwent several stages. We had collectively decided through audience and participant feedback from the third cycle that the design developed for the showcase was not reflecting the Rainforest's network (see appendix AP 2.3 for further details). Many of the performers during our post-show discussion felt that the use of balloons was unsuccessful, and myself, Oliver and

Jingya all decided that the costumes themselves were making good use of Wanshu's material but not clearly representing a network to the audience. Wanshu was not able to participate in the final cycle so we developed a new design concept without her guidance. In the second cycle we had carried out several performative workshops with Wanshu, where we focused on the use of hanging ribbons to represent the underground network. For the final cycle we decided to go back to these ideas and create costumes which would reflect the various aspects of a communicative network (see appendix AP 2.2 for details of second cycle workshops). The costumes themselves (Fig. 16) show many voices overlapping and the main prop for the scene (one UV reflective ribbon) represents one thread in the network, passing messages between the various voices in the Rainforest.

During Covid restrictions I created some videos in the first cycle to explore ways of representing the underground world of the Rainforest and the plantation. As you can see from these videos (see Fig. 17 and appendix AP 2.1.e) one key element that emerged was the use of the body as a bright object in a dark space to mimic the imaging process of roots and plants in soil. I used a white morph suit and recorded myself in a black box environment so that I would then be able to explore manipulating the image with video software more easily. These initial explorations into movement provided a score which myself, Wanshu (designer), Jingya (choreographer) and the performers would be able to refer back to during the rehearsal and development process. After re-recording scene 1 and generating these videos I also created a series of animations to help explore further ways of expressing the context and drama of the subject of this scene. We used this film as a projection alongside the performance in scene 1 (this film can be seen in appendix AP 2.1.g).

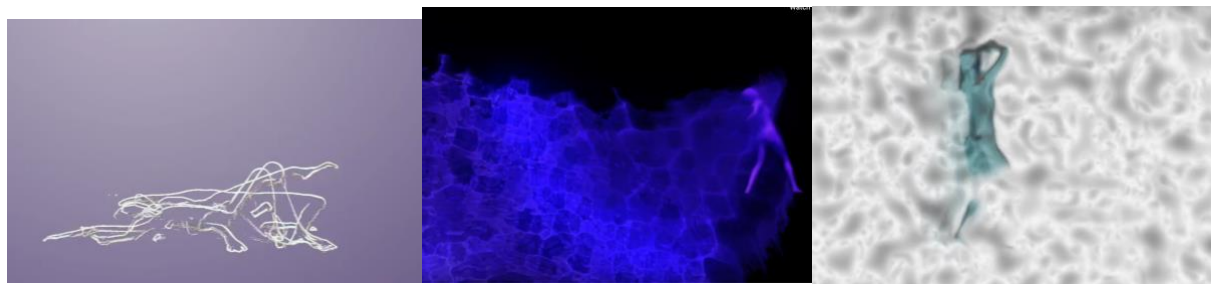


Figure 17 Stills from video work exploring the rainforest and plantation

3.4.h The Palm Tree Plantation

The initial plan for the story was for the palm trees to revolt and cooperate with the trees on the edge of the Rainforest, allowing for a spread of the Rainforest across the Palm Tree Plantation. When we expressed this narrative to Prof. Newton he asked that we might reconsider. To him it was important that we do not give the palm trees any credence, or allow them to be any kind of hero in the story. He told us that to him the most obvious issue is that it was wrong to plant these palm trees in Borneo at all as it is only the Dipterocarp trees which can successfully integrate with the fungal network. He explicitly stated that ‘the only way to get the forest back would be to destroy the plantation’ (Newton, 2021: personal communication) After considering this with Oliver we decided that we could indeed change the trajectory of the story. I also added references to the foreign nature of the trees in the libretto. In scene 4 the narrator asks us (p. 10, lines 231-232): ‘Are they happy to be here? In a foreign soil, flown so fast and so far from their home.’

We also learned from Dr Eichhorn that in tree plantations the ground is overplanted and two thirds of the trees are expected to be removed before reaching maturity, and it is likely only 10% of trees planted in plantations will reach adult height. A common practice in forestry and the creation of plantations is to deliberately overplant to produce trees which grow tall and straight. In addition, the palm trees themselves are removed and replanted once they are 25-30 years old, even though they can live for over 100 years (Quezada et al., 2019). We therefore explored characterisations of the palm trees which

would be more youthful and naïve than that of the Rainforest. In a workshop on scene 2 we created the word list below to describe the palm trees in the plantation:

Mirror, Isolation, Vanity, Slave, Repetition, Fragile, Brittle, Regular, Decontextualised,
Domesticated, Prisoner, Immigrant, OCD, Traumatized, Stockholm Syndrome, Constructed
Reality, Hypnotic, Factory.

Many of these qualities made themselves into the scene's libretto and music. The information about the overplanting can be seen reflected in their song lyrics from scene 2 (p. 5, lines 104-110):

Each one of us is born to be
Bred, watered, fed, for quality
We live out the same histories
Cloned life bred through equality
If one becomes a casualty
They won't affect our unity
Lost life not our priority

Lyrically, scene 2 involves many rhymes and a very structured verse and chorus, with 8-syllable lines.

The music is reminiscent of a dance music track with a typical four-on-the-floor rhythm. The vocal quality makes use of close mic singing and pop-influenced vocal techniques. The palm trees all sing the same text (even if sometimes in close harmony) and the music moves in and out of each of their pods of existence as we have sung and non-sung moments, reflecting travelling through the soil between, and through the tree roots. The land between the roots is not filled with echoes of the sound of their voices, as it is in the Rainforest music. The original libretto had the Latin name of the plant – *elaeis guineensis* – to reference the Western influence on this species. This element was lost during various workshops; however, the pervasive use of the plant's oil is now reflected in the genre and construction of the music which involves an organised 4/4 at 120bpm, something commonly used in popular music globally. Our

workshops also led us to decide to end scene 2 by restarting the song, to signify the rotational cropping of the palm trees. All of these choices were made in conversations between librettist and composer, to reflect the qualities of the lives of the plantation palm trees.

The palm trees have some main lyrical content which they repeat often. First they sing the phrases (p 5, lines 96-102):

All propagation representatives:

Chorus:

Grow fast, make oil.

Have fun, sing soil.

Don't rot, don't spoil.

In tune, our toil.

Be fed, be picked.

Nitrogen addict.

This was inspired by my recent work on *Autohoodening: The Rise of Captain Swing*, which focused on the experience of workers in an Amazon fulfilment centre (see appendix AP 3.3). Through this I discovered that the internal slogan of Amazon is *Work Hard, Have Fun, Make History*. The workers in the fulfilment centres are monitored and controlled intensely by machines, which is comparable to how the palm trees are monitored and decided upon by the farmers (Delfanti, 2021: 30). A palm oil plantation is another type of factory and has also been organised in a deeply homogeneous way. This influenced me to begin the text of the palm trees with these two-word slogan-like phrases. You can see that I have directly referenced this slogan with the phrase 'Have fun'. These phrases also refer to the cyclical process of the palm trees' work to grow and produce fruit. Finally they name themselves as 'Nitrogen Addict', referencing the use of fertiliser to maintain and replenish the soil, and the fact that they would not be able to exist in this type of 'forest' and be grown if it were not for the use of extra fertiliser (Quezada, 2019). The soils in palm oil plantations have found to be lower in nitrogen and phosphate

pools, making the trees in plantations far more dependent on implementation of fertilisers (Sahner et al., 2015). The Palm Trees reference this directly in scene 2 when they say (p.5, lines 122-125):

'Trusted victual providers / Who feed us with dogmatic drip / Trickling through the earth we grip / Without whom we could not exist'.

We decided to perform scene 2 to a fully recorded soundtrack, with the singers only dancing on stage to pre-recorded voices. This depersonalised the palm trees and removed their agency. It puts them into a more factory-like setting where we might not be sure if the voices heard are theirs, or what they are told to sing and feel, over some kind of tannoy. It makes a very clear distinction between the world of the Rainforest experienced in Scene 1, and the plantation. During the third cycle Jingya choreographed a sequence for us to perform to the recorded track which would help to show the palm trees as uniform workers, uncommunicative, childlike and addicted to artificially fertilised soils. We also made use of the video I had created in cycle 1 as a projection during this scene. For the palm trees I decided not to work with my body as I had discovered that I was using my body to represent the messages/materials being carried through the root and fungal network during the storm. The palm trees, however, lack this ability in comparison, and therefore I focused on animated computer-generated images for this initial stage. See timecode 00:11:13 for a performance of scene 2 (see figure 18 for example stills and Appendix AP 2.1.d for the animated film).

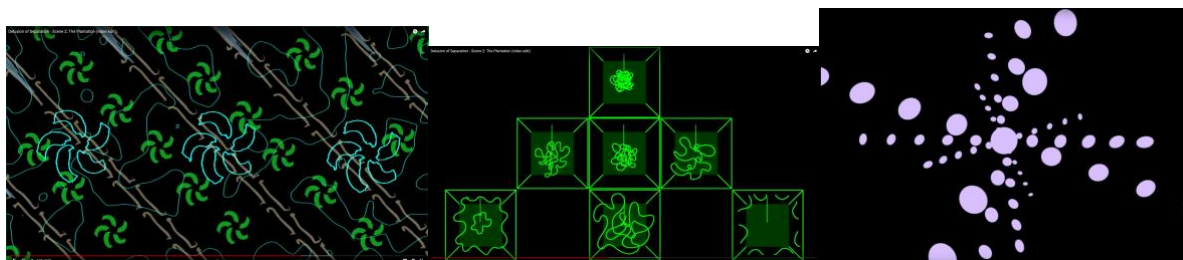


Figure 18 Stills from animated video created for scene 2 based on visual representations created in workshops in cycle 1

In scene 4 the Lipote tree unsuccessfully attempts to connect with the palm tree. The staging uses frames with material covering it, to show the edges of the soil that each palm tree can inhabit (see Fig. 19). They are attached by a kind of umbilical cord to the frame, which is passing the nutrients from the fertilisers above ground. The staging for this whole scene is designed to show an inability to communicate despite being adjacent in space. In the first case Lipote only confuses the palm tree 1, sending it into a short-circuited tailspin where it begins to rearrange all of the words in the two-word phrases so that they become destructive rather than productive (p. 12, line 269-270): 'Rot fast. / Make toil. / Don't tune. / Our spoil. / Rot fast. / Don't oil.' (Please see timecode 00:34:45). In the conversation with palm tree 2 this palm tree repeats lines from its song whilst closing its roots in on Lipote as it sees it just as a source of food or potential competition. Ultimately Lipote realises that these trees are not able to communicate in the way the Rainforest needs and moves on.

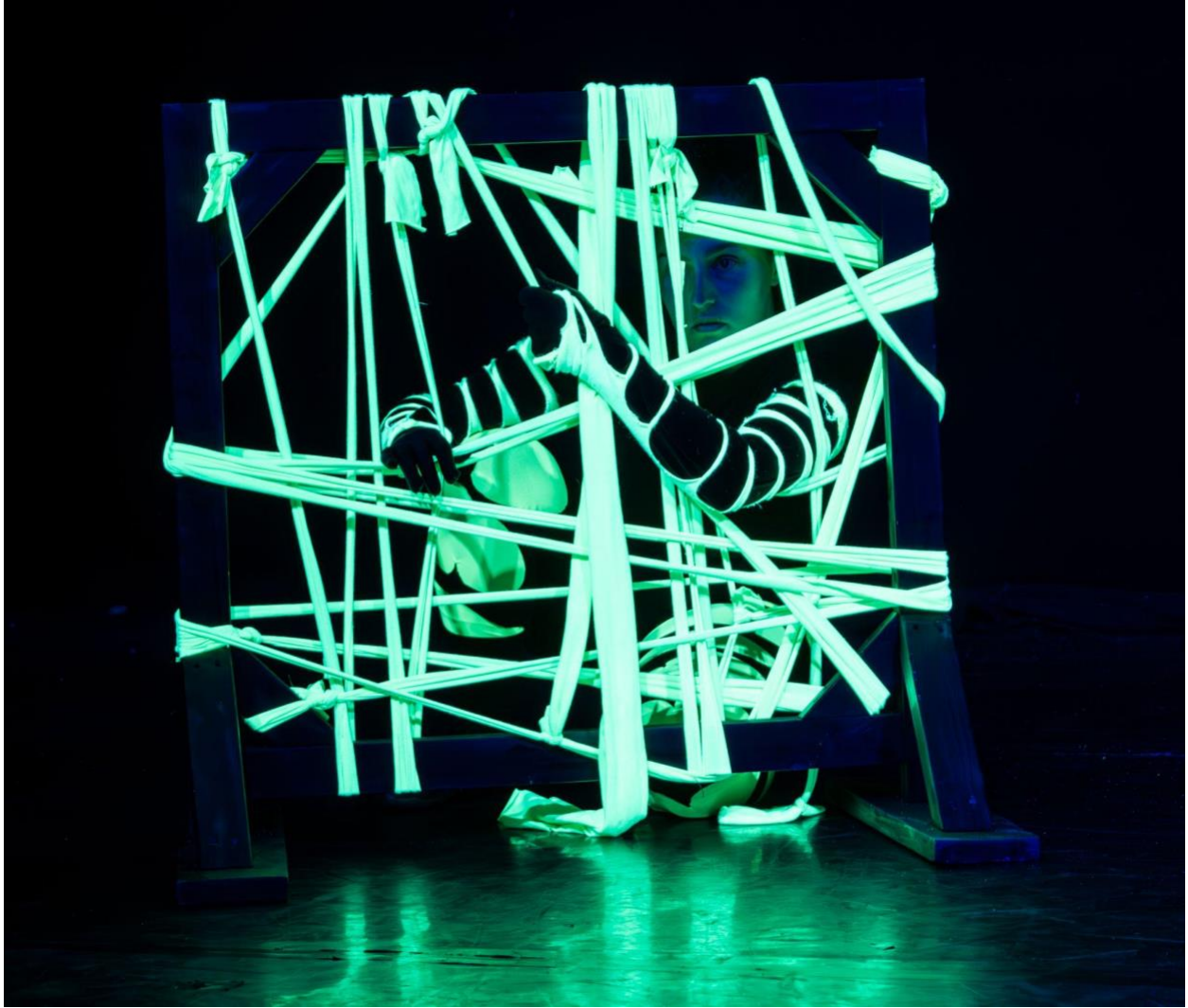


Figure 19 A palm tree from Lipote in Edinburgh Fringe (Image courtesy of Shaky Crown)

3.4.i Lipote as the Loner Tree and the 'Fiery Edge'

I chose to make the main character a fruit tree that is not originally indigenous to Borneo due to research and comments from scientists. Many people who study forests have suggested that there are in fact no real primary and untouched forests, and that it is likely all areas of forest were at some point co-inhabited by man (Seeland, 1997). Charles M. Peters discussed this in an interview saying:

You walk through it, you think you are in pristine forest and the people tell you, 'Oh, no, no, this is an orchard that we have created.' These forms of indigenous resource management had been invisible to us. There are tracts of forest all over the world in Brazil, in Africa, in Southeast Asia that have been intensively managed for generations by local people and that's precisely why they are still forests — because they are important to local communities and carefully managed by them. And then somebody in a district forest office comes along and draws a circle and says, 'This is a virgin protected area' and kicks the people out — that sort of thing happens a lot.

(2018b: online)

One key marker that man has in the past inhabited an area of rainforest is the presence of foreign trees. Borneo, and the surrounding areas of south-east Asia, are often described as a fruit desert. This means that there is a distinct lack of fruit trees. The presence of any fruit trees therefore implies that man has brought them there and planted them at some point, to create a more harvestable forest system. The Lipote tree or *Syzygium polycephaloides* (or *curranii*) is a type of fruit tree akin to plum. The *Syzygium* genus grows in wet tropical rainforest and the Lipote is a species of the genus native to the Philippines. I chose to use a tree that is not native to Borneo, but a seed of which could easily have been transported there, in order to make reference to this idea that there may be no areas of rainforest which have not at some point been touched and managed by man. The Lipote is also classed as a vanishing tree and so making use of it as the title of the work is helpful to promote its existence around the world.

The Lipote tree introduces itself as lonely in the libretto. In the popular science book by forester Peter Wohlleben *The Hidden Life of Trees* (2017: 169), he describes trees as having different personalities. In particular he cites Beech trees as bullies and Willow trees as loners. In contrast to the typical Western view that forests are predominantly competitive spaces where trees fight for resources and light, he believes that trees are communicating and acting cooperatively. In particular he mentions a 400-500

year old tree stump which he encountered in a forest as being kept alive. He postulates that the only way this stump could possibly be still alive is if it were being supported by its neighbours and supplied with nutrients from underground. He takes a particularly evocative anthropomorphic approach to the trees in his book. Many notable scientists have, however, criticised Wohlleben's work and approach to the subject of forests and trees. In a review of Wohlleben's book in the *New Yorker* by Robert Moor he cites an interview with silviculture professor Jürgen Bauhaus, who contests the representation of the tree stump being supported by other trees saying:

Bauhaus put forward a leaner theory: the other trees are not sustaining that stump to glean its memories; they are keeping it alive to draw water through its vast root system, an act of pure, unthinking opportunism. (2021: online)

It interested me that some trees live more communally and others are more obviously separate to the group. Suzanne Simard's work also touches upon this as she has monitored how family groups of the same species appear to help each other in forests by sharing resources. If this unusual Lipote tree were by some chance to have been planted in a Bornean rainforest, it is possible that it would not have a large number of related trees around it, thus giving it a lonelier existence than some of the other trees. The Lipote tree self-defines this way at the start of scene 3 saying (p. 7, lines 145-146): 'I, a lonely Lipote tree, listen in the midst of this vertigo'.

In order for the Lipote to be able to grow into other types of land it also needs to be on the edge of the Rainforest. In the script this edge between the Rainforest and Palm Tree Plantation is called 'the fiery edge'. In discussions with Dr Eichhorn, he suggested that the trees existing on the edge would quite possibly be attempting to extend across it to the land where the forest had been removed. In contrast to the polyphony of the surrounding Rainforest, I also imagined this edge to be expressed as a barrier through the use of white noise. The idea of this destroyed space around the Rainforest as a (fiery) edge

and white noise came out of the workshop on scene 1. During this I explored different mythologies from traditional Bornean and Filipino cultures. I found the myth of Santelmo (Ramos, 1990) to have particular similarities with our story. This is traditionally described as a ball of fire or blue light (possibly related to lightning) that appears on swamps or marshes. It is the lost soul of a man killed in heavy rains or a storm. In relation to this work's narrative I imagined this ball of fire existing in the areas of trauma, such as the edge between Rainforest and Palm Tree Plantation. The Lipote describes their position on the edge of the rainforest in scene 3 as (p. 7, lines 147-148): 'Rooted on the edge of the forest, / One side facing the sheer emptiness' and later in the scene goes on to tell us (p. 8, lines 182-183): 'I live on the fiery edge / Where past traumas deafen the soil'. At the end of the scene they describe the land beyond the edge saying (p. 9, lines 209-210): 'I will push towards the white noise / Invade the shell-shocked land'. The Lipote again refers to it during the deforestation in scene 6 when it likens the experience of the Forest Garden there to its own experiences (p. 20, lines 499-502): 'Is this what happened to our lands? / The fiery edge - / A white noise will surround your home.'

Considering the placement of the Lipote tree on the edge of the plantation, it is also possible that fungal or grafted root connections to trees were destroyed or cut during the process of deforestation in order to make space for the plantation. In reference to this Lipote's character is sad and in a state of grief. They have experienced a deep trauma from the separation of itself from one half of its habitat. As such it is ready to revolt and so volunteers to help. Throughout the opera the Lipote meets three different worlds and in a sense undergoes three different trials of communication as it tries to pass on the message that it is in search of help. Even though it cannot communicate with humans, it is important that this message reaches us, as well as the rest of the ecosystem. As another key player in nature we also have the capacity to help and the audience can also be made to feel like this is not just the story of

the rainforest, but also a major part of our story as a species. This constant call to action is not spoken sentimentally, or laden with feelings of guilt within the text, but rather as a pragmatic solution to a desperate and extreme situation. In scene 4, Lipote first encounters another tree (Palm Tree 1) and passes on the message. Tied into their message is the idea of balance and reciprocation as mentioned earlier in the rainforest commandments (p. 11, lines 241-247): 'I am seeking help / In need of support / Anything given is always returned'. Overall the Lipote and the whole forest repeat their message for help verbally 17 times, however ultimately they end up offering help to the human settlers, the people of the forest garden, in scene 7 (p. 25, line 619): 'We will offer you our help'. The physical movement of Lipote is always referencing the SOS message, either by drawing it in the air, or at times repeating it in morse code. This movement referencing SOS can be seen towards the end of scene 3 at timecode 00:25:30 – end of scene. Here the 'anthropomorphic moment' (Barad, 2012: online) is taking centre stage as the trees take on a human form to generate an empathy that will enable us to see their struggle, and also make us fully complicit in their distant lived experiences.

3.4.j The Strangler Fig

In order to engage with the kinds of spaces and forests which have been used for humans in a spiritual nature, rather than to profit from, I searched for more unique forest spaces than rainforest or plantation. I wanted to find something that would still be reflective of the highly competitive nature of trees, and display ways in which they are not just helpful or supportive towards each other. Eventually I came across the strangler fig.

In my exploration of famous trees around the world I came across the Thimmamma Marrimanu. This is a strangler fig which is also in the *Guinness Book of World Records* (2020) for being the largest single tree canopy at over 5 acres of area and a circumference of 846m, is at least 550 years old. Strangler figs are banyan trees which start life as a sticky seed left on a host tree by a bird or another creature (Richard & Halkin, 2017: 153). They then send their roots down from the host tree's branches to the soil, and wrap some roots and branches around the host tree. Often they will end up killing the host tree by suffocating it. The Thimmamma Marrimanu has overtaken the area of a small forest and is large enough to encompass a whole temple at its centre. It is worshipped by Buddhists and Hindus as a symbol of fertility, life and resurrection. Across southeast Asia banyans such as strangler figs have a spiritual significance to Buddhists, Hindus and other religious communities, and people will often place shrines near them or tie bands around their branches. The religious significance of such trees means that they may be protected and conserved in regions which would otherwise be undergoing stresses from deforestation or overuse. The Thimmamma Marrimanu²⁴ is one such example. This is referenced in the Strangler Figs text (p. 16, line 367): 'They make their yearly pilgrimage / Tie bands around my branches'.

²⁴ Since last being admitted to the *Guinness Book of World Records* in 2020 it is claimed that it has grown to 8 acres in area, and that it may actually be closer to 660 years old. The many myths and legends surrounding it have led to it being closely loved and protected by many people.



Figure 20 The Thimmamma Marrimanu and a strangler Fig in Borneo. Source: Creative Commons

Strangler figs, however, are a highly competitive and deadly species to other trees in the forest. The hollow cavities they create once the host tree has perished and rotted away leave valuable habitats for many animals. In the libretto this is reflected in the Strangler Fig's proud declaration about its above ground successes (p. 14, lines 330-333):

Strangler fig:

Many creatures come to feed above,
 Living together in the air.
 A skeleton made from sunlight
 Brings shelter and food.

It is immediately followed up by Lipote's acknowledgement of the root system of the dead trees of the original forest (p. 15, lines 334-338):

Lipote:

Empty tunnels, forgotten pathways
 There were friends here,
 Not dug away.
 Their networks rotten,
 Their threads decayed.

I wanted to use this plant as a further metaphor for the effect of the deforestation for palm oil on the rainforest. Just as the strangler fig slowly cuts off resources for the host trees, and in some extreme cases such as the Thimmamma Marrimanu can lead to a protected area of monoculture, the palm plantations are isolating patches of rainforest which are becoming depleted of nutrients, diversity and a supportive ecosystem. In this moment we see the Strangler Fig entrap and begin to strangle the Lipote, whilst also psychopathically declaring the close relationship this will create between them (see timecode 00:49:04) (p. 16, lines 375-377):

Strangler Fig:

Come closer. Let us hug.
Let us heal each other's loss.
Stay with me - you will not live or die alone.

They go on to describe the lives of the friends they have already trapped and killed saying (p. 16, lines 385-392):

In my sun made skeleton,
In my sheltering walls,
Many creatures made their homes

They stay then rot into the soil.
Now still inside these hallowed halls
Abiding, residing memories

Written upon
My sun made skeleton.

I felt it was important to include this scene, not as a pivotal development in the narrative, but as a way of exposing the highly brutal and competitive reality of living in a natural environment such as a rainforest, and the ways in which human interference can make that even harder, not only through deforestation, logging and agricultural practices. The strangulation of the other trees in the forest by this

one plant is a metaphor for the strangled rainforest encircled by plantation. The Strangler Fig is only acting in its most natural manner, but in doing so it has caused the destruction of other trees, but due to its cultural prowess, this has also led to the preservation of this area of forest.



Figure 21 The Strangler Fig in scene 5 at Edinburgh Fringe (Image Courtesy of Shaky Crown)

3.4.k The Forest Garden (or Taungya) and the Marriage

As previously mentioned, when talking to Prof. Adrian Newton we were pointed in the direction of exploring the concept of forest garden or taungya. This is a type of agroforestry system in which crops are planted and rotated in cycles around the forest to ensure the health of both the forest and the harvest. It is a food production system which emulates the ecosystem of a woodland or forest as closely as possible (Nair et al., 2021). It makes use of technologies and knowledge to maximise the forest's

rewards. It is a system which has been employed all over the world at various different times, although there are many accounts of forest-dwelling societies in rainforests making use of such a system. Soils are allowed to remain healthy; fertilisation is not so important and humans manage the forests to make best use of the resources available while also acting as guardians, monitoring and maintaining the health of the system.

In *Managing The Wild* (2018) by professor and ecologist Charles M. Peters he describes communities who live in tropical forests around the world, taken from his 35-year career as a researcher. The book contains an account of the practices of the Dayak people in the forests of West Kalimantan. The Dayak people are the indigenous non-Muslim group in Borneo who have been living in, planting, and managing the forests for centuries. He describes how the people knew each tree by name, as well as the name of the person who had planted each of the fruit trees. This is referenced in the Forest Garden song in scene 6 when the King Durian says 'Cared for and named / Beneath their feet . . . Names exchanged for floors of nuts' (p. 18, lines 435, 436, 458). When referring to a walk across the forest Charles M. Peters says '[t]o the untrained eye, I appeared to be in a beautiful, relatively undisturbed, piece of mixed Dipterocarp forest. How had these people created such a marvellous homemade forest?' (2018: 60). In his account of the Teduray society Stuart Schlegel says:

In the local version of Teduray creation stories, Tulus, the Great Spirit who created all things, actually made human beings four different times, but in each case the purpose was 'so that they could take good care of the forest.' In the fundamental Teduray cosmic scheme, the forest - or nature in general - was created to supply humans with abundance of life, and they were to live harmoniously with it and to see to its wellbeing. (1998: 80)

This account, along with discussions during seminars held by Nature Art and Habitat, is what lead me to describe the forest garden with 'walking caretakers'.

Charles M. Peters goes on to describe in his book how the Dayak people live in communal housing, around which they plant fruit trees. Once the trees grow too tall for them to live in that particular spot the residents will dismantle and move their houses to a new site. They will then go back to visit the previously planted trees to harvest, weed and engage in recreational activities. In particular, when the Durian trees start fruiting the whole village will move out to the old housing sites (called tembawang). The women will prepare rice while the men prepare small huts and weed to make the fruits easier to find. During this weeding process the unwanted plants are taken away while the more valuable seedlings and saplings are saved. This becomes the community's new home for the entire durian season. This is referenced in the Song of New Knowledge in scene 7 (p. 23, lines 561-564): 'We learned how trees are planted / We heard how grounds are cleared / We felt the fruits are picked / We saw with tall trees huts disappeared'. One chapter particularly describes the fruit forests of Borneo, and cites the durian as the king fruit of the market:

Durian can be counted on to be a conversation starter. . . . everyone speculates about the harvest. Will the fruits be large, meaty, and aromatic? Will the price be as good as last year? Which villages will bring the best fruits to market? Once the durians start showing up in town, the conversation turns to where to find the tastiest and best-priced varieties. . . people talk about it all the time. (2018: 53-54)

Due to the great reverence and ritualistic importance given to the durian, as described in this book, I decided to create the character of the King Durian in the Forest Garden. The end of scene 6 shows another type of system collapse, as the ground is razed by machinery. The 'walking caretakers' disappear as the Forest Garden is destroyed.



Figure 22 The King Durian in scene 6 at Edinburgh Fringe (Image Courtesy of Shaky Crown)

In this scene the music is closer to musical theatre, with elements of plantation (voices in harmony) and elements of the Rainforest (polyphony). This is due to the nature of the Forest Garden as a world which has been kept as rainforest whilst being managed and planted by humans. It is somewhere on the scale between opera and pop without settling on either, as we move towards a more human but not anthropocentric, world. The trees in this landscape are less burdened with competition than those in the Rainforest. Many of the fruit trees, especially the King Durian represented on stage, are kept alive and aided in their growth and health by the human communities that live among them. The design and concept of this scene therefore took on a party atmosphere, where the Durian King and surrounding trees are able to dance and enjoy (see figure 22). Please go to timecode 00:57:50 for the full song.

The ending of the work (scene 7) was decided through chance. It did not appear obvious to me what outcome the Rainforest might incur after its long journey, and just as the future safety and security of such systems is under question, the ending of this work seemed to me to be open and unanswered. In order to decide the form of the ending I wrote down various different traditionally structured endings e.g. death, marriage, death and marriage, birth etc, as well as the possibility of moving away from this underground world of trees across the globe to see the life of the humans who are purchasing the commodities which directly affect these forests. One was chosen at random and the ending I was provided with through chance was 'marriage'. This actually enabled me to create an open ending which would still involve the human element of the systems, as well as integrating Fleiss's research mentioned above, which suggests that human intervention is now necessary in the patches of pristine rainforest left between plantations (2020). I decided it should be a marriage between the humans of the Forest Garden and the Rainforest. This begins with the knowledge transferred from the fusing of the fungal networks of the Rainforest and Forest Garden. I directly referenced some of the practices, as described above, alongside others such as tooling – growing branches in the shape required for tools then pruning those branches, which in turn encourages the tree to grow more – in scene 7's song of knowledge. Please go to timecode 01:11:10 to watch this section.

The people of the forest garden, their land having been deforested in scene 6, were displaced and so went in search of a new home: the Rainforest. The way the Rainforest becomes aware of the presence of the people of the forest garden is through the planting of a new baby durian tree. They tell the rainforest of the displacement during their short aria at timecode 01:14:35 (p. 24-25, lines 592-595):

'Caretakers in crisis / Became displaced / A changing of state /
Defoliated and dislocated / We were forced to go'. Charles M. Peters tells us of rainforest foresting communities that:

What all of these community silvicultural systems have in common is that they are operating at the seedling and the sapling stage to create a forest that you won't see for decades in the canopy. (2018b: online?)

The help and management of the people of the forest garden will have brought some of the support that the Rainforest now needs, to recover in the wake of the violent storm in scene 1, and the pressures from the surrounding environment, but it also means that they are now inextricably and directly linked.

3.5 Film and Libretto

See file '3.5 Lipote An Interconnected Journey Film and Libretto' to watch the filmed performance of the final show at Edinburgh Fringe Festival on 18th August 2023 and read the final libretto.

3.6 Future Steps and Conclusion

The main element which I have not yet had time to explore is the impact of venue and location on the performance. One joint goal, agreed by all collaborators in the creation of this work, was to de-prioritise the venue, creating a flexible performance which could be transported and performed in a variety of locations. We achieved this, having now performed both at a music festival and in a more traditional theatre. Something we had discussed exploring, but never had the opportunity to do, was to put the audience in different places. A testimonial from an audience member at the Edinburgh Fringe also expressed interest in this further stage saying:

I think the psychedelic way into it is a really keen observation. I think what was really nice for me is that being in the front here it feels very immersive, and I think by the end the dramaturgy of the piece is very much like this is our story, this is connected. It is not just like we are

watching the story of the trees but this matters for the world this matters for us. So I would see this leaning more towards putting the audience in different places, maybe what happens if the audience is behind you. I think there are a lot of ways you can play with space that are really exciting. It's in a really interesting place where you can experiment a lot, and it is really great material. (Ed Fringe Audience Testimony, 2023)²⁵

In particular the audience member from our final performance in Edinburgh highlights the use of UV materials as a way into a more physically immersive performance. The lighting and design prioritises the object, costume or prop, over the human performing. Making use of this material allows the performers to focus even further on the non-human subjects they are representing. This responds well to the process of anthropomorphising that we are taking the audience through. The necessity for darkness in order to highlight the UV materials was also reflective of the darkness in the soil, allowing us to create vivid representations of an invisible world. The brightness of the materials, and the subsequent designs for the different characters, were also in response to the images created by scientists of the inner workings of plant roots through the use of radioactive dyes or ultrasound imaging. Wanshu has written of her own work:

Deep shadows and darkness are essential, because they dim the sharpness of vision, make depth and distance ambiguous, and invite unconscious peripheral vision and tactile fantasy (Li, 2021).

Within this type of design it is the experience of the reflected light which creates the performance space making it a truly flexible medium for various locations. With future funding we will seek to expand the

²⁵ This comment, part of a Q&A after the performance, was made anonymously.

piece in this way, performing to a broader audience and allowing the location or venue to influence the experience of the work as well as the subject, music and design. Another element we will seek to develop for future productions is the scene changes, and possibly bring in further narrative or dramaturgical sections which can represent other elements of soil health and interactions during these moments (such as the abundance of micro-organisms around the roots of trees).

During the creation of this work I was able to explore a deep and integrated collaborative partnership with the composer, designer and choreographer. We were all focused on how to best serve the concept, the subject and the story, allowing the characters and the research behind them to guide our decision making. The process of working in cycles also helped us to notice those choices which had not been made in service of the narrative or characters. Having such an invested and conscientious team meant that we all searched for answers to the reasoning behind the smallest details. I am sure that with further cycles of development this work would be able to grow into a tighter representation of the research behind it. Our various audiences in each cycle not only gave valuable feedback, but helped to push our production development forward.

I found that the use of anthropomorphism in reference to ecology was at first harder to grasp, especially in the context of the many anthropomorphic representations of trees and forests that already exist globally across many cultures. Ecology is not as clear cut as physics: the laws and definitions which guide it are less universal and I had spent less time during my life studying and thinking about it. By sticking to the core principles of this work, displaying the ways in which forest systems differ from the perspective of the soil, and talking to other scientists who had spent their whole working lives with the topics, I was able to find an access route to the work and to create the narrative. The co-creation element, in which the work was constantly tested and explored through participatory workshops, development sessions and rehearsals, helped to shape the characters and story, allowing the dramaturgy to emerge from the

research and understanding of the topic. By sharing my thoughts with scientists at a key stage I was able to gain a greater perspective on how this science is studied and communicated by those most engaged with it. Reading anthropological texts and accounts of living in forest- based societies also gave me greater insights into the different ways that knowledge of ecosystems and forestry has been created.

4 Conclusion

Through the process of exploring, writing, performing, and producing the works in this PhD I have found that opera, as a multidisciplinary artform, provides an ideal framework through which to explore, embody and represent scientific concepts and subjects of research. The two examples presented here show that the method of 'librettising' can be transferred from physics to other areas of science, if there is a focus on in-depth research into the topic, which includes engagement with scientists currently active in the field, and therefore that there is space for many more works to be created in this genre. By developing the work in collaborative cycles of creation and performance, I was able to explore the performativity of each piece as it was being created, to adapt and edit the script and production elements towards the final performances.

Both works present operatic performances based on and guided by scientific research and concepts, alongside expressing the philosophical, social or even political issues surrounding the science presented. The use of archetype in narrative and character was a helpful tool in grounding the topics of the operas within forms and formats that are commonly experienced by audiences and other artists. This was particularly noticeable in *The Flowering Desert* where the characters derived from Jung's archetypes were more easily formulated than in *Lipote: An Interconnected Journey*. Creating stories in which the main subjects are embodied representations of the science itself enables the science to become fully embedded in the operatic characters on stage, whilst also blending the science with the human experience of drama and emotion through performance. Constant reference back to the science during the creative and production process, along with guidance and input from experts in the field helped all creators of the work to maintain sincerity to the scientific research. Using archetypal relationships and narratives enabled the science to be transferred easily into opera, providing space for a poetic

exploration of the subject through the text alongside a multimodal response to the subject in music and design. During the research phase of creating *Lipote: An Interconnected Journey* I found that there are structures associated to the science which can also be used to scaffold the narrative and characters. This enabled me to embed the outputs of other disciplines beyond ecology into the narrative, such as panarchic transitions from the field of socio-ecology, which can play an interdisciplinary role in the study and understanding of ecosystems within academic research. For *The Flowering Desert* it was useful to focus the archetypal associations around the discipline of psychology, to highlight the impact that humans can have on the trajectory of astrophysics through how open they are to exploring beyond the boundaries of their immediate experiences.

Collaboration was also a vital aspect to both works. As a non-specialist myself it was key that I made use of the skills and expertise of specialists in the other fields required to produce opera. Having frequent contact with my collaborators, and space to explore the topics together (both online and in person) was a necessary stage to developing an embedded approach to the subject matter. I did find, however, that it was easier to generate the joint language and collaborative approach when you are working in person, rather than virtually. With *The Flowering Desert* most of the initial creative work happened online meaning that we had less time to explore the performativity of the characters before they were set in the libretto, music and design. We also did not have an overlapping collaboration between Tadas Stalyga and Leon Trimble, meaning that not all collaborators were integrated fully into the entire creative process. Despite this, the thorough research and integrated collaboration conducted by myself and Daniel Blanco provided a strong enough framework to involve a wider range of collaborators on the project beyond the first cycle of work. Having now performed the work and seen the audience feedback, along with the recording of the dress rehearsal, I can see that there is still space for improvement in the quality of the projections, the integration of the subtitles, some revamping in costume, and a deeper connection between the movement of the performers and the projections on the dome. I hope to be

able to carry out this work before any other future performances. The opera has however been successful in its initial aims to convey the deeper philosophical implications of the discovery of the TRAPPIST-1 system, as well as some of the key theories that underpin the search for exoplanetary systems through an embodied approach. It was also successful in delivering a site-specific operatic performance in a subject driven venue which served to further embody the topic within the space itself.

On the other hand, the work for *Lipote: An Interconnected Journey* happened all in person, and as such enabled us to carry out a more thorough exploration of the various dramaturgical, scenic and choreographic elements from the very start of writing and composition. We were also able to work with the designer and choreographer, allowing them to shape the development of the story and music towards the needs of these disciplines as well as the demands of the topic. A further cycle of this work would allow us to refine elements of the production that were hard to perfect due to time and funding constraints. For example, I would now like to be able to explore performances of *Lipote: An Interconnected Journey* in a variety of venues, with a new staging that could reconsider the position of the audience among the action. There is plenty of scope to make this work a deeper sensory and immersive experience now it has been fully realised and dramaturgically set.

Even though the aim of this work was not to provide a different type of pedagogical tool to disseminate and teach in-depth scientific research, this would be a potential future area of research beyond the work done here. This type of research could seek to answer questions around the impact this type of transformation of a subject can have on a non-specialist audience, but also whether this type of work could help the scientists themselves to reframe and reconceptualise their own discoveries. Post-doctoral research could also further explore this new field of post-qualitative research/inquiry by creating new works which seek to understand the embodiment of science from the performer to the audience in a more fully immersive manner. Making the audience a more active participant in the work might help

academics and researchers to understand the limits and power of performance to change the perception of the viewer.

The act of writing in the creation of libretti was the first step on the pathway towards the formation of new representations of science through character and narrative. St. Pierre (2012) discusses the value of writing in response to her theory on post qualitative inquiry and states that:

post qualitative inquiry became for me, as Foucault (2984/85) wrote, what “can and must be thought” (p. 7), and so the phrase, post qualitative inquiry, wrote itself in 2010. Linger on the edge of the not-yet is not uncommon for those who acknowledge that writing is thinking, that writing is, after all, another method of inquiry (2018: online)

This research uses both writing and collaborative performance in its method of inquiry. In a thorough exploration of this new field of post qualitative research Lesley La Grange (2012: online) breaks it down into several parts which include the notion that: ‘(Post)qualitative research sees researchers questioning why knowledge should be the point of departure in inquiry, decentres knowledge and embraces the inseparability of ethics, ontology and knowledge’. The projects conducted here into the performance and the creation of new operatic works to further inquire and explore the nature of the topics of scientific inquiry, constitute an element of this type of research. They both explore the boundaries of ontologies, and gives space for ethical consideration alongside the subject matter. Le Grange goes on to say that:

(post)qualitative research recognises that method is performative. In other words, we can choose methods which are transformative – methods that make possible the transformation of the world. In other words, the methods of (post)qualitative research unfold through intra-actions with the world. (2012: online)

The use of both anthropomorphism and an operatic staging enables an exploration of a highly dramatic, emotive and embodied version of the topic. The embodiment of the science occurs not only in the body and voice during performance but also in the emotional and cerebral connection the performers and audience make with the characters. As Coetzee tells us '[b]rain, thought, mind and learning have a physical and bodily nature – as do affect and meaning' (2018: online). As such the performer may be shaped by the subjects they represent through physicality and thought, but also the empathetic representation of the subject on stage must have some embodied impact on the audience, through both their experience in the space and their thought responses to the actions on stage. In doing so, and by making use of a non-human subject, this work serves to decentre our thoughts and experiences towards the experiential existence of the more-than-human. Generating and performing anthropomorphic representations of science creates a space where thought and imagination are able to interact with physical and tangible experience. The projects in this thesis therefore work towards a post qualitative inquiry as they have attempted to bridge the gap between this physical and embodied experience of a subject, alongside the empirical scientific approach to it. McGilchrist tells us that:

we can begin with the description in terms of physics, but could never progress from that to the experiential tree; whereas we can begin with the experience and later incorporate within it the physics. (2021: 822-823)

Ultimately the multimedia assimilation of the subject matter in opera enables space for an 'intra-active' and interdisciplinary inquiry between the subject, the music, the text, the visual nature of it, the performers and the audience. The theatrical space provides a new situation to encounter knowledge of science that is very different to the more common exposition of the subject through an academic text. The scientific subject is given space to be met by the audience, via the immersive operatic work on

stage. This was achieved by: working with multiple disciplines; collaborating with other creative practitioners; conducting an extended period of research into the subject (including talking to experts); and searching for archetypal or transpersonal frameworks in which to express the subject. All of these methods served to constantly remind the creative team to decentre themselves from their own viewpoint, and to find a mental realm beyond the approach of a single discipline, through which to interface with the potential experienced existence of the subject itself.

This work acknowledges that there are many metaphysical elements present in the work of scientists that evade the experimental and positivist nature of the scientific method, but which have been explored and theorised by philosophers. These questions such as the nature of consciousness, chaos and causality in time, the origins of the universe, or the reason for life, are embedded in our scientific quest for knowledge and can be explored alongside the science in the type of interdisciplinary approach that a theatrical representation, and a post qualitative inquiry, can offer. The operatic stage allows us to continually refer back to these seemingly unanswerable questions, igniting imaginations, and giving us renewed curiosity towards our continually unfolding descriptions of the world around us.

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