

# ASTRONOMY

# FIRST KNOWLEDGES

Edited by MARGO NEALE

## Sky Country

'A chance for readers to see the universe through a new lens – in the eyes of two emerging Indigenous scientists – and to learn how we should share first knowledges for a better future.'

**BRIAN SCHMIDT**

'Aboriginal people ... have always shared relationships with the land, sea and sky. This much-needed book is the tip of the iceberg of what we are learning about the world's First Scientists. Go out, find out more, talk and listen to elders and knowledge keepers.'

**COREY TUTT**

KARLIE NOON &  
KRYSTAL DE NAPOLI

**What do you need to know to prosper as a people for at least 65,000 years? The First Knowledges series provides a deeper understanding of the expertise and ingenuity of Indigenous Australians.**

Aboriginal and Torres Strait Islander people are the oldest scientists in human history.

Many Indigenous people regard the land as a reflection of the sky and the sky a reflection of the land. Sophisticated astronomical expertise embedded within the Dreaming and Songlines is interwoven into a deep understanding of changes on the land, such as weather patterns and seasonal shifts, that are integral to knowledges of time, food availability, and ceremony.

In *Astronomy: Sky Country*, Karlie Noon and Krystal De Napoli explore the connections between Aboriginal environmental and cultural practices and the behaviour of the stars, and consider what must be done to sustain our dark skies, and the information they hold, into the future.

**Karlie Noon** is a Gamilaraay astronomer and science communicator who has worked with audiences around the country for the past ten years promoting Indigenous astronomical knowledge systems and advocating for more women in STEM. Karlie is the first female Indigenous Australian to graduate with combined degrees in mathematics and science and is currently undertaking a PhD in astrophysics.

**Krystal De Napoli** is a Kamilaroi educator and astrophysicist devoted to the advocacy of Indigenous knowledges and equity in STEM. She is undertaking an honours degree and researching star formation rates in galaxies. In 2018 Krystal became the first astrophysicist to be awarded the Illumina Women in Genomics bracelet, and she has curated a national public database on Indigenous science for the Australian Council of Deans of Science.

*This is the fourth title in the First Knowledges six-book series. The fifth and sixth books in the series will be published in 2022 and 2023.*

Praise for *Astronomy*...

‘*Astronomy: Sky Country* is a chance for readers to see the universe through a new lens – in the eyes of two emerging Indigenous scientists – and to learn how we should share first knowledges for a better future. Discover the wonder of 65,000 years of Indigenous astronomical knowledge, but also understand the challenges Karlie Noon and Krystal De Napoli have faced in their quest for knowledge, as well as their hopes and aspirations for the future.’

—Brian Schmidt

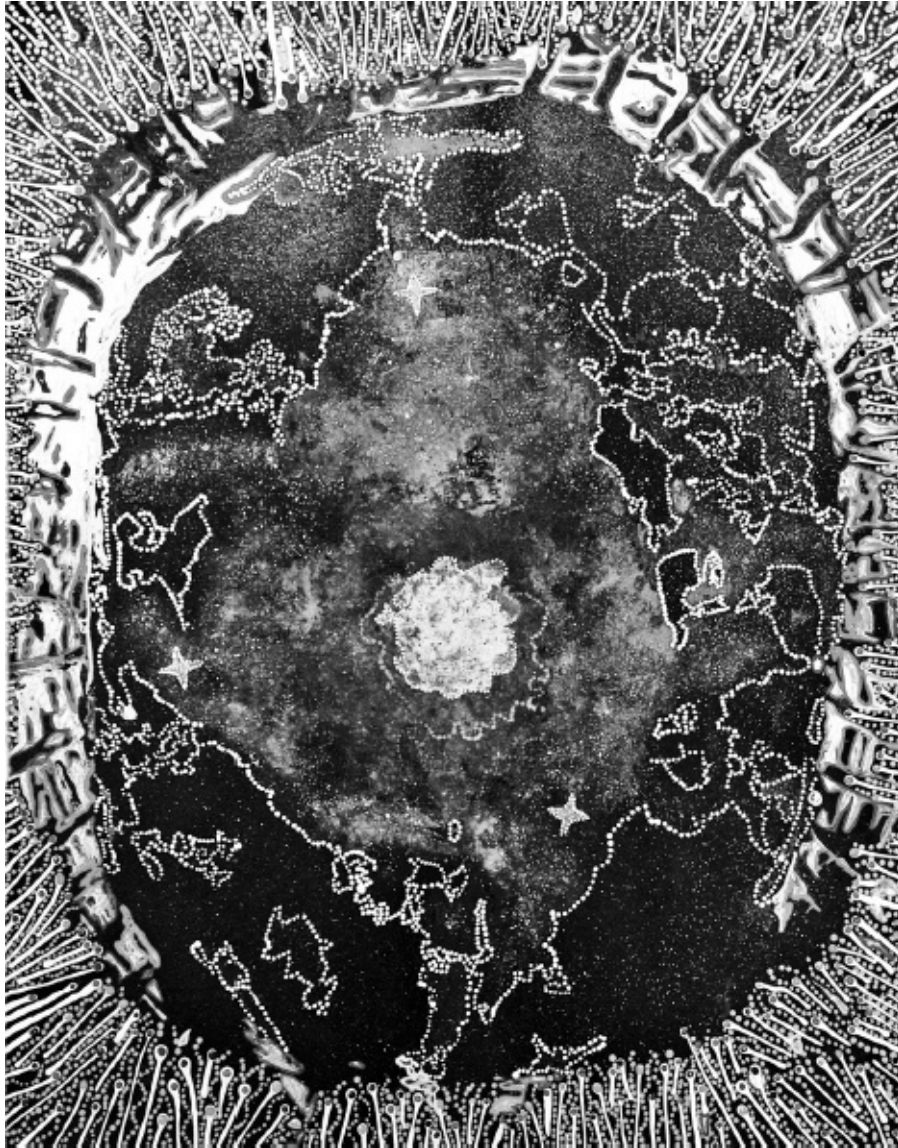
‘Aboriginal people across this vast land of over 500 clans and nations have always shared relationships with the land, sea and sky. This plays an important role in Gamilaraay culture, featuring in stories ranging from thousands of years ago to the modern day that keep us connected to the ancestors and over 65,000 years of scientific practice.

‘This much-needed book is the tip of the iceberg of what we are learning about the world’s First Scientists. My challenge to the reader is this: always was and always will be First Nations knowledge owned by the First Nations people of this country. But the opportunity to learn and grow is owned by everyone. Go out, find out more, talk and listen to elders and knowledge keepers.’

—Corey Tutt

‘This book is about far more than just astronomy or culture. It contextualises the night skies we see over Australia in a web of profound meanings that ask us to reconsider what we think science is. Karlie Noon and Krystal De Napoli give us rich tools to forge new understandings of this most fundamental of human experiences: gazing up at the stars in order to know ourselves.’

—Alice Gorman



Danielle Gorogo, *Yuludarla – The Dreaming*, 2012

*Yuludarla – The Dreaming*, the artwork detail used on the cover and reproduced in full above, speaks to the deep connection between the spiritual, celestial and terrestrial realms. The Dreaming provides the matrix from which our physical world is formed, and without it, our world would not exist. For everything that exists around us, there has to be an entity in the Dreaming that dreams it into being. In this sense, the Dreaming always was and always will be. It came to be when the creator of all that is dreamt the first dream, and from this first dream came everything else.

Danielle Gorogo is a Clarence Valley First Nations artist living in the Northern Rivers region of New South Wales. She is a direct descendant of the Dunghutti, Gumbaynggirr and Bundjalung nations. Danielle's multifaceted cultural heritage, which includes First Nations Australian, Papua New Guinean, Māori and Micronesian ancestry, is reflected in her art.

Aboriginal and Torres Strait Islander peoples are advised that this book contains the names of people who have passed away.

The stories in this book are shared with the permission of the original storytellers.

# ASTRONOMY

Sky Country

KARLIE NOON &  
KRYSTAL DE NAPOLI

Thames  
&Hudson | national  
museum  
australia



*To Didi Maree, Joshy B and to our Big Mumma. May Wadhaagudjaaylwan  
guide you home.*

*To my six wonderful siblings, Kaitlyn, Sebastian, Katarina, Keziah, Xavier,  
and Kyotti.*

*You are my entire Universe and my source of strength and inspiration. I love  
you.*

## NOTE ON STYLE AND SPELLING

Readers may note that for different language groups, variant spellings occur for similar words, cultural groups or names. In the case of the Gamilaroi people:

|                            |   |
|----------------------------|---|
| <i>Gamilaroi/Kamilaroi</i> | the people  |
| <i>Gamilaraay</i>          | the language/Country and/or the people                                    |
| <i>Gomeri</i>              | abbreviated version of Gamilaroi (more common in east Gamilaraay Country) |



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# FIRST KNOWLEDGES

MARGO NEALE, SERIES EDITOR

In Aboriginal thinking, Country is not just land, it is a worldview. It is more than land as expressed in the Western view of land as landscape. It is as much about the visible as it is about the invisible, the animate as the inanimate, whether it be a grain of sand, a rock, a bee or a human being. ‘Everything and everyone has a place’, as Karlie Noon, co-author of this book, reminds us in her opening sentences. All that exists has a place in the Indigenous worldview. It is a continuum that takes everything into its orbit, including land, waterways, sea and sky – all are incorporated into our understanding of Country, with little separation.

Sky Country is the focus of this book on Indigenous astronomy. It reveals how it is impossible to truly learn about Indigenous astronomy without also learning about how the sky connects to the land. Connectivity is a strong thread running through these pages, which will extend your mind beyond our planet and enlarge your understanding of how knowledge can be held and passed on across thousands of generations without the written word.

Time, place and space are all included in this worldview, which is sometimes referred to as the Dreaming or the less accurate Dreamtime. In grappling with this concept, the anthropologist WEH Stanner coined the multidimensional term ‘everywhen’ in 1956, conflating time and place to capture something of its essence.<sup>1</sup>

The first book in the First Knowledges series, *Songlines: The Power and Promise*, establishes the foundational truths about how all knowledge resides in Country, including astronomy, medicine, engineering, ecology, kinship systems and social mores. *Design: Building on Country*, the second book, explains the importance of building as an extension of Country and of designing spaces as a collaborator, not a usurper. It shows how we invest objects made from Country with the spirit of our ancestors. The third book, *Country: Future Fire, Future Farming*, is a timely call to action for a conversation about who we are as Australians on this continent that has been so badly exploited for generations, and about how to take responsibility for its restoration.

This, the fourth book, directs your gaze upwards. In *Astronomy: Sky Country*, Karlie Noon and Krystal De Napoli urge the restoration of the connectivity between sky and earth that Western thought has lost sight of. It is also a call to action for the preservation of our knowledges held in the stars and the significant dark spaces between. It also invites a timely conversation about how the degradation of our environment has an equally corrosive impact on our Sky Country and the subsequent loss of tradition and culture. The authors offer some achievable solutions that can guide us towards taking responsibility for the restoration of dark skies, and they conclude with a letter from the future to the present. This letter picks up

on threads from the book and weaves its way along an ‘astronomical highway’ that we can travel together towards a more sustainable future under shared skies, to the year 2044 at least. This book, like others in the series, offers provocations for the bigger national discourse on the expertise of First Peoples and the increasing awareness among Australians, and indeed all peoples of the world, of the critical relevance of first knowledges to a shared and optimistic future.

Krystal and Karlie take you deep into Sky Country and expose how the knowledge written in the land is also written in the sky. One mirrors the other; as the Bawaka Country group note: ‘Land, Sea and Sky Country are all connected, so there is no such thing as “outer space” or “outer Country” – no outside. What we do in one part of Country affects all others.’<sup>2</sup> What we do on land affects what happens in the sky, resonating with a well-known ancient aphorism, paraphrased from the *Emerald Tablet*: ‘As above, so below’.<sup>3</sup> So the loss or degradation of one diminishes the other. Light pollution produced on the land, and more recently in our upper atmosphere, reduces the visibility of the night sky and thus access to the knowledge held in the stars.

What makes Indigenous astronomy different from Western astronomy? How can they complement each other and work expansively together? In the Western system, astronomy is seen as a science, separate from the arts and humanities and even other branches of science, a field of study that belongs to experts and specialists generally known as astronomers. Indigenous astronomy, however, is an integral part of the Indigenous knowledge systems that inform all aspects of everyone’s life, visibly refreshing traditions, culture and practices nightly.

Today we are witnessing Indigenous astronomers, such as the authors of this book, and their Western colleagues drawing on elements from both knowledge systems. In this dynamic fusion, a third archive is being created. Of course, the two types of knowledge are related and connected like two sides of the same coin, as Karlie and Krystal note: ‘Interactions between the rigorous scientific method and innovative technologies of the West and the holistic, adaptable, sustainably focused perspectives held by Indigenous people offer a way forward through the chaotic times of climate and environmental change that we find ourselves in.’

This book reminds us that ‘the history of this land has been mapped to features and events in the sky’ for over 65,000 years through the ‘power of language, song and dance’ and visual images, and has passed across some 2000 generations. Just as the Songlines that crisscross this continent are visualised as pathways or corridors of knowledge linking natural features – understood as archives of knowledge – so too are the Songlines in the sky, described by the authors as ‘astronomical highways’. They too contain knowledge critical to our physical, spiritual and social survival. For example, it is along these highways that the epic saga of the Seven Sisters and their relentless male pursuer is played out nightly in the Pleiades star cluster and the Orion constellation. Different episodes of the story unfold with the changing position of the stars across the passing night. The seasons, and one’s viewing position on the planet, also animate different phases of the unfolding story. This gives rise to variations in different parts of the world: ‘the Greeks, the Aboriginals, and the Plains Indians

all lived continents apart and all, independently, looked at the same septuplet knot of the Pleiades and believed them to be seven young girls running away from something that threatened to hurt them.’<sup>4</sup> Each variation is grounded in the Country below.

The authors tell of the lessons their Gamilaraay Seven Sisters story teaches them: lessons that emanate from their own environment and culture. What all these Seven Sisters stories seem to have in common is a range of universal themes that include not only lore and protocols around gender relations, marriage rules and kinship but also how to care for each other and Country. In varying degrees they are aids for navigation and seasonal tracking and serve as a calendar for ceremonial events, holding information about the location and availability of resources in any particular season in different parts of the country. This knowledge is also scripted into features of the land below, visible to those who learn to read their tract of Country. Scientific research indicates that the individual seven stars would have been much more visible 100,000 years ago.<sup>5</sup> ‘If this is the case,’ the authors note, ‘the Seven Sisters Dreaming may be the oldest known story in human history.’

More broadly, they go on to say, the skies hold stars that ‘are crucial reference points for knowledge systems relating to astronomy, ecology, medicine, design, history and all things in between,’ just as landmarks below act as memory aids. The skies, like the land, are libraries of archived knowledge essential for an oral culture, where each star cluster or constellation forms recognisable images triggering stories that release required knowledge. In other words, these associative images – including emus, turtles, saucepans and various characters such as the Seven Sisters – act as mnemonics, where stars can be likened to a book that will, on cue, release the traditions and knowledges associated with them. As Lynne Kelly, co-author of *Songlines: The Power and Promise* and author of the renowned *Memory Code*, tells us, the human brain is wired to indelibly hold images and place and associated information through stories.

For example, the authors tell of Gawarrgay, the Celestial Emu that ‘journeys across our skies’ periodically and predictably from one year to the next, noting that First Peoples know that the emu ‘sweeps across the entire celestial sphere, legs and neck stretched out as though running’ in autumn, before he ‘dives toward the horizon’ in winter. The story tells when to collect emu eggs and when not to, to ensure that embryos are left to develop into the next generation. On land in Ku-ring-gai Chase National Park near Sydney, the authors describe an emu engraving approximately 8 metres in length that aligns with the positioning of the Celestial Emu in the sky during the winter months, a time for male initiation rites. Gawarrgay is showing us in the sky what the *dhinawan* (emu) are doing on the land.

Arrente people of Central Australia have a star classification system that groups red, white, blue and yellow stars.<sup>6</sup> Such systems of classification are useful for categorising different areas of the sky but are also a way to disseminate knowledge of the stars among members of the community. This distribution of custodial responsibility is similar to that which occurs on land, where sites and associated Dreaming stories are inherited by custodians.

Enthusiasm for the preservation of knowledge and culture embedded in our land-based

heritage sites is sadly missing for the preservation of knowledge and culture embedded in our dark skies, referred to as ‘space heritage’ in this book. Karlie and Krystal make an urgent plea for the protection of our celestial heritage from increasing levels of light pollution that trespass on our Sky Country and diminish its heritage values.

The authors’ concerns for our dark skies through light spillage include not only the erasure of constellations that depict animals but also harm being done to land animals. Artificial light negatively impacts on native fauna, leading to reduced reproductive output and quality of life. It affects the REM sleep cycles of magpies, the wayfinding mechanisms of migratory species, marine turtles’ breeding levels, and circadian rhythms in humans. As the authors point out, only some 100 stars are visible to the naked eye in the more populous parts of our continent, compared to the 2000–5000 stars that are visible in pristine dark skies.

Colonisation of the skies with artificial satellites by the world’s wealthiest companies, including SpaceX and Amazon, is also advancing at an alarming rate as they compete in a space race to dominate Earth’s low, medium and outer orbits. Karlie and Krystal tell us that there are thousands of these satellites already, with tens of thousands more planned, and that they form megaconstellations that create a new type of skyglow. They warn that this is another imminent threat to our dark skies, not just for astronomy and for Indigenous peoples with cultural connections to the sky but for everyone living under the skyglow if the perpetrators are allowed to continue unregulated. They also expose the dangers of an estimated 20,000 pieces of derelict space debris orbiting our planet as its atmosphere becomes increasingly privatised, industrialised and used for military and civil purposes. First the land and now the skies! ‘When will they ever learn?’ resonates here with a prophetic ring.

In the process of opening us up to a whole realm of traditional cultural knowledge so close but so far, which few of us know about, *Astronomy: Sky Country* lights the way forward with an Indigenous approach to astronomy. This approach demands that we revisit our limited view of Country with a 360-degree scope that embraces Sky Country, and that we acknowledge our small place in the universe we inhabit, that we value it, learn from it and protect it.

The authors urge us to invest in lighting our worldly spaces intelligently and with purpose, and to demand that our governments hold the wealthy colonisers of space accountable for the mess they are making with their satellites and insist they clean up after themselves before it is too late. Karlie and Krystal view the future of Indigenous astronomy optimistically, with the incorporation of it into school curriculums and examples of successful collaborations between Indigenous and non-Indigenous astronomers and scientists in this relatively new teaching field. They refer to Professor Martin Nakata as the first Torres Strait Islander to obtain a PhD, and cite the increasingly popular slogan ‘Nothing about us without us’ as a personal mantra and a guiding beacon to enable and assure Indigenous agency with all work in this area.

Though language cannot effectively capture the many new ideas and cultural perspectives you will encounter in this book and others in the First Knowledges series, they will serve as signposts to new areas of discovery for those who wish to venture further into a little-known

part of Australia's culture. We are hopeful that the concepts and content in these books will stimulate and provoke you to enlarge your mind and expand your worldview to encompass limitless other possibilities, including ways in which you can learn from the Aboriginal archive of knowledge embodied in Sky Country and feel some responsibility as a joint custodian under a shared sky.

# PERSONAL PERSPECTIVES

KRYSTAL DE NAPOLI

I can pinpoint the moment when my fascination for the night sky began.

It was a warm night. I couldn't have been more than eight years old and I was lying on a trampoline on Bpangerang Country with my mum, Tamara, and my older sister, Kaitlyn. I was locked in an observational rivalry with my sister. She was always claiming to see things in the sky that I could not and making wishes on a seemingly infinite number of shooting stars.

I was indignant and complaining to my mum. She patiently pointed to features in the sky and described them to me: the Southern Cross, Orion and his belt of three stars, and her favourite, the cluster of faint stars that made up the Seven Sisters. Regardless of her assistance, my eyes still struggled to track down each object, and I finished the night without getting to make a wish on that ever-elusive falling star.

Despite my frustration, I was left with a yearning to learn more about the nature of the skies. As I grew older, this curiosity amplified every time I experienced the beauty of the dark night sky, taking a midnight stroll down the quiet streets of my home town under rural skies yet to be lost to the effects of light pollution, or staring past the thousands of twinkling stars swimming in an infinite sea of darkness. Reminders that I am a speck compared to all that lies in the universe.

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I had a very turbulent childhood. My family is one among many who have experienced the devastating effects of intergenerational trauma. My pop was removed from his Gomeroi mum and community at a young age, severing his footing in his Aboriginal identity. My mum was raised in unfavourable circumstances, in an environment of dysfunction, violence and

dependencies that my six siblings and I regrettably lived through, too.

I spent most of my childhood living in public and emergency housing on the east side of my town, which was marked by higher incidences of crime and violence than other parts of town. Often we were victims of it, other times perpetrators. Much of my life was based on survival, rather than the everyday concerns of a young child. I was always worried about the state of things at home and felt entirely disconnected from my peers at primary school, envying the familial support and normalcy they seemed to have. I remember periods of intense hunger. I remember witnessing a lot of violence inside my home and outside in my neighbourhood. I remember feeling the need to serve as protector and 'parent' to my own parents and my siblings. Desperately needed support wasn't there for us, and failed if it was.

My primary school was situated on the opposite side of town from where I lived, at the crossing of the Ovens and King rivers. I felt privileged to be enrolled there, but it became difficult for me to access it. In the early days, I would often set out alone at 7.30 am, the air cold, and walk for an hour to cover the 5 kilometres to school.

I loved learning – even at a young age I had a thirst for it – but was rarely able to engage with my education. On days that I was able to physically be in attendance, mentally I would be distracted by events at home. Unfortunately school life wasn't much easier than my life at home. I have clear memories of walking into class on many mornings only to have my teachers tap their watches at me for being late. It was humiliating. I was the kid with the dirty uniform, which gave other children ammunition to bully me. My long hair was always knotted, and teachers would take it upon themselves to brush it before class. I often didn't have a hat to wear in summer and was forced to sit on the school verandah away from my friends at lunchtime. This may sound like a minor inconvenience, but it solidified the feeling of isolation that consumed me. I felt really discouraged but now realise the teachers and other kids knew little about what it had taken for me to get there. Many times I would be held back by the school staff after the final bell rang because they had been informed it wasn't safe for me to return home that night.

So many aspects of my upbringing were lonely and scary but, being the second-oldest child, I always had the wellbeing of my siblings in mind to push through for. At times it felt impossible to imagine the breaking of the intergenerational cycle. But my life, and my siblings' lives, today are testament to building a different future. I couldn't be more proud of the strength and resilience they've shown. They are all becoming very fine and capable adults, and have done all of that hard work themselves.

It is evident that I slipped under the radar of many authority figures around me, which makes it easy for me to recognise the adults who took notice, decided to act and ended up changing my life for the better. By the age of sixteen I had found a second family in that of my best friend, Louis. In his parents and sisters, I finally had people I could lean on in tough situations. I also had two fantastic teachers who stepped in at crucial moments and provided listening, understanding and support to get me through to the end of high school.

During my VCE studies, a freak accident saw one of my younger siblings taken to the Royal Children's Hospital in Melbourne, approximately 250 kilometres from home. As a



protective older sister, the severity of this accident and my helplessness devastated me. I remember having a quiet cry in class and my teacher, Mr Barron, taking me aside and saying, 'I know you're not crying over the maths, so what's really wrong?'

This was the first time anyone had asked what was going on in my life outside of school. He was very sympathetic and flagged the situation with my other teachers, who provided a degree of leniency and compassion. It was a step in the right direction, but unfortunately did not mitigate the existing factors. Very little tolerance was shown when a student missed more than five classes during their VCE studies, and as the cumulative stress of my home life started to impact my attendance, I became at risk of failing altogether. Graduating Year 12 truly felt like my only ticket out of the cycle of alcoholism and unemployment in my family, but I couldn't see a way forward and my future looked very bleak.

As I have travelled further into my studies and academic career, it has become clear that there is always a path towards where you want to go in life, even if it may not be the shortest or most direct one. I was fortunate that at this crucial turning point, another teacher reached out to me. Mr Wong, my literature teacher, took me out of class and asked about the cause of my despair. I was honest with him about the fact that I was at risk of failing and said I was finding that prospect overwhelming. He responded surprisingly jovially, with an air of determined optimism about structuring a way for me to pass and succeed. I can still remember how light and full of purpose I felt after this discussion. It was as if I had been given a second chance at life.

Our plans unfolded perfectly and I graduated with my VCE in 2013. Without a doubt, those two conversations changed the direction of my life and I will always be grateful for the impact these two brilliant teachers had on me.

At the age of eighteen I became the first in my family to pursue tertiary education. I was offered a position in the Indigenous Enabling Program at Monash University in Melbourne, a semester-long alternative entry pathway that upon successful completion would lead to a Bachelor of Science. These alternative pathways exist to enable students to access an education that the hurdles in their life may otherwise exclude them from. Tertiary education is a resource inaccessible to many. Without enabling pathways, the current system perpetuates cycles of inequality that disproportionately disadvantage those who may be living pay cheque to pay cheque, or with some sort of trauma or disability. They exist to acknowledge that an individual's circumstances and the impact they might have on a person are separate from what they are capable of accomplishing. It is clear that our circumstances do not define our capabilities, but our system dictates it is so. I will always champion these programs, and encourage anyone who may have experienced similar situations and setbacks to me to seek them out.

Not only had no one in my family attended university, but most of them had been unable to graduate from high school. I felt daunted and insecure about my lack of understanding of what tertiary education or a career might look like – I had never witnessed my parents holding jobs – but I summoned the courage to move, and soon found myself flourishing in my new university environment.

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On a cold June morning only four months into my move to Melbourne, I was awoken by the last of a barrage of missed phone calls. I had already sat two of my final exams for the program, and planned to spend the day preparing for my final one, which would grant me entry to the Bachelor of Science degree. I answered, entirely unprepared for the heavy weight of the words I was about to hear.

‘Krystal, your mum is dead.’

This is the single worst day of my life and the date, 7 June, is burnt into my head and my heart. I can’t imagine a pain greater than the loss of a parent. My mum had passed away unexpectedly at the young age of thirty-seven, leaving seven children behind. I had lost someone who shaped me, who featured in the core memories of my life. I saw her in everything I did, and navigating the grief that followed was exceptionally challenging.

It was with a conflicted heart that I made the decision to return to university the following semester and complete my final exam. I wanted to stay home with my siblings but knew I had a responsibility to myself, too. I began to reflect a lot on my experiences in my home town under those beautiful dark rural skies, and reconnected with the curiosity that had resonated within me when I was growing up. I decided that if I successfully passed my exam, I would trust my gut and enrol in astrophysics-focused subjects, and so it came to be.

I was very lucky and privileged that my first-year astronomy lecturer was the exceptional Dr Jasmina Lazendic-Galloway. I have never had a teacher as passionate and knowledgeable, as inspiring and engaging as she is in her approach to astronomy education. Her classes became the one positive outlet I had during that period of grief, and really cemented my interest in astrophysics, fanning a raging bonfire of passion that burns stronger every day.

I have since learnt many things about the skies from an astrophysical and cultural-astronomy perspective. I can identify all the objects my mum shared with me under those Bpangerang skies, and would be able to return the favour by divulging a depth of knowledge in return. It grieves me that I can never share this with her. Mum was never able to engage with her studies growing up and lacked the support structure to complete secondary school. Her knowledge of the skies was something I took for granted as a child, before I could understand the significance of her holding it. Where she had learnt that knowledge is a question I don’t think will ever be answered.

The impact of my childhood has resulted in my having a mental health condition known as complex post-traumatic stress disorder (C-PTSD). It has been exacerbated by the grief I experienced through my years of tertiary study related to the tragic death of four other family members as well as my mum. Every year my exams fall either on or around the anniversary of her death and my brain struggles to inform my mind and body that I am not going through the original trauma and relives that physical stress, fear and anxiety. I carry the burden of grief and missed loved ones with me always. As a result, I still don’t get to engage with my studies as purely as I would like to. I’ve had to get comfortable with the fact that my pathway won’t have the typical timeline of someone my age. There is no single correct way to achieve

an ambition, and I feel I have done well to adapt to difficult circumstances with resilience and determination.

After starting my undergraduate degree at university, I was quickly introduced to a community of exceptional and passionate Aboriginal and Torres Strait Islander students – aspiring doctors, nurses, lawyers, teachers. I remember how out of place I felt listening to their motivations for their studies, where they had come from, and how the knowledge they wanted to acquire would directly lead back to their communities. I felt guilty because my academic pursuits seemed entirely selfish. I was driven by my curiosity about the skies, but could not see how my work would do anyone any good, other than the field itself.

Since then, I have had the privilege of connecting with Indigenous people not only across the country but around the world. I have begun to understand that my experience of guilt is not unique. There is nothing selfish about pursuing your own dreams, and the desire to give back in one way or another is common. This dual mentality sets the foundation for why the fields of Indigenous astronomy and Indigenous science are so important for me. I have found a niche in which I can feel passionately connected to my culture and community while devoting myself to the area of science that I love.

I began to obsessively consume all available resources about Indigenous astronomical traditions. In 2017, I booked a weekend trip to Byron Bay in New South Wales to attend an astronomy convention called Star Stuff. My motivation was to hear a talk on Aboriginal astronomy that was being presented by one of the field's leading cultural astronomers, Dr Duane Hamacher. After strong encouragement from other attendees at the convention, I fought past my social nerves and introduced myself to him. He seemed just as excited to meet me as I was to meet him, and I was soon after warmly welcomed into the Australian Indigenous Astronomy Project, through which I also came to know my co-author, Karlie Noon. By 2018, Duane and I had started to deliver regular public talks on Indigenous astronomy together across Melbourne. We began several research projects, including an exploration of the Pleiades in Aboriginal astronomical traditions, analysis of the role of moon cusps in Indigenous weather prediction (see Chapter 3), and a general dive into the astronomy of the Muruwari nation with Muruwari man (and now dear friend) William Stevens.

In the following years, an unexpected passion for science communication took hold of me. I began to speak regularly about Indigenous science at schools, libraries, planetariums, observatories and conferences. This public speaking role was naturally born out of my eagerness to educate willing listeners on Indigenous sciences and STEM (science, technology, engineering and mathematics), and resulted in my being involved in some large-scale projects. After an article I wrote for the Indigenous-owned media organisation IndigenousX called 'Indigenous Astronomy to Revitalise the Australian Curriculum' received international attention, I was invited to co-produce and feature in a radio documentary for the BBC, *Emu in the Sky*. In 2021, I worked as an astronomer tour guide with Chimu Adventures on the history-making first-ever commercial flight from Melbourne towards Antarctica to observe the aurora australis, also known as the southern lights. I became the first non-

genomicist to be awarded the Illumina Women in Genomics bracelet, a token of appreciation given to women contributing to the scientific field with distinguished leadership. From 2019 I started collaborating with composer and cinematographer Ross Calia and Wiradjuri dancer Ella Havelka – the first Indigenous dancer to join the Australian Ballet – to create the immersive dance film *Our Starry Night*. The film is inspired by the Aboriginal dark sky constellation the Celestial Emu (see Chapter 2), and accompanies the Van Gogh exhibition at The Lume, Melbourne’s digital gallery that opened in 2021. The 360-degree immersive experience of Ella’s self-choreographed dance is projected onto the four-storey-high walls and the floor of the exhibition spaces, and also features time lapses of my own paintings of the emu.

In 2020, my work as a science communicator was recognised by Monash University with the Faculty of Science’s Science Communication Award. I started to focus on embedding Indigenous sciences into tertiary and secondary school curriculums and became part of a working group that designed and executed Monash’s first Indigenous science course, ‘SCI2030 – Indigenous Science: Science through the eyes of Australia’s First Peoples’. I have since curated a public database of Indigenous science resources alongside Dr Angela Ziebell for the Australian Council of Deans of Science (ACDS) to assist tertiary educators in accessing reliable resources for the classroom. These two projects are explored in Chapter 5. Through the construction of the ACDS database, I gained a greater awareness of the ingenious work done by Aboriginal and Torres Strait Islander scientists and knowledge holders beyond the field of astronomy. Inspired to learn more, I launched a weekly radio show called ‘Indigenuity’ on Melbourne community radio station Triple R 102.7FM, where I host conversations with Indigenous knowledge holders to give a platform to their ingenuity.

My proudest achievement is that I have successfully completed my Bachelor of Science. At the time of writing, I am nearing the end of an honours degree in astrophysics under the supervision of astrophysicist Dr Michael Brown. My research aims to determine the star formation rates of galaxies, and I have my sights set on commencing a PhD in late 2022.

My engagement with Indigenous knowledge perspectives has entirely changed the way I view not just the skies, but the land around me. Everything is connected, and this idea of fundamental universal interconnectedness has become undeniable through my study of Indigenous science. I feel that until recently I have been walking this earth with my eyes closed, not fully appreciating the depth of what is being shown to me. Aboriginal oral traditions encode knowledge in endless layers that extend so deeply that once you feel you have learnt enough, you realise that you have only scratched the surface.

Now when I revisit the nightly strolls I made as a child under the stars of my rural town, I have a different perspective. There is so much more to appreciate than just the beauty of the twinkling lights above: the sky is an ocean of knowledge that reflects our experiences on the ground. What is found in the sky is reflected here on Earth. I can look above and navigate my way across the land. I can look at the stars, the planets and the Moon and know that they are ready to inform me about changes I need to understand in my environment.

My aim with this book is to participate in the act of knowledge exchange that has been

practised across thousands of generations by my ancestors. I hope this perspective evokes a sense of responsibility to Country in all readers, and that you will join me in championing the preservation of our dark skies.

## KARLIE NOON

Everything is connected, and everything and everyone has a place. I knew these words were the truth from the day I was born. It is what my mum and her mum knew to be true as their elders passed this knowledge on to them, and my sister and I knew as we received it. My sister taught this lesson to her daughters, and it's what I hope to continue to show them after asthma took her life in the aftermath of the 2019–20 Black Summer bushfires, after a 35-year battle with the disease.

We learn this interconnectedness and we know it through watching – observing our matriarchs and how they navigate, process and heal, taking in their everyday actions. Their ability to survive and adapt and exist despite struggles, disabilities and setbacks has been shown to me by their supreme love of the natural world and all of its creatures.

I was lucky enough to receive an Aboriginal education from my preschool. The school's name is Birrelee, an Aboriginal word for 'baby'.<sup>1</sup> At the centre of the school's logo is Garriya, the Rainbow Serpent. The story of Gamilaraay Country refers to how Garriya woke up one day and started creating chaos all over the land. He was travelling around trying to find a resting place, his colossal body creating craters, waterways and mountains as he travelled. Many different nations believe the Rainbow Serpent to be responsible for making all the features in the land. Garriya created the underground water systems that made what we call Boobera Lagoon above ground, and this is where he rested.<sup>2</sup> The site is very sacred to Gamilaraay people (a large Aboriginal nation whose lands span New South Wales and southern Queensland) not only because it is Garriya's resting place but also because of the water it gives. Water is the giver of life, the blood that runs through the veins of Gunii, Mother Earth, and as such, Garriya is a creator of life.

Learning about our stories and our culture with respect has stuck with me my whole life, but going from the culturally safe setting of my preschool to mainstream primary school was a shock. I struggled with socialising and bullying, which ultimately led to low attendance, and teachers barely acknowledging my existence. My poor attendance was due to many other reasons, too, with poverty and speaking difficulties being key. It's hard to go to school when there's no food to eat or clean clothes to wear, or when you're one of the punching bags for all the other troubled kids to take out their frustrations on. But also, my family did not really value school. They had never had the chance to experience the benefits of education. So when I did go to school, I would stay quiet and out of people's way from fear of kids or teachers. I was terrified of them noticing my uniform was dirty or the moonies (head lice) running around in my hair, and of the endless hurtful comments they made about my poor

disabled mother.

It was normal to treat Aboriginal people and poor kids with disdain. We came from a housing commission suburb called Coledale in the country music capital of Australia, Tamworth, in north-western New South Wales. I have many memories of growing up in a community surrounded by family and friends. Corroborees and other community meet-ups were a normal part of life in Coledale and at the community centre where my grandma worked. So I always struggled to understand why some people were scared to walk around the area or even deliver pizza to the part of town that I felt was the safest.

One of my earliest memories of hearing about Aboriginal people at school was that they couldn't count and had no 'useful' knowledge. I knew as a kid that these comments were not accurate or fair, that everything has its place, but this racism nevertheless resulted in feelings of shame – shame in publicly identifying as an Aboriginal person, shame in not being dark enough, shame in being poor. Despite the shame I experienced and witnessed publicly, things were different privately. On the inside, we are proud and staunch and have great strength. Within our communities we are connected and clever and determined.

From a young age, mathematics brought me huge joy, even though I disengaged from school very early as my mum and sister and many others in my family had done. By the time I got to Year 3 (when I was about nine years old), it had become evident that my school situation was not getting any better. My mum and grandmother picked up on my disengagement and introduced me to a deadly and caring older Aboriginal woman who started coming to play maths games with me every week. She taught me that learning could be fun and that someone like me could do something like maths. She would time how fast I could go through the multiplication tables and would celebrate any little success or improvement. Whenever I got to  $6 \times 7$  I would forget the answer every time and we would both laugh. To this day,  $6 \times 7 = 42$  is my favourite multiplication, cemented deep in my memory.

And just like that, all of the racist remarks I had heard about Aboriginal people were no longer true. I saw them for what they were, and for the first time I saw potential in myself and potential in maths. I started listening to my teachers and stopped holding back, and soon I was top of the class in maths. I would regularly beat the boys at maths quizzes and became excited to go to school if I knew we had a maths lesson. But despite this, nothing else changed for me. The teachers had the same attitude as before. They probably assumed I had cheated somehow, and my maths prowess was very rarely acknowledged compared to the 'good' kids in the class who got similar results. The teachers expected particular students to do well, and I wasn't one of them.

Their low expectations and the relentless bullying from other kids inspired me to change schools. I continued my education on the 'rich' side of town, going to the most popular high school in Tamworth. The experience was confusing. For example, I was often punished for not having the correct school uniform. We couldn't afford to buy a proper uniform and we didn't have a washing machine. I frequently had to attend detention for not wearing the right socks or the right shoes, or for wearing my sports uniform on the wrong day, or for countless

other issues that had nothing to do with my ability to learn. Once I got sent to a camp for 'troubled kids'. I had never been in trouble for anything other than my uniform and was generally very quiet and respectful. The camp included anger management classes, along with many other activities designed to encourage kids to listen to authority. I could not understand why I and others were perceived as troublesome. In reality, I was troublesome because I was poor.

As for classes, I was placed in the second-lowest class for every subject. Despite how amazingly I had done in primary school maths, my primary school teacher had recommended I enter high school at a low level. I asked the teacher about this when I saw him at the supermarket one night and he smiled in confusion. I could see that he believed the second-lowest class was where I belonged, despite having been top of his class in maths. These low expectations left me feeling uninspired, bitter and bored. I resented being in the lowest classes and knew I was capable of much more. The flip side was that I was with my friends. Luckily for me, the boredom turned out to be a blessing. One day I was helping one of them in maths. We were doing Year 7 algebra, and I taught her some order-of-operation steps, which meant she was then able to move on to the next problem. The teacher was thrilled at what he witnessed because, well, kids who have low expectations placed on them, like me and my friend, don't often listen to those who assert their poor prospects. Basically, the kids didn't listen to the teacher very much, but they listened to me – at least enough for me to teach them some maths. I had no idea how significant this moment was initially, but in hindsight it had a profound impact.

The following year, I was placed into the second-highest maths class and it was my proudest moment. Every other class was still low, but that didn't matter. I think I believed I could achieve anything if I could just do some maths. That same year, my father's mother, my nan, suddenly passed away. She was a parent figure to me and her death was a massive loss to my family. Added to this, my home life was becoming increasingly difficult due to an abusive partner of my sister's. It was all a bit much, and I stopped going to school entirely. I drifted away from my friends and stopped dreaming about my future. I eventually asked the school if I could leave, and they let me sign out immediately, despite the fact that I was only thirteen.

Luckily, this was a turning point in my story. One of the key lessons from Aunty's maths games was that I could teach myself, so I started doing this again. Between the ages of thirteen and sixteen, my education was a combination of school, TAFE, learning independently and one-on-one tutoring. By the end of what should have been my Year 9, I was doing maths two years ahead of my age group. It eventually got to a point where TAFE could no longer keep up with my demand for Year 11 maths and I went back to school to attempt HSC. I did really well for a while. I was put into advanced English and extension history classes and felt very seen and capable in this respect. Further, I was at the top of my maths class and thought I may as well ask my teacher if I could be considered for advanced maths. My request was immediately dismissed as the teacher believed I would do better in general maths. I won an award at the end of the year for coming third in the class, but this

still wasn't enough to change that decision. Many boys who received a lower score than I did were allowed into advanced maths, but not me.

At the start of Year 12, I found myself having to choose between finishing school or moving away from Tamworth with my mum, who was going through a divorce. I decided to stay and finish school, but it was a lot easier said than done and I spent my Year 12 moving between houses and families and couch-surfing. I received an HSC mark (called an ATAR) of 57 per cent and had never been so disappointed in my life. It was frustrating because I knew I could have done so much better than my score reflected. In a way, I think doing so poorly at school drove me to attempt university. I wanted the chance to prove I could achieve more, so I enrolled, packed up, and moved from Tamworth to the big smoke of Newcastle.

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Choosing what I wanted to do at uni was a no-brainer. I have always loved history and had studied ancient and extension history at school, so I thought this was going to be my path. But like a lot of life's plans, it didn't turn out as I thought it would. I fell asleep in my second lecture learning about the Roman Empire, and the boredom pushed me to pursue other courses within the Arts faculty. I tried sociology, religious studies and English and then stumbled across the field of philosophy. Philosophy was the perfect gateway for me to get into STEM. It used logic and considered historical arguments alongside scientific facts, all the while considering the human experience.

It was through philosophy that I was introduced to the field of physics. In class one day, we were discussing the many theories of creation. The multiverse, simulated realities and parallel universes were all covered. I began reading Stephen Hawking's *A Brief History of Time* and was smitten. The following semester I enrolled in a combined Bachelor of Maths/Bachelor of Science, majoring in physics. I was nineteen years old, and it was the first time I had access to the world of STEM. It blew my mind. The idea that there was a whole field that tried to understand the universe, and you could study that at university? Like, at the university I was currently attending? I was stoked! I filled my days by teaching myself advanced maths and physics, and read as many books by Hawking and textbooks as I could get my hands on. For the first time in my life, I took control of my narrative and followed what interested me the most rather than settling for what others believed I was capable of. *Gayaa ngaya*. I was happy.

In my first year of the STEM degrees, I failed three times. At first, I was heartbroken and felt like I had let myself down all over again, just like in the HSC, but eventually I realised it was all a part of the journey. I might have failed a course (or three), but I did not fail at learning. Each semester I knew so much more than I had known the one before, and I was grateful for that knowledge and experience. This gave me the confidence to keep going. By my fourth semester I was passing everything, and by my final semester I had five high distinctions under my belt.



It was by no means easy. Most of the time, it wasn't even fun. Uni can be a very isolating place, especially if you are the first in your family to undertake a tertiary course – even more so for blackfullas, or those who have had to move off Country. And there was racism. I had one encounter with a person I believed at the time would be my first uni friend. She was also doing physics, and there weren't many other women in that course. During our first semester, we were having lunch and I mentioned I was Aboriginal. She stopped eating, looked up and exclaimed, 'How are you Aboriginal?!' I think I was just as confused by her question as she was by my identity. Growing up in Tamworth around family and community, my identity had never been questioned. Mob knows who mob is. I had never had to explain my light skin before this moment. I looked at her with amusement and said, 'My mum and dad had sex. Why? How were you born?'

This interaction illustrated my friend's lack of awareness about Indigenous Australia and my naivety about Indigenous identity in the broader Australian context. I didn't understand that being a light-skinned Indigenous person in this country can be controversial. I was aware of the different experiences I had faced being light-skinned compared to having dark skin, and the countless ways my light skin privileged me in navigating the world. But these never made me think I was any less Aboriginal.

As for surviving (and thriving) through tertiary education, I couldn't have done it without the Indigenous departments at the universities I attended. While I rarely had racism directed towards me due to my light skin, I experienced many instances of people being racist in front of me. I think they thought it was okay because I am white-appearing. For example, in a second-year electromagnetism course the lecturer warmly greeted me after discovering I came from Tamworth. He excitedly explained that he also came from Tamworth, and we began sharing stories in front of the class. He asked what school I had gone to, and when I told him, he cried, 'But that's in Vegemite Village!' – referring to Coledale, the suburb I lived in for my entire childhood and where some of my family still lives. For those not familiar with this language, 'vegemite' is a derogatory term used against black people. I was horrified. To know that this person could be so overtly racist in front of the entire class showed me the power imbalances at play within Australian society. I had no response and quietly took my seat. I didn't say a word for the rest of the course. Sadly, I felt powerless to challenge his attitude, considering he was responsible for my marks. His response has haunted me for years.

Situations like this highlight why Indigenous departments are vital at tertiary institutions. While I never felt able to report the incident with the electromagnetism lecturer, I knew I had a space I could go to that was safe among all the chaos. These departments support countless mob entering culturally unsafe institutions and help them not just to survive but to thrive. The amount of support they give students is immeasurable. They helped me get through two degrees, and they helped my sister obtain her HSC equivalent and get on to a nursing pathway – not bad for two Koori high-school dropouts from Coledale.

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One thing in particular that helped me flourish in this environment is the great interdisciplinary field I find myself in today. I spent all of my undergraduate degree working in the field of science communication and for years travelled across Australia visiting some of the most underprivileged schools to perform exciting science shows. Ever since I gained skills in science communication, sharing science with people of all backgrounds has become a priority for me. The difficulties I faced gaining access to my own STEM pathway is not a situation any child should find themselves in, whether they are poor or Indigenous or troublesome or otherwise. Further, the isolation I felt during my studies is not something I want anyone else to experience. Since graduating, it has been my mission to encourage people from under-represented backgrounds to consider themselves potential scientists. This work has been supported by many. Notably, the University of Newcastle's Science, Maths and Real Technologies (SMART) program sent me around the country to visit schools in low socio-economic areas and in very remote places, exposing students to the magic that is STEM.

Not long after finishing my undergraduate degrees, I found the Australian Indigenous Astronomy Project led by Professor of Cultural Astronomy Dr Duane Hamacher. Duane introduced me to the fascinating and complex world of Indigenous astronomy within academia. I had, of course, been exposed to Aboriginal sky knowledge before in cultural settings. I'd once been lucky enough to hear an Aboriginal version of string theory from a leading Darkinjung elder while sitting next to a camp fire in the middle of the bush. The parallels between quantum theory and Aboriginal creation stories blew my mind and I was intrigued to learn more. Until then, I had no idea that what I was learning at university could help me understand my culture and the Dreaming. I was also amazed to discover that other people and institutions were just as interested as I was in elevating First Peoples' stories and knowledge systems.

One piece of information I have left out of my story so far is that I was the first Indigenous woman to obtain combined degrees in maths and physics. I have failed to mention it because, despite the celebrations and congratulations I have received since, it's not a nice statistic. I should be the thousandth, especially considering the scientific foundations of Aboriginal and Torres Strait Islander cultures. Despite this, there are too few Indigenous academics. In a country where we make up 3 per cent of the population, we make up less than 1 per cent of the academic workforce;<sup>3</sup> and in the STEM space, which represents about a fifth of Australia's graduates, Indigenous representation is even lower.<sup>4</sup> Considering the inherent scientific nature of Indigenous culture and the high number of graduates STEM fields are attracting, STEM is an area that should be booming with First Peoples. Instead, it is in dire need of Indigenous researchers and perspectives. Indigenous peoples deserve equal access to these careers. With a growing awareness of the scientific feats of the Indigenous peoples of this continent, these disciplines hold huge potential in contributing to Indigenous sovereignty. For me, being one of the first Indigenous people to enter this space has been difficult at times and a blessing at others. Regardless, it has always been an honour to

represent and advocate for my family, community and Country.

Unsurprisingly, Duane and I immediately began working on a research project together. We looked at the weather prediction capabilities of moon halos, which frequently appear in Aboriginal and Torres Strait Islander oral traditions. Chapter 3 explores the results of that research, of which I am incredibly proud both as a scientist and as a *yinaar* (Aboriginal woman). Being able to engage with my culture and community intellectually and academically has been the saving grace for my success as one of the first yinaars in the world of physics and maths. My work and message have been supported by the Australian public and organisations around the world, including the BBC and Google. More locally, the Sydney Observatory has provided immense support to my platform and work by making me their first astronomy ambassador. Further, various broadcasting networks have engaged me to talk about Indigenous sky knowledge, such as SBS, for *The Feed*, and ABC – the latter in many different capacities but most notably to present a season of their celebrated podcast *Cosmic Vertigo*, alongside Gamilaraay brother and CEO of Deadly Scientists, Corey Tutt. These and many other opportunities have allowed me to show people in Australia and around the world who can be a scientist.

What led me to the world of STEM was my experiences with my Gomeri aunts, who taught me I could enjoy learning. The fun I experienced learning maths with her stayed with me throughout my childhood and into my adult life, and then my fascination and admiration for the beautiful natural orchestra happening around us led me to physics. My education has undeniably given me a solid understanding of our observable universe, but more than this, it has unlocked some of the complexities hidden within my heritage and culture. What has kept me in the world of STEM is the cultural relevance of the sky to Indigenous peoples across this country and around the world. Learning about the sky knowledge embedded in my culture has reaffirmed to me that everything is connected, and everything and everyone has a place.

## INDIGENOUS WAYS OF KNOWING

Aboriginal and Torres Strait Islander peoples have vastly different cultures, knowledge and knowledge systems than those of the Western world. Aboriginal cultures also differ from Torres Strait Islander culture. Each Australian Indigenous culture was an oral society, meaning knowledge was transmitted through story, song cycles, ceremony, dance, art and other forms of environmental manipulation. In contrast, since the early modern period Western societies have primarily transferred advanced knowledge, and particularly scientific knowledge, through the written word. Today, the written word and, increasingly, the spoken word are the dominant forms of knowledge transmission in Australia for Indigenous and non-Indigenous people alike, as they are for much of the world.

Oral traditions have certain inimitable qualities, however, and remain central to Aboriginal and Torres Strait Islander cultures and knowledge systems, which continue to be danced, shared, sung and spoken today, as well as written.

### INTERCONNECTEDNESS AND THE CELESTIAL EMU

*Look in the space between the stars, what do you see?*<sup>1</sup>

Viewing the world as interconnected is core to Aboriginal and Torres Strait Islander knowledge systems and communities. As such, it is not only inappropriate but also impossible to truly learn about Indigenous astronomy without learning how the sky relates to the land, which all makes up what Indigenous peoples call Country – as captured by the Bawaka Country group in a 2020 paper:

Country includes lands, seas, waters, rocks, animals, winds and all the beings that exist in and make up a place, including people. It also embraces the stars, Moon, Milky Way, solar winds and storms, and intergalactic plasma. Land, Sea and Sky Country are all connected, so there is no such thing as ‘outer space’ or ‘outer Country’ – no outside. What we do in one part of Country affects all others.<sup>2</sup>

The story of the Celestial Emu exquisitely illustrates the holistic nature of Country and Indigenous knowledge systems.

On a moonless, cloudless night, away from the streetlights' orange hum and the confines of tall buildings, the dazzling speckled infinite awaits. If you're close to town, you might see vast darkness with the occasional twinkle. But if you're far enough away from town, you will no longer see the dark but instead be overwhelmed by the light – point sources dancing and shimmering, performing an astonishing display in the vastness of the cosmos. It's here we get to know the sky in all of its complexities and subtleties. No one knew this better than the First Astronomers.

During the late southern summer, the Milky Way's dominating light takes prominence over the entire night sky. As each day passes and winter approaches, the daylight reduces, and as the length of night grows, so too does the Milky Way's presence in our skies. Among the bold, bright discs of light dwell pools of darkness. These uniquely shaped dark gaps are framed by a dazzling stellar spectacle. The combination of light and dark creates an undeniable feature with which nothing else in the observable sky compares (Figure 2.1). Different peoples see various creatures or places emerge from these features, each with its own meaning. To some, it is a big rip across the sky. To astronomers, it's an entire galaxy shrouded by space clouds, behind which hides a supermassive black hole. The Wardaman people of the Northern Territory see the Milky Way as the Rainbow Serpent, accompanied by the Sky Boss and Earth Lady.<sup>3</sup> The Yolju people of north-east Arnhem Land see a crow.<sup>4</sup> For many Aboriginal nations, from east coast to west and from the Top End to the south, it is the Dark Emu (Figure 2.2).

The Dark Emu has many names. It's sometimes referred to as the Celestial Emu. In Gamilaraay it's called Gawarrgay, and its Dreaming tells us of *dhinawan*, with 'Gawarrgay' referring to the featherless, ceremonial Celestial Emu and 'dhinawan' referring to the land-dwelling, flightless bird. These Dreamings are of particular importance to the Gamilaraay/Kamilaroi as the *dhinawan* is the nation's totem. The Dreaming connects the *dhinawan*'s breeding cycle and its movement across Country, mirroring the movements of Gawarrgay across the sky.

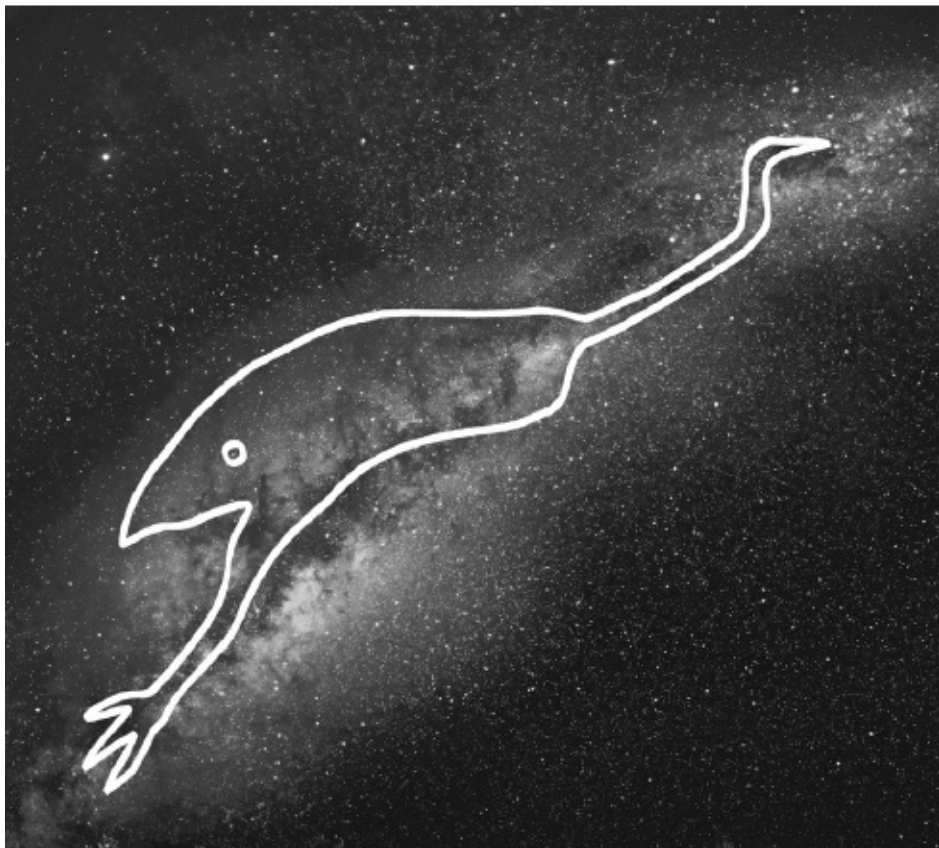


FIGURE 2.1 and 2.2: The Dark Emu (or Celestial Emu), a dark sky constellation visible in the Milky Way, as seen over Australia during the winter months.

In the months of April and May, Gawarrgay sweeps across the entire celestial sphere, legs

and neck stretched out as though running. Kamilaroi man Ben Flick describes its positioning:

Just under the Southern Cross, you'll see a dark spot. That's the head of the emu. In front of him is, of course, his beak, and as you follow it down, you can see his neck in the dark spots of the Milky Way. It comes right down to his body. You can see his legs and a couple of eggs underneath.<sup>5</sup>

At the same time, on the land, the female dhinawan are chasing the males for breeding. After May, the dhinawan's *gawu* (eggs) appear. These are early days for the *gawu*, before the embryos have had time to develop. The male dhinawan sits on the *gawu*, protecting the young. The dhinawan is important for Gamilaraay males, as the Dreaming teaches young men about their role in looking after the children in community, as the dhinawan look after the *gawu*.<sup>6</sup> This is the best time for *gawu* to be collected, but people should only take what they need and leave the rest. If they wait too long in the season, the *burrGay* (emu chicks) form in the *gawu*. People should not disturb these *gawu* as the new generation of dhinawan is taking shape. In the sky, Gawarrgay's legs disappear as he dives toward the horizon, signalling that the male dhinawan is sitting on the *gawu* on the land. The Celestial Emu is signalling to the Gamilaraay people to stop hunting as the eggs are now in incubation. As Flick describes it, 'At that certain time of year, it's time for us to go out and collect emu eggs. We go out into the bush, always leaving some eggs for next year and for generations to keep going.'<sup>7</sup> BurrGay is also the Gamilaraay word for this time of the year (July), further illuminating the animal's importance to Gamilaraay people and the culture's holistic nature.

As the year progresses, Gawarrgay changes form and appears as a featherless emu crossing Country. Finally, in November, only the body of Gawarrgay remains, signalling that the dhinawan are currently occupying waterholes. Gawarrgay's shortened form signifies to the Gamilaraay people to move across Country to access the same reservoirs as the dhinawan, but also to protect them from being overused and destroyed by the thirsty, cheeky dhinawan. When Gawarrgay reappears in February, people start moving from their summer camps and the waterholes to their winter camps. Just a few months later, the annual cycle of Gawarrgay, the dhinawan and the Gamilaraay people repeats.

Analysis of sixty-eight ceremonial grounds by cultural astronomers Dr Robert Fuller and Dr Duane Hamacher and CSIRO astronomer Dr Ray Norris found that the alignment of the Celestial Emu in the night sky throughout the year relates to the positioning and directionality of emu engravings on the ground.<sup>8</sup>

The sky knowledge connects to the food knowledge, which connects to the seasonal knowledge. It is relational, practical and cyclic. Through an Indigenous lens, everything is connected. This mirroring is a core belief for many Aboriginal and Torres Strait Islander peoples. We see it in the Dreaming of Gawarrgay and the land dhinawan. Similarly, in Gamilaraay, Bulimah or Sky Camp is positioned behind the Milky Way, where camp sites, tribes and ancestral places reside.<sup>9</sup> Same same but different. This mirroring is so essential to life on Country that it is immortalised in Country. The Big Warrambool is a flood plain

located in southern Queensland that runs down to the Barwon River in New South Wales. The water plains of the Big Warrambool reflect the sky above and the land below, acting as a portal between land and sky. This place of Country holds further significance to the Gamilaraay people as it is seen as the start of their Country.<sup>10</sup> In Victoria on and around Dja Dja Wurrung Country, a similar place is known in which a large pine tree acts as a portal intertwining people on Earth to the sky world, much like the Big Warrambool does for the Gamilaroi.<sup>11</sup> The interconnected nature of Indigenous knowledge means Indigenous astronomy is never just about astronomy.

## SKY INFORMING ABOUT THE LAND

The big rip across the sky is not just the home of our many beloved dark sky constellations but also stands as a visual remnant of a critical moment during the Dreaming. To some, the land and the sky were initially one. The universe was a whole until it was ripped in two. The Milky Way's dark shadow is the scar that remains, showing the boundary between the land and the sky world above.

The belief that the land and sky were originally one until they diverged resonates through many nations' Dreaming traditions. Despite this division, the land and the skies are intrinsically and ceaselessly interlinked. What is observed in the sky is mirrored on land, and what is observed on land is echoed in the sky. We see this in Gamilaraay/Euahlayi traditions, such as the connection between the land and sky emus, as taught to us by Gamilaraay/Euahlayi law man Uncle Ghillar Michael Anderson,<sup>12</sup> but it is repeated by many others. On the opposite side of the country, Ngarinyin elder Uncle David Mowaljarlai from the Kimberley region in Western Australia teaches us that 'Everything under Creation is represented in the soil and in the stars. Everything has two witnesses, one on Earth and one in the sky ... Everything is represented in the ground and in the sky.'<sup>13</sup>

The endless interrelations between ecological, medicinal, celestial and technological knowledge systems illustrate the sky and land's fundamentally interconnected nature. If we allow ourselves to represent the links between these areas of understanding as a fine thread, we can observe the ways in which it weaves in and out of all areas of knowledge.

For example, we may begin with our understanding of the position of a single star in the sky. It could be any star – perhaps Alcyone, the brightest star in the Pleiades star cluster, renowned in Indigenous astronomical traditions for forecasting seasonal change. Or perhaps Alpha Crucis ( $\alpha$  Crucis), the brightest star of the Southern Cross, which often serves as a navigational device directing Indigenous astronomers southward. We note the star's position and pierce it with our thread, readying ourselves to make our next link.

We follow the thread through to our understanding of how this star's position is shifting in our sky. Heading out each night and looking for our star of choice, we carefully observe its path. Observing Alcyone over the course of a year, it becomes apparent that it rests at varying heights in the sky depending on our day of viewing. If we are far south on the continent, we



realise that Alpha Crucis is circumpolar, meaning that it never sets below the horizon as it rotates around a set point in the sky called the South Celestial Pole. We take this observation and pierce it again with our thread, acknowledging that we have related our stars to an understanding of the flow of time and the movement of the skies itself.

We may then notice that our days are long and hot when Alcyone lies high above us at night. We start to associate this star and its movement with the heat and pierce this knowledge with our thread, extending our system of knowledge from astronomical positions into the forecasting of seasonal change.

In Gamilaraay traditions, Alcyone and the rest of the Pleiades are sacred women's business.<sup>14</sup> The Pleiades are known as a group of sisters, ice maidens called Mirrai-Mirrai or Miyay-Miyay, who touch the ground as they set below the winter horizon. For the Gamilaraay and many other nations, they bring frost. In traditions from southern parts of the Western Desert, the Pleiades are known as Kungkarungkara and their rising marks the *nyingga* cold season from May to September.<sup>15</sup> They act as a signpost for the time of year when local women collect various vegetable foods, such as grass seeds. Again, we weave our thread through this understanding, coupling astronomical knowledge to that of seasonal changes in native plant cycles.

Similarly, in Ngarrindjeri traditions, if the Pleiades are making their highest altitude in the sky during early morning, it indicates the onset of the flowering of yam daisies.<sup>16</sup> This leads us to join knowledge of the stars and the plants to our local food economy. Another thread might then link the migratory patterns of a local animal to the fruiting of said flower. There are threads about local schedules in fire-farming and ceremonial practices and weather patterns, and so on.

The threads that pierce each and every single thing in our universe, from people and animals to every grain of soil, every drop of water in our river systems and every star in the sky, are infinite in number. Our initial thread has revealed a network, much like a spider's web, that quickly becomes a complex woven blanket extending into all of time and space.

Suppose we follow a thread that couples the Gawarrgay in the sky with the dhinawan of the land. In that case, we find a layered and intricate mesh reaching into many aspects of both land and sky. We see how this one constellation informs us of animal behaviour throughout the year. The dhinawan's movements and breeding cycles echo those of Gawarrgay above. We see tethers that hold our understanding of the changes in our climate: we meet the cold nights of winter when Gawarrgay is high, and know that the dhinawan is roosting and protecting the gawu when Gawarrgay is low. The dry, arid conditions of summer encourage the dhinawan to seek comfort. Immutable bonds draw the skies onto the land, into the animals and food and water sources.

This depth of knowledge about Gawarrgay comprises only the top layers of a very intricate, multilayered and holistic knowledge system, much of which is not public knowledge outside of the communities to which the knowledge belongs. The Dark Emu has interpretations and ties that run deep within the varied nations of these lands, from the Boorong who know it as a human-eating goliath named Tchingal,<sup>17</sup> representing the emu as it

was more than 10,000 years ago, when megafauna roamed the continent, to those living under Kokatha skies who know it as Kalia<sup>18</sup> and the Wiradjuri folk, who call it Gugurmin.<sup>19</sup>

In acknowledging the vastness of these knowledge systems and the spiralling depth of their interconnected layers, we encounter fundamental incompatibilities when we try to capture them in the static written form. The extent of the knowledge and how it is communicated is endless, limited only by the number of nations and knowledgeable people. How the skies inform about the land varies from Country to Country. Interpretation is largely unique to each nation and extends so deeply into all facets of human experience and understanding that writing it down changes it, imposing a stillness on the knowledge. There is more to the Dark Emu than we can possibly include here. There is more to the sky–land relationship than we can present in words, because words have limits and because, as two young yinaars navigating our way through the two worlds of being Gamilaraay and astrophysicists, we don't hold all of this knowledge.

## **AN INTERCONNECTED WAY OF LIFE**

*Our spirituality is oneness and an interconnectedness with all that lives and breathes, even with all that does not live or breathe.*

– Mudrooroo<sup>20</sup>

If we value the relationships between things, then everything is vital to everything else, with no human, animal, plant or object being more important than another. The dhinawan is just as important as any community member for Gamilaraay people – as the rocks, waterways, stars and insects are living, knowledge is also living. It grows and evolves from that which originates from the ancestors themselves. In the words of Aboriginal elder Tom Dystra, 'We cultivated our land, but in a way different from the white man. We endeavoured to live with the land; they seemed to live off it. I was taught to preserve, never to destroy.'<sup>21</sup>

When these beliefs are applied to a way of life, we see a culture of 'treading lightly', of cohesive communities and sustainable practices based on a web of intimate, relational knowledge. Integral to this culture is a belief system that is animistic in nature, meaning all things in existence possess some level of agency and value. With an animistic view of things, Indigenous communities fiercely and relentlessly protect all things as they would protect family. Indigenous kinship goes beyond people and includes Country. Totems are an example of this. In the words of Gamilaraay woman, healer and cultural leader Rosie 'Bumble' Armstrong Lang, founder of the Culturally Informed Practices Institute, 'The Country is family, so I look after the Country as if I look after family. This is all of our country, let's all look after it together, walk together, be together, share together and love together.'<sup>22</sup>

Indigenous communities have made countless efforts to defend the environment

throughout colonisation and to this day because of their inherent belief in the rights, purpose and sentience of everything. There are countless Dreamings for inanimate objects that describe their purpose in the grand scheme of things, such as their relationships with other animate and inanimate matter. In many Indigenous stories of the Moon-Man, he is powerful and quick to punish community members if they act selfishly. A great Euahlayi/Kamilaroi story speaks of the Sun as a mother, *gunni*, and of her relationship with her child, Jupiter:

In the grasslands of the eastern riverine corridor west of the Great Dividing Range, peoples of several tribes have stories based on the idea that Jupiter is a young boy wandering about the heavens. He is much disliked by his mother, the Sun, so much so that she sends men to spear him at a time when he is moving low down in the western sky.<sup>23</sup>

In this story, the relationships between the objects reflect human kinship systems while also embedding physical information – Jupiter does indeed wander around in our skies, thanks to the fact that we share the same solar neighbourhood and orbital plane. Further, the planet can appear to drift backwards due to an optical illusion known as apparent retrograde motion. Because we orbit the same sun at different speeds and distances, as we pass Jupiter it can appear to briefly change direction, to ‘wobble’ or ‘wander’, as we speed by. Connecting celestial movements to human relationships aids in the memorability of the story, to help ensure its layered meanings are conveyed correctly.

The relational nature of all things is not just relevant when talking about Indigenous peoples, it is vital for the future of everyone and everything. Australia is one of the world’s most biodiverse continents. However, colonisation has had devastating impacts not only on its First Peoples but on the country itself, and has caused our nation to become a world leader in extinct and endangered species. As of 2021, the International Union for Conservation of Nature named us the third-worst country for animal extinctions,<sup>24</sup> and in 2021 the Department of Agriculture, Water and the Environment updated its threatened species list, confirming that thirty-nine mammals had officially gone extinct since 2000.<sup>25</sup> The major cause they cited was introduced species, such as feral cats.<sup>26</sup> The Australian Bureau of Statistics lists four causes for the drastic decline of our biodiversity: direct exploitation, introduced species, and habitat change and degradation; often it’s a combination of some or all of these.<sup>27</sup>

These problems exist because the people in power fail to acknowledge one fundamental rule: everything is connected. Clearly, Australian politicians have not yet conceived of this country’s connatural, relational nature. In the words of social anthropologist Janet McIntyre-Mills, ‘Morality becomes politically disposable, because of a lack of understanding of our interconnected existence.’<sup>28</sup> It is imperative that we remember and acknowledge the interwoven nature of all things, land and sky, as known and taught to us all by the world’s Indigenous peoples.

## OUR DYNAMIC SKIES

One may easily be misled into thinking that an Indigenous view of the skies is a static and unchanging one. But if we were to study all the sky and star stories held and maintained by Indigenous peoples, we would see that the storylines evolve over time, depending on the physical observations being recorded at each time and place. Although we see periodic and predictable cycles of movement in the positioning of stars and features over the course of a year, much like the way the Gawarrgay emu journeys across our skies, if we were able to observe the skies from the same location across several millennia, we would see the positioning of the stars shift. And as the environment grows and changes, so too do the stories and knowledge that it inspires.

Earth's axis is not perfectly perpendicular when compared to the orbit it makes around the Sun. This means that Earth does not stand upright but instead spins about an imaginary line that runs through the planet on an approximately 23.4-degree tilt. Much like a spinning top that has started to topple, Earth's axis shifts its alignment and the direction in which it is pointing on a cycle that takes approximately 26,000 years. This shift in alignment is called a precession cycle and it means that the positioning of the South Celestial Pole – the sky-based counterpart of the South Pole of the land – will look to a new extreme in its viewpoint approximately every 13,000 years, when it is halfway through its precession. For Aboriginal and Torres Strait Islander astronomers whose knowledges span 65,000+ years, a 26,000-year celestial cycle has a significant impact.

In Indigenous astronomy, the precession cycle, and the resulting change in the position of the stars relative to Earth, means that each stellar tradition has a maximum age of accuracy, at least in their current structures and tellings. Take the story of Gawarrgay, for example. Over the course of several millennia, the movements of the Celestial Emu will no longer be synchronised to the time of year when the dhinawan's eggs are available for collecting. This also then implies that there is a limit on how old the Celestial Emu tradition can be. When we acknowledge this, we see that astronomical knowledges must be dynamic and evolving. They emerge, change and transform over time, responding to the conditions of the skies and Country as well as societal and cultural shifts. It is this adaptability and evolution of Aboriginal and Torres Strait Islander knowledge systems that has allowed them to collectively maintain the world's longest continuing culture.

Because of the continual co-evolution of stories and Sky Country, the precession cycle of the skies can guide astronomers in dating the antiquity of Indigenous astronomical oral traditions. Astronomical traditions belonging to the First Peoples of Tasmania illustrate the long-term shift of Sky Country through their description of a star that rests near the South Celestial Pole.<sup>29</sup> In the present day, the South Celestial Pole is located in a blank, starless space of the southern skies. However, due to Earth's precession cycle, this may not have always been the case. A team led by Dr Duane Hamacher is currently using historical astronomical and geological records to determine possible dates for the origin of this South

Celestial Pole star story. Their research suggests that this particular oral tradition may have originated 12,000 years ago, meaning it is one of countless stories that highlight the phenomenal longevity of Indigenous oral traditions.

Dynamic skies document the birth and death of stars on these millennia-long timescales. Large stars often die a fiery death, which we call supernovae and which produce enough energy for the remnants of the explosion to be seen both during the day and at night. Traditions belonging to the Yolŋu clans in the Northern Territory record the possible appearance of a supernova in their Sky Country.<sup>30</sup> They detail the journey of two brothers, Nuruguyamirri and Napiranbiru, who go fishing together in their canoe. They are unexpectedly caught by a ferocious storm, which capsizes the boat. The older brother is able to use his greater strength to help his younger brother to shore, but unfortunately he loses his life in the process. To honour the courage of the older brother, the community held a ceremony during which a new star erupted into existence. As it faded from sight over the coming weeks, two stars emerged in its place. These are represented by the stars Shaula and Lesath of the constellation Scorpius, and are said to be the brothers standing close together on the banks of the sky river Milnguya (the Milky Way galaxy). Ancient Chinese astronomers recorded the appearance of a star in the same spot; this is known to be the supernova SN 393. It is possible that the bright transient star of the Yolŋu tradition is detailing this exact 2000-year-old event.<sup>31</sup>

There are also moments when sky and land collide, providing physical evidence that facilitates the dating of oral traditions. The crashing of a meteor through Earth's atmosphere can be as harmless as the short-lived light emitted from a shooting star, or as destructive as the devastating crash-landing of a meteorite as it plunges into the ground, leaving a sunken cavity in its wake.

In Central Australia, 145 kilometres south of Alice Springs, there are over a dozen craters forged by the impact of a large, fragmented meteoroid 4200 years ago. The largest of the craters is 180 metres wide. This place is now known as the Henbury Meteorites Conservation Reserve, or the Henbury craters. An Aboriginal guide reported to scientists visiting Henbury in 1931 that they should not approach the craters, as doing so was forbidden. The knowledge holder told how a fire-devil had come down from the Sun and set the land ablaze, killing many people and forming the giant holes. This tale was echoed by Luritja elders the following year: they warned that the fire-devil would burn and eat anyone who broke sacred Law, as he had done long ago.<sup>32</sup> Much like the Tasmanian traditions and the supernova, this highlights the longevity of Aboriginal knowledge systems, with the description of a one-off event persisting in the understanding of the community over 4000 years after it happened.

## **ASTRONOMICAL COMMUNITIES**

Astronomical knowledge is used for a variety of reasons. Monitoring seasons or the time of day, predicting the weather and navigating across large distances are just some of the ways

that Indigenous peoples use holistic, observational knowledge. As such, astronomical knowledge has always been a key feature in Aboriginal and Torres Strait Islander cultures, shared by most in the community.<sup>33</sup> Individual community members are often responsible for storing and protecting elements of a much bigger saga. In some instances, knowledge is spread across several nations, with different elements existing in different languages. This is evident with the Central and Western Desert's Seven Sisters Songline, which describes the journey of seven sisters being pursued by a man. The chase begins on Martu Country, near Roebourne in Western Australia. Heading east, the sisters leave a trail of features in the land as they flee, eventually reaching Anangu Pitjantjatjara Yankunytjatjara Lands in Central Australia. There, their pursuer becomes confused and the sisters are able to escape, heading back west to Ngaanyatjarra Lands (near Blackstone, Western Australia), where one of the sisters is eventually captured. Each language group in the story has their own episode of the saga, as beautifully described in the 2017 book *Songlines: Tracking the Seven Sisters*.<sup>34</sup>

In addition, specific genders and ages are responsible for certain knowledges, with different parts or layers being maintained by the appropriate people within the community. For example, in the Torres Strait, 'When the rising of a star is expected, it is the duty of the old men to watch. They get up when the birds begin to cry and watch till day break ... The setting of a star is watched in the same way.'<sup>35</sup> This is a useful technique in terms of sharing the knowledge among different members of the community and not overloading any single person.

Knowledge of different parts of the sky can be divided among the different moieties, or Indigenous kinship groups. Kinship systems are a way in which members of a community are placed into groups; they ultimately determine who one can marry and are implemented to avoid inbreeding. Depending on the ancestral stories of specific stars or objects, a particular moiety will be responsible for certain Dreamings.<sup>36</sup> For example, on Groote Eylandt in far west Arnhem Land the sky is split in two, with stars to the east belonging to the Wirinikapara moiety and stars to the west belonging to the Oranikapara moiety. Another example comes from the Arrernte people of Central Australia, who have devised a star classification system that groups red, white, blue and yellow stars. Such systems of classification are useful for categorising different areas of the sky but are also a way to disseminate knowledge of the stars among members of the community.<sup>37</sup> Interestingly, stellar classification systems in Western epistemologies only emerged in the late 1800s.

Other parts of Indigenous knowledges are split up by associating objects with genders. For example, the Moon-Man is very often related to women in some way. The Moon has a cycle of 29.5 days, similar to that of the female fertility cycle of approximately 28 days, so in many Aboriginal and Torres Strait Islander traditions, its monthly waxing and waning is linked to that cycle. However, this does not mean that the Moon-Man's stories are kept or maintained by women. In fact, for many groups it is forbidden for women to look directly at the Moon for fear of their becoming infertile. Conversely, the Yolju people of east Arnhem Land and some other nations believe that looking at a full moon causes a woman to fall

pregnant.<sup>38</sup> In some cultures, people warn that doing so can even lead to death! In Gamilaraay/Euahlayi traditions, Bahloo the Moon-Man is responsible for making girl babies; sometimes Wahn the Crow helps.<sup>39</sup> In another tradition, the father of creation (Buwadjarr/Baayina) has one of his wives, positioned in the Large Magellanic Cloud, help out: ‘When Wadhaagudjaaylwan (Buwadjarr/Baayina’s wife) sings to a girl, she sends the child’s spirit on the rays of the Moon.’<sup>40</sup>

The ways in which Indigenous astronomical knowledge is shared among a community, with each member responsible for their own part of the sky, means the knowledge is accessible and also maintained, with its own protocols. Techniques used by our oral cultures to ingrain information have ensured not only the survival of Indigenous peoples who have lived linked to their land for 65,000+ years, but also serve as the oldest scientific database observed and collected by humanity.

## SONG, STORY AND CEREMONY

*Long dismissed as children’s stories or “myths” by Westerners, Australian Aboriginal stories have only recently begun to be taken seriously for what they are: the longest continuous record of historic events and spirituality in the world.*

– Karl-Erik Sveiby and Tex Skuthorpe<sup>41</sup>

Since time immemorial, Aboriginal and Torres Strait Islander peoples have danced, sung and shared stories about their understandings of the cosmos. Each song, dance and story is packed with complementary observations and theories woven together by the peoples’ lore and Country. Knowledge of how to perform the songs, dances and stories is handed down from the ancestors and passed on to those able to receive, maintain and transmit it to future generations. This information communication technique is part of an oral culture, not dependent on the finality of the written word but based on the adaptability and fluidity of language spoken and performed.

Oral traditions present knowledge as inseparable from culture – in contrast to the modern scientific method, which aims to insulate knowledge from its context. As such, in oral societies culture and knowledge are often interchangeable concepts. Knowledge is also more likely to survive the passage of time if it has a practical use, as we explore in Chapter 3. Giving knowledge meaning is one of the many techniques oral cultures use to ensure the successful transmission of knowledge – they make it relevant for day-to-day life.

Aboriginal and Torres Strait Islander peoples’ knowledge is embedded within the Dreaming or Songlines. Dreaming stories describe the Law, culture and creation of everything, while Songlines are pathways of knowledge that crisscross the continent. They carry stories enshrined in the land, where features of the land act as mnemonics. This knowledge conveys essential information about living on the land and with each other, and

how to care for Country. Nothing is purposeless. Transmitting knowledge orally requires impeccable memory or memory cues as communities are dependent on the knowledge to survive. To improve a story's memorability, efficiency and longevity, it is constructed and layered to convey information. The layers can include customary Aboriginal laws, a person's rights and responsibilities, and the natural processes of the land, ecology and natural resources. This means that most stories are not just stories: they are vehicles that carry knowledge. And contrary to fairly common dismissals of Dreaming stories as 'myths', they are far more than tall tales. They are very rarely for entertainment value alone. Dreamings are multifaceted tools with many practical, moral and societal applications.

Storytellers and knowledge holders will often manipulate an ancestral story so that listeners have access only to the relevant pieces of the story, generally the first few layers. Some stories have thirty to forty different layers of knowledge, many of which are known only to the appropriate knowledge keepers. Multilayered stories can link seemingly unrelated events or processes, like a web that can be unravelled through story, song, dance and art. Prioritising and valuing relational knowledge is an efficient way to transmit large volumes of information. It is also a unique and sophisticated way in which to view the world.

Another essential feature of Indigenous knowledge systems is their sometimes fanciful, dramatic nature. Anthropomorphism is a commonly used technique. For example, Gamilaraay people call Venus 'Gindamalaa', which translates to 'You are laughing', and describe the planet as a laughing older man, personifying the object.<sup>42</sup> This description captures the observation of Venus scintillating, or twinkling, in the night sky. Scintillation is an effect that usually only affects starlight, not reflected sunlight off a planet's surface, as the Gamilaraay traditions of Venus suggest happens. However, there is an exception to this: if a planet is low in the sky, the light is required to travel through more of Earth's atmosphere than if it was higher up, making scintillation – a disruption to the light's path – more likely. The Yolŋu people of north-east Arnhem Land call Venus 'Barnumbirr', the morning star. She is seen as a creator spirit for the Yolŋu people and is believed to have guided the first humans to Arnhem Land.<sup>43</sup> They observed that Barnumbirr never went too high in the sky and said this was because she was tied down by her friends with rope to prevent her from getting lost.<sup>44</sup> The twinkling features of Venus observed by the Gamilaroi people and the low position of Venus in the sky documented by the Yolŋu people inform us of the unique positional astronomy observations Indigenous peoples hold.

Venus being described as laughing and tied down may seem frivolous to the untrained reader or listener, but to an astronomer or Indigenous person there is clearly significant information stored in these details. Embedding physical information into a memorable story is required for cultures and communities to survive. Lives depend on the knowledge contained within such stories. If the knowledge holders forget any detail of a chronicle, food, shelter, community and kinship could be lost. Retelling elaborate, exciting and relatable stories aids in them being remembered and passed on.

## **SONGLINES**



With a holistic understanding of the world, it should come as no surprise that Aboriginal and Torres Strait Islander peoples have known just as much about the sky as they have the land – so much so that many First Peoples across this continent believe that the sky reflects the land and the land reflects the sky. Today, this idea is alive and well in culture and stories, and in indentations on the ground at particular sites. The stories, the rock art, the dances and the songs combine to produce what we call Songlines.

Songlines are many things: stories, histories, visas (that is, communicating to neighbouring groups who you are and why you are or were on their land), navigational tools, and ‘books’ filled with information documenting land, seas and sky. Physical stores of memory and knowledge, Songlines mark routes on the ground that can often be reflected in the sky.

Nations all over this continent have travelled for a range of purposes, including for ceremonies, trading, catching up with family and arranged marriages. Associating knowledge with features of the land is a mobile memory technique, as discussed at length by author and researcher Lynne Kelly in her book *The Memory Code*.<sup>45</sup> It is also featured in the first book of this series, *Songlines: The Power and Promise* by Margo Neale and Kelly. Today, we have GPS to aid us in navigating. However, Songlines are more multifaceted than just this one use. Knowledge of a Songline or even part of a Songline is like holding a university degree in that Country. It also authorises cultural responsibility over the part of Country that the Songline permeates.

Those same tracks laid out by generations of Aboriginal ancestors were shown to the first European settlers and colonial explorers of Australia, to be imprinted into the landscape and given new names unrelated to their histories, such as the Eyre, Great Western and Kamilaroi highways. But there are other tracks – unique Dreaming tracks that are not highways on the ground but are known all across Australia and the world.

When thinking about Songlines and astronomical highways, one shines bright – that of the Seven Sisters, a story known well by Aboriginal and Torres Strait Islander peoples and many others worldwide. As explained by Manyjilyjarra artist Ngalangka Nola Taylor and artist Kumpaya Girbirba in the book *Songlines: Tracking the Seven Sisters*, ‘Seven Sisters is not just one Songline – they travelled all around Australia. And even other people overseas know the Seven Sisters story in their own way, so it’s a special story. It’s not only happening here in Australia but it happened everywhere else.’<sup>46</sup>

The significance of the international Seven Sisters story is not just fascinating to Indigenous peoples. For example, popular novelist Jodi Picoult appreciated the commonalities in stories found around the world in her novel *My Sister’s Keeper*:

Come to think of it, the Greeks, the Aboriginals, and the Plains Indians all lived continents apart and all, independently, looked at the same septuplet knot of the Pleiades and believed them to be seven young girls running away from something that threatened to hurt them. Make of it what you will.<sup>47</sup>

## EMBEDDING INFORMATION

How astronomical information is woven into story can be seen in the Seven Sisters Songline, which has many variations across the Australian continent. Some Seven Sisters stories relate the physical properties of the Pleiades cluster to the Orion constellation, situated 444 light years and over 1000 light years away from Earth respectively. Most stories worldwide related to these two celestial bodies refer to the Pleiades as a group of women or sisters, and to Orion as a male or group of men.<sup>48</sup> The story and its variations are ingrained in the vast Australian landscape, informing the cultural protocols of various nations, as well as helping with navigation, seasonal tracking and other applicable knowledges.

To the Gamilaraay people, the Pleiades are seven sisters called Miyay-Miyay, meaning 'several girls'. With their long hair and bodies made of icicles, they are known for their beauty. As in other tales, the Orion constellation is a group of young, desiring males called Birray-Birray, meaning 'young boys'. The story tells of the Birray-Birray's desire to marry the Miyay-Miyay, despite their being from the wrong moiety. They leave traps baited with honey for the sisters. The sisters eat the honey and enjoy it, but do not accept the Birray-Birray's advances in respect for the Law. One day, the old fire spirit, Wurrannah, steals two of the sisters in an attempt to warm their icy bodies, but their bodies extinguish Wurrannah's flame. Still, Wurrannah keeps them captive. Eventually, he orders them to cut some bark from a great pine. The sisters know the pine tree to be a bridge to the sky world, and warn Wurrannah that they will not return if they attempt his order. Angered, he instructs them to do as they are told. The sisters start to cut bark from the pine and, as they had warned, soon begin to rise. As they ascend, they hear their five remaining sisters up above and climb towards them. Soon they are reunited, and have remained so ever since, but the two sisters did not escape unharmed, their light dimmed by Wurrannah's flame.<sup>49</sup>

Across Indigenous Australia, the Pleiades/Orion saga varies depending on the story's original location. For people in the Western Desert, when the Pleiades rise it signifies the arrival of dingo pups.<sup>50</sup> For Central Desert people, their Pleiades/Orion Songline can direct them from their home across to the west coast of Australia, over 2000 kilometres away. For the Yolŋu people, the sisters are said to bring with them berries and fish, representing the time of the year when these foods become available.<sup>51</sup>

Many stories include astronomical observations like those in the Gamilaraay telling of the Miyay-Miyay saga. Another Gamilaraay version speaks of one sister being timid and hiding behind the other sisters. Her name is Gurri-Gurri, meaning 'shy'. This embedded feature could relate to some of the Pleiades stars not being visible to the naked eye, or perhaps acknowledges that seven stars were once visible but some have since faded. This theory is being examined by astronomer and cultural astronomer Dr Ray Norris from CSIRO, and University of Sydney astronomer Dr Barnaby Norris. In a recent paper they investigate the possibility of there having been seven stars visible in the Pleiades cluster, despite only six being visible today. Using astronomical knowledge on the stars' proper motion – that is, the

motions of stars as viewed in the sky from here on Earth – they extrapolate this knowledge back through time to see what the Pleiades cluster used to look like and conclude that the seven individual stars would have been much more visible 100,000 years ago.<sup>52</sup> If this is the case, the Seven Sisters Dreaming may be the oldest known story in human history.

Another example of embedded properties comes from the Western Desert people, including the Kokatha nation. This story was documented by amateur anthropologist Daisy Bates in the early 1900s at Ooldea, South Australia. It has since been analysed by cultural astronomers Trevor Leaman and Dr Duane Hamacher in order to understand its underlying astronomical content.<sup>53</sup> It tells of the Ming-arri sisters, who particularly enjoy the single life. They live in solitude and have no intention of marrying or procreating. In order to protect themselves, they always have their pack of dingos nearby to scare off potential predators.

In the same region lives a great hunter called Nyeeruna (Orion), who is used to getting anything he wants. He decides he wants one of the Ming-arri sisters and starts chasing them. They run to the sky and he follows in pursuit. The oldest of the sisters, whose name is Kambugudha (the Hyades star cluster), considers herself a fierce protector of her younger sisters. She places herself between the Mingarri and Nyeeruna, staunching Nyeeruna in a wide, taunting stance (shown in the inverted 'V' shape of Hyades). Angered at the hurdle before him, Nyeeruna summons fire magic into the club he holds in his right hand and takes aim at Kambugudha. She has a special defence tactic and summons fire magic into her left foot. When Nyeeruna goes to strike, she defensively lifts her foot and uses the fire magic to kick dust in his face. This humiliates Nyeeruna and his fire fizzles out. In the peace that follows, she dulls the fire magic in her foot.

All too soon, Nyeeruna is inspired to battle Kambugudha again, and summons his fire magic once more. Kambugudha needs time to prepare her magic and so calls upon the father dingo, Babba, and his pups (Orion's shield) to serve as the Ming-arri's defence. The dingos rush over to Nyeeruna, shaking and swinging him by his middle while Kambugudha and the other sisters point and laugh at him. Once again, he is thwarted and his fire magic dies down. Ever since, Kambugudha and Nyeeruna have been engaged in an eternal cyclic battle over the Ming-arri, in which their fire magic repeatedly dies down and reignites.

Nyeeruna's fire-magic club is the red giant star we know today as Betelgeuse, while Kambugudha's left foot is the giant star we know as Aldebaran. These two are variable stars – a type of star that dims and brightens over a period of time. The changes in brightness occur either due to an instability in the star's composition, where it is intrinsically cooling down and heating up, which impacts its brightness; or because there is something blocking its light from reaching Earth. The first awareness of variable stars in the Western world occurred in 1638 when Frisian (north-western Germany) astronomer, doctor and philosopher Johannes Holward discovered that the star Mira varies in brightness over a period of eleven months. American astronomer Henrietta Swan Leavitt advanced this discovery in 1908, when she classified a specific type of variable star called Cepheid variables that are observed to vary in both size and temperature. The discovery of Cepheid variable stars was a remarkable astronomical feat that led scientists to the understanding that other galaxies exist aside from

our own Milky Way.

Nyeeruna's fire magic has a variability period of around seven years, while she restores her power, which means that over a seven-year period the star goes from really bright to barely visible. This is represented in the Ming-arri Dreaming through Kambugudha and Nyeeruna's cyclical battle. Kambugudha's fire magic is a particular kind of variable star, what we call a slow irregular variable star. That means its period is long and unknown. It is also believed in Western astronomy that such a star's period is undetectable by the human eye, but the Ming-arri people probably have something to say about that.

The remarkable observations held within Indigenous stories such as these are a testament to the people's observational skill sets and the culture's ability to encode and transfer information across generations.

## DIFFERENT WAYS OF KNOWING

In the past ten years, Australia has seen a significant increase in interest in Indigenous peoples and their knowledges. The body of knowledge about Indigenous peoples is also often referred to as the Archive and is made up of a variety of sources largely originating from settler times. With the newly found recognition from non-Indigenous people, we find that the knowledge itself changes and morphs as it is viewed through a Western lens. This altering can occur when Indigenous knowledge becomes segmented, so as to fit within existing Western groupings such as astronomy, ecology and agriculture. The nuances of culture and Law are often removed in this process, and the knowledge is presented in fragments, not as a cohesive whole. This is an example of extractive practices – taking intellectual property that is inherently owned and managed by Indigenous people and manipulating it to fit within a Western framework. This space, where Western and Indigenous knowledge meet, is referred to as the 'cultural interface' by Torres Strait Islander education professor Martin Nakata. According to Professor Nakata, Indigenous knowledge within the academy is:

the body of knowledge, both historical and ongoing, that is produced by others 'about us' across a range of intellectual, government, and other historical texts. In the Academy, this corpus was once primarily the domain of the discipline of anthropology, but now extends across a range of disciplines where Indigenous concerns, or concerns about Indigenous peoples and issues, intersect with the established disciplines.<sup>54</sup>

Conversely, by keeping Indigenous knowledge and stories intact as much as possible, cultures outside of the Western model can be respected in their own right and not just for how they compare to Western systems. In this space of mutual respect, learning is shared and a completely different type of knowledge base is generated. In the first book of this series, Neale refers to this space as the third archive, a place where Indigenous knowledge is

supported by Western systems and technologies. She gives the Ara Irititja archive project as an example:

Ara Irititja was set up to preserve cultural knowledge and record story, song and performance using various Western technologies. This epic intercultural and interdisciplinary research project integrated Indigenous and Western knowledge systems and pioneered a radically new approach to understanding and managing our shared cultural and natural environment.<sup>55</sup>

The Indigenous knowledges shared in public and academic spaces are based on traditional knowledge held and kept by knowledge holders. But the two are not the same. Due to the colonial origins of the Archive, maintaining the knowledge and knowledge systems stored within these records is crucial in keeping them accurate and appropriate. This is an achievable feat with modern technology's ability to nest information, allowing particular levels to become available only to the appropriate people at the appropriate time, mirroring the systems of Indigenous protocol in an electronic format. There is more on this in Chapter 5.

Other records capture Indigenous star knowledge, too. For example, Charles Mountford, a significant amateur anthropologist during the 20th century, released secret knowledge that had been entrusted to him in a book called *Nomads of the Australian Desert*. In 1976, the Pitjantjatjara Council took him to court over the sacred business contained within the book. The judge ruled in favour of the Pitjantjatjara people and the book was banned from the Northern Territory (it is still accessible outside of the Northern Territory).<sup>56</sup> Despite this controversy, Mountford's records remain staples of the Archive used today by researchers investigating precolonial Indigenous life. For example, his reports that Indigenous people knew every star visible to the human eye was one of the first Western documentations of Indigenous astronomical accomplishment: 'It would appear from my limited research that many [Aboriginal people] of the desert are aware of every star in their firmament, down to at least fourth magnitude, and most, if not all, of these stars would have myths associated with them.'<sup>57</sup>

Wardaman law man, traditional owner and artist Bill Yidumduma Harney has similarly been recorded as knowing every visible star, in addition to understanding their individual motions across the sky. As captured by Norris in his review of Aboriginal astronomy, 'to name most of the ~3000 stars visible to the naked eye from Northern Australia is a memory feat that rivals winners of the World Memory Championships'.<sup>58</sup>

Both traditional and contemporary Indigenous knowledge systems are the result of evolving practices, encapsulating how people have negotiated ever-changing landscapes and environments through ice ages, food insecurity, drought and colonisation. Without adaptability, Aboriginal and Torres Strait Islander peoples could not claim to be the oldest continuous culture to exist today. The importance of adaptability for Indigenous peoples did not stop when colonisation came to these lands. Living in missions and reserves under

colonial regimes became essential for many Aboriginal and Torres Strait Islander peoples in the early 19th century. Food sources and land were near impossible to access without acclimatising to colonial life.<sup>59</sup> Adaptation was not a means to assimilate but to use whatever was necessary to secure self-determination and retain connection to Country.

Astronomical knowledge is embedded in oral traditions and practices that are held and maintained by appropriate knowledge holders. Additionally, as mentioned earlier, there are new fields emerging, such as the third archive, as discussed in Neale and Kelly's *Songlines*, or the cultural interface theorised by Nakata. These spaces allow oral traditions to be analysed and integrated by community members and academics, both Indigenous and non-Indigenous. It's worth noting that knowledge held by the community is not necessarily the same as that held in the academic corpus, and vice versa. They can be different secular versions of the sacred or closed knowledge. Publicly available knowledge on Indigenous cultures and peoples should be considered an extension or sample of what is held by the appropriate knowledge holders. This sampled knowledge is what allows two completely different systems to coexist respectfully. It is also a space where new knowledge can form, which is the function of the third archive. Interactions between the innovative technologies of the West and the holistic, adaptable, sustainably focused worldview held by Indigenous peoples offer a way forward through the chaotic times of climate and environmental change that we find ourselves in.

# PRACTICAL SKY KNOWLEDGE

Over millennia, Aboriginal and Torres Strait Islander peoples have become experts in documenting and analysing subtle variations in their environments. Observations of changes in the atmosphere, celestial objects, animal behaviour and other environmental conditions offer vital insight into the ever-evolving life on Country. Indigenous knowledge systems are the oldest and most continuous data sets known to human history, having successfully informed Aboriginal and Torres Strait Islander peoples about how to live with the land sustainably and auspiciously. As such, they contain some remarkable techniques to support reading and living on Country, including various complex techniques for weather-prediction, timekeeping, hunting, agriculture and land management, and navigation across vast distances.<sup>1</sup>

## MOON HALOS

Moon halos are a type of optical phenomenon, like rainbows or mirages in the desert. They occur when light reflected from the Moon passes through cold clouds and produces a ring, or halo, around the Moon ([Figure 3.4](#)). The following story, ‘The Moon and Its Halo’, was originally told by members of the Kurnu-speaking nation on the Darling River in New South Wales.

Two women were walking across the Culgoa River carrying Giwa, the Moon-Man, seated on a pole between them. When they reached midstream Giwa was either thrown off or fell off the pole, and he drowned. After a while he came to life again and went out into the mulga country near the Warrego River, which is known for its low rainfall. He gathered a lot of bark off leopardwood trees and carried it a long way to a place that is now known as the Multaguna Run, where he made a large camp for himself. He saw some people and invited them to come and watch his corroboree (dance ceremony). Giwa had his bark propped up with forked branches in a circle around the corroboree ground. He asked the people, men and women, to enter the ring of bark. One man decided to stay outside but Giwa told the other people to bring him inside. A woman who was sitting quite a distance away and had just

given birth was also made to enter the corroboree. He said, ‘Now, all of you must keep your eyes cast on the ground and don’t look at me for a little while.’ He then pulled down his leopardwood bark quickly, causing the structure to fall on top of the people, crushing and smothering them all. Giwa rose to the sky to escape any vengeance and was protected by a ring of bark surrounding him. His reflection can still be seen in the bark of leopardwood trees (Figure 3.1).<sup>2</sup>



FIGURE 3.1: Leopardwood tree (*Flindersia maculosa*) bark, said to contain the image of Giwa, the Moon-Man.

The halo or large ring sometimes seen around the Moon during a wet period represents the ring of leopardwood bark under which the people suffocated in this story. The scene of the catastrophe is now a small lake on Multaguna Station.

At face value, ‘The Moon and Its Halo’ appears to be a bit of a spooky story. And, well, it is. In many Aboriginal and Torres Strait Islander nations the Moon is a man and he is very powerful. Numerous Dreamings associated with the Moon-Man display his influence over the weather while teaching cultural lore. For example, a Euahlayi story from New South Wales tells of Bahloo the Moon-Man and Mooregoo, a weapons maker. Mooregoo was also a



possum-rug maker, but for some reason he would never give any of his creations away. Bahloo heard about this and decided to approach Mooregoo one night to see if he could have one of the rugs. He started by giving Mooregoo praise for his techniques and then asked if he could borrow one of his rugs. But, as per his reputation, Mooregoo declined. Bahloo then asked if he could have one to keep, not to borrow, and once again Mooregoo declined. Annoyed, Bahloo made one last attempt. He explained to Mooregoo that it was very cold and pleaded for a rug, but the answer was the same. Disappointed in Mooregoo, Bahloo went to the hills, where he cut some bark and made himself a *dardurr* (shelter). He stood outside, called to the sky and went back into his shelter. It rained for many days. It rained so much that Mooregoo drowned and all of his creations rotted and floated away.<sup>3</sup>

As with the Kurnu story of the Moon-Man, this story connects the appearance of moon halos – represented by the shelter – with stormy weather. In the Kurnu story, the halo is the ring of bark that protects the Moon-Man but is a danger to the people during storms or flash flooding. Similarly for the Euahlayi people, the halo around the Moon is the shelter in which the Moon-Man takes refuge during the storm. Another obvious lesson here is to be generous and willing to share, traits that are at the core of many Indigenous communities.

However eerie, these two stories subtly explore the First Peoples' profound understanding of the complex relationship between the weather and optical phenomena. And they do so in a dramatic, memorable way, ensuring that it will be passed on to future custodians.

'The Moon and Its Halo' and many other stories were recorded around New South Wales by surveyor Robert H Mathews in the late 19th century. Mathews spent his life engaging with Aboriginal people and communities, growing up alongside Aboriginal children and becoming a self-taught anthropologist in his later years. He published over 170 works about his time spent with Aboriginal nations across eastern Australia, despite having no academic training and receiving ridicule from the anthropological community of the time.<sup>4</sup> The lessons and stories recorded by curious people such as Mathews are integral to piecing together what life was like precolonisation for Aboriginal and Torres Strait Islander peoples.

Many Indigenous nations across the continent and the world believe that light halos appearing around the Moon indicate that rainy weather is approaching. This connection is particularly common and widespread in Australia, from the east to the north to the Western Desert, where stories allude to the halo protecting the Moon-Man from rain.<sup>5</sup> This knowledge is embedded in a story to help ensure that nations have access to food and water throughout all seasonal variations.

The many Indigenous nations were right in their observations: atmospheric halos, such as moon halos and sun dogs (an optical illusion of bright spots around the Sun), can indeed precede storms. A moon halo is generated by ice crystals suspended in wispy cirrus clouds. Cirrus clouds form when warm air, or a 'warm front', encounters a cold air mass. Because cold air is denser, the warm air rises above it, encouraging cloud formation and pushing the warmer air high into the atmosphere – where temperatures reach approximately -55°C. Any liquid water in the air freezes, forming the distinctive thin clouds that are then accelerated by high-velocity winds that push them ahead of the trailing body of cold air (Figure 3.2). When

light passes through these clouds, a halo phenomenon can occur due to the passage of light through the ice crystals. Similarly, if temperatures are low enough on the ground, hexagonal ice crystals can form closer to Earth's surface, producing a phenomenon known as diamond dust, where the air appears to sparkle.

As cirrus clouds and thus moon halos are symptoms of a trailing low-pressure system (storm clouds), the appearance of these phenomena is a great indicator for approaching stormy weather, as acknowledged by many Indigenous traditions.

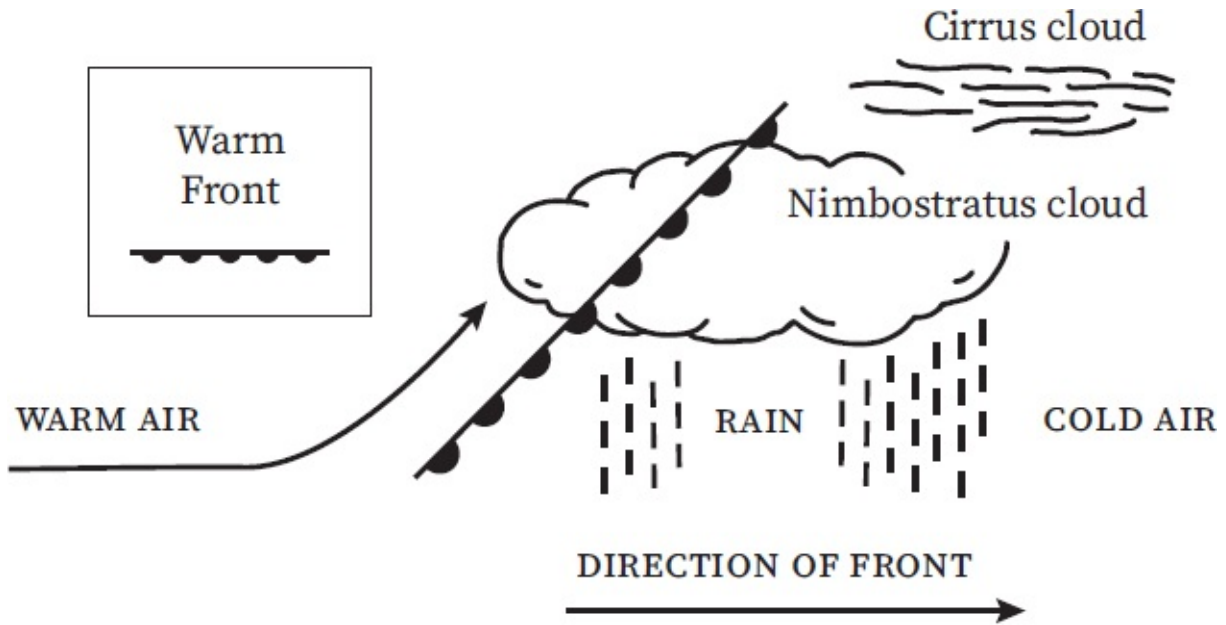


FIGURE 3.2: When warm air meets a cold air mass, the warm air is pushed upwards. As it rises, the moisture in the air condenses into clouds. At high altitudes, any remaining moisture freezes, creating the distinctive wispy cirrus clouds.

When light travels through the atmosphere and comes into contact with an ice crystal, it enters through one face of the crystal and is refracted, meaning the path of the light changes direction. Refraction occurs because the medium through which the light is travelling has changed, causing the light to lose velocity and thus change its direction. The effects that the light experiences due to the change in environment can be quantified by a measurement called the refractive index. As the light travels through the crystal, it is refracted again when it exits through the other side (Figure 3.3).<sup>6</sup> A great example of this is looking at an object through glass. Because the light is required to travel through the glass to reach your eyes, its path is distorted and therefore so is the image you see. The thicker the glass, the more the light is refracted, giving a more distorted image on the other side. For an atmospheric halo, the ice crystals are the glass and the halo is the distorted image produced by the light transiting through them.

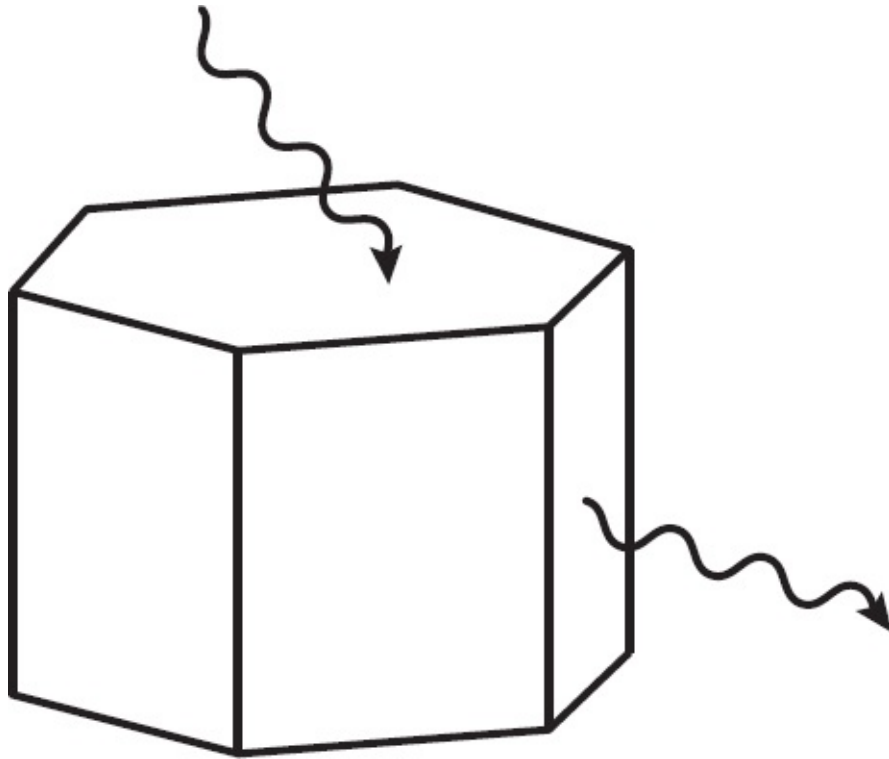


FIGURE 3.3: A simplified representation of light passing through the molecular structure of an ice crystal.

As the light from the Moon passes through one face of a crystal it is instantly bent. The molecular structure of all ice crystals is roughly the same, generally containing hexagonal plates and column faces where the angles between the faces and edges are identical (60 degrees). This means the path the light may take is limited, resulting in identical-looking halos with identical radii (the distance from the centre to the outer edge), with only a few variations.<sup>7</sup> Due to the similar geometry in the majority of crystals, the light is usually bent at exactly 22 degrees from its original path, producing what we call a 22-degree moon halo (Figure 3.4).<sup>8</sup> This 22-degree angle is known because of a law called the minimum deviation, which states that light has a minimum angle it can be refracted by. This minimum angle is determined by the refractive index of the new medium – and since the molecular structures of the ice crystals do not differ greatly, we mostly see 22-degree moon halos. So assuming at one point a patch of the sky is full of ice crystals and they are all rotating about their horizontal axis, falling through the sky at various orientations, the result is a bunch of halo points for each light path that has been refracted. Since the crystals are rotating and falling in random orientations, we get a point of light in every possible direction. This collectively results in a halo surrounding the source of light (the Sun or Moon).<sup>9</sup> Wider 46-degree halos are generated by larger ice crystals that rotate slightly differently from the ice crystals responsible for 22-degree halos.

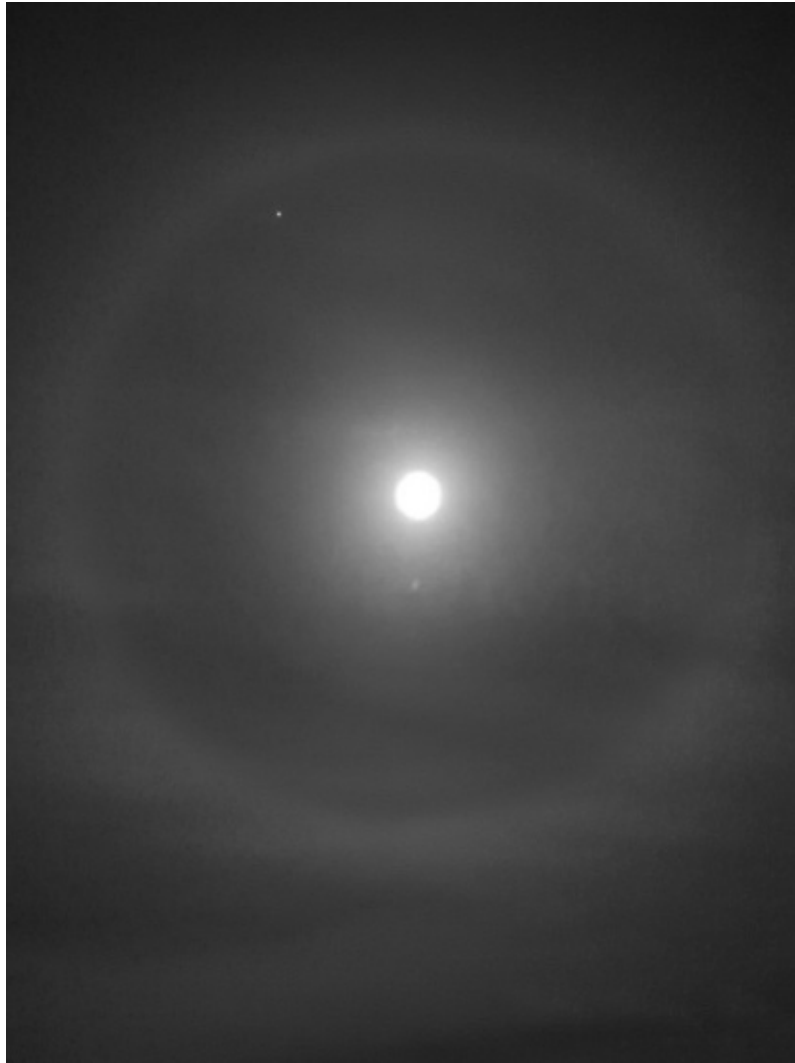


FIGURE 3.4: The faint band of light encircling the Moon shows a 22-degree moonhalo, caused by light refracting through ice crystals in Earth's atmosphere.

Sun dogs are another optical effect caused by light passing through ice crystals, and are an example of how the orientation and shape of the ice crystal can produce different visual effects. They occur when sunlight enters the hexagonal face of an ice crystal and the vertical axis is randomly orientated, as opposed to moon halos, which are generally generated from the horizontal axis being randomly orientated. Provided the ice crystals are positioned this way, two bright faux suns will be projected on either side of the real Sun at the same distance as the 22-degree halo. Furthermore, various types of ice halos can occur at the same time, such as sun dogs appearing on a 22-degree halo. These variations and others on the land and in the sky contribute to the many ways in which weather predictions can be made.

The variations in halos were well known by Indigenous nations, who understood that the halos indicated atmospheric conditions and so were important in making accurate weather predictions. The Aboriginal people of western New South Wales analyse the size of halos to determine the quantity of rain approaching: if a halo is large, large amounts of rain are assumed to be approaching, while a small halo suggests a small amount of rain is on its way. Larger ice crystals are able to form when there is sufficient water saturation in the

atmosphere, meaning there is more water contained in the cloud. This level of saturation is higher than that needed to form a smaller 22-degree halo, thus larger halos can indeed signify that large amounts of rain are imminent.

This is one example of how complex traditional Indigenous weather forecasting has an observational, scientific basis. Other methods of Indigenous weather forecasting include analysing the position of the Moon with reference to the halo (centre or off-centre) and how this can give information about any approaching winds.<sup>10</sup>

People on Badu Island in the Torres Strait consider the weather at the time a halo is observed to be a variable in predicting future patterns. In the painting *Kabuwai: Halo Around the Moon*, Torres Strait Islander artist Dennis Nona shares how a halo connects to the weather in the western Torres Strait. He explains that a moon halo on a windy night means that rain is imminent, whereas a halo on a calm night suggests rain won't occur for days. He also explained that the colour of the Moon at the time of a halo holds further insight – a bright Moon could suggest the weather might not change at all.<sup>11</sup>

Combining Indigenous ways of reading Country such as moon halos with the teachings of atmospheric physics and optics science, we are able to see the contextually significant and practical knowledge held by First People. This knowledge serves as a powerful tool for Indigenous peoples, is important for broadening and deepening the scientific understanding of academia, and is highly valuable and relevant for all who live on and with the land.

## STELLAR SCINTILLATION

Torres Strait Islanders' astronomical knowledge is intimately connected to plant cycles and seasonal change. Clear skies and hot days are seen when there are clear, colourful stars hanging above. When the stars begin to twinkle, it is known that the seasons are changing as winds start to arrive. This signals to Torres Strait Islander fishers that it will be a good day at sea, and to make the most of the conditions.

This knowledge is shared by Meriam elder Uncle Alo Tapim in a research paper co-authored by two other Torres Strait Islander elders, Uncle John Barsa and Uncle Segar Passi, and Dr Duane Hamacher.<sup>12</sup> These knowledge holders contributed significantly to the paper and actively participated in reviewing the work prior to publication. It stands as a solid example of communicating Indigenous knowledges with Indigenous voices, and stepping away from the 'about us, without us' approach to Indigenous knowledge sharing that has long been a feature of academia.

As coastal communities, Torres Strait Islander people are reliant on their ability to understand the open waters and anticipate the climate conditions they will face. Local astronomers, fishers and gardeners observe the stars to inform themselves of impending environmental change. Stars encode a wealth of information through the variations in their observable appearance. The information can be communicated by the nature of a star's scintillation, otherwise known as twinkling, and by any perceived changes in its colour. The

variations in the brightness of notably bright stars, such as Vega, of the constellation Lyra, signify the approach of the wet and dry seasons, and indicate native plant and animal cycles.

In polar and temperate regions of the world, seasons are commonly defined by the date of the summer and winter solstices and the autumnal and vernal (spring) equinoxes. Our planet completes one orbit of the Sun across the span of one year, while also completing one full rotation on its axis approximately every twenty-four hours. As noted in Chapter 2, Earth's axis is an imaginary vertical line through the planet around which it spins. However, it is not perfectly vertical: instead, it is tilted on an approximately 23.4-degree angle. The consequence of this tilt is that as Earth completes its orbit around the Sun, its surface is not uniformly illuminated. The North and South poles each experience twenty-four hours of sunlight when they are pointed towards the Sun at one extreme of the year, marking their respective summer solstices, and twenty-four hours of night-time exactly six months after that, marking their winter solstices ([Figure 3.5](#)).

In the Southern Hemisphere the summer solstice occurs on 22 December, which makes it the longest day of the year in Australia. The winter solstice, which is the shortest day of the year, occurs on 21 June. The equinoxes fall in between these two extremes, signifying the two days of the year that experience equal lengths of daytime and night-time. In Australia, the solstices and equinoxes don't mark the change of the four seasons specifically; instead we define the seasons' start by the first day of the months in which these four points occur. Considering the observational nature of the many Aboriginal and Torres Strait Islander knowledge systems and the long-studied connections between the sky and the land, the signposts for Indigenous seasonal change vastly differ; they are not set by convention but by meaningful environmental changes.

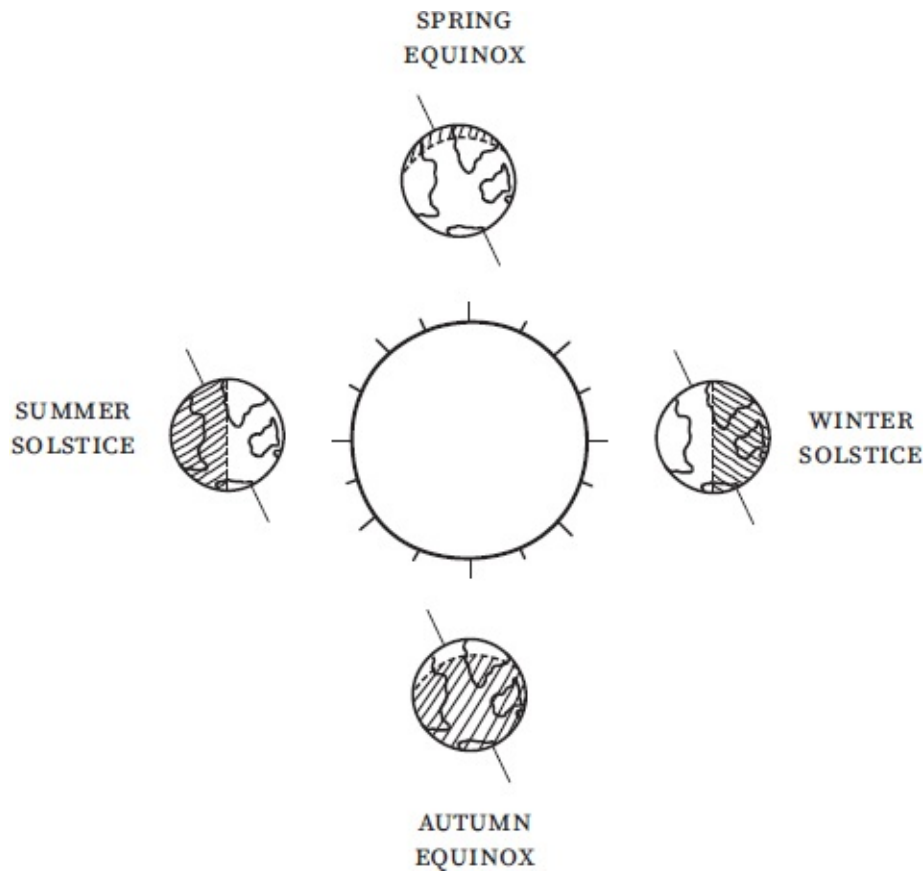


FIGURE 3.5: The position of Earth relative to the Sun at the extremes of each solstice and equinox, at a condensed scale for clarity. The diagonal line represents Earth's tilted axis.

As the islands of the Torres Strait are situated only approximately 10 degrees south of the equator, they experience less of a contrast in the amount of daylight received throughout the year compared with countries further from the equator. The significance of this is that the seasonal change relevant to the Torres Strait is defined by variance in trade winds and rainfall rather than the variance in day length that dictates the timing of Western seasons. At the equator, days are approximately twelve hours long throughout the year, with a greater variation the further from the equator one travels. This means that despite the tilt in Earth's axis that contributes to seasonal variation in much of mainland Australia, communities closer to the equator do not experience the stark extremes in day length that communities closer to the North and South poles experience.

The trade winds in the Southern Hemisphere are strong winds near the equator that typically blow east to south-east. In the Torres Strait, four seasons are defined by the trade winds and local rainfall. In the Meriam Mir language, the seasons are known as *Kuki*, *Sager*, *Nay Gay* and *Zey*.<sup>13</sup> *Kuki* is a period dominated by strong, moist north-westerly trade winds that replace the typical easterly winds and result in monsoons, which produce convective clouds and heavy rainfall. This is the wet season, and it occurs from January to April. From May to December, the Torres Strait is in *Sager*, the local dry season. This season sees the typical south-easterly winds blow and weather conditions are dry. From October to December *Nay Gay* is present, regarded as the hot and humid season as northerly trade winds return

along with high temperatures and humidity. Zey describes the sporadic periods through the year in which the southerly winds blow again.

Uncle Alo Tapim shares how Meriam fishers and gardeners observe the state of the stars in the sky and the plants in the earth to know when Kuki is coming. Following the dry, hot, cloudless conditions of Nay Gay, the stars begin to shine and twinkle intensely. Uncle says this is a good sign. Local fishers and gardeners continue to observe the stars, the plants and the path of the Sun and, although the Sun is hot during the day, they are aware that dew is now collecting at night. It seeps past the dry, brittle upper layer of the ground, creating cool, muddy earth below. The lower soil is kept soft. The wet season is near.

The late Meriam elder Uncle John Barsa further explains the role of stellar scintillation and colour variation in informing people of coming storms and weather. Blue and white twinkling stars that rapidly change colour to red and orange signify the presence of wind and temperature variations. Blue and white stars that do not change colour indicate the fine weather and hot temperatures of the Nay Gay season. Blue and white rapidly twinkling stars signify the approach of storms around the monsoon season.

The most significant descriptors of the last two examples are the blue hue of the stars and the noticeably rapid twinkling. Blue stars are associated with impending rain by Torres Strait Islander elders, and rapid twinkling is caused by the presence of strong north-westerly trade winds that trigger monsoon events. When the twinkling stars appear crisp and clear, this indicates that the skies are dry. When there is high humidity in the atmosphere, the stars may appear blurred, which is a warning of incoming storms and a consequence of ice crystals in the atmosphere that obscure the starlight as it passes through.<sup>14</sup>

Forecasting seasonal change with the observable properties of stars is a skill that also features in the astronomical traditions of mainland communities. For example, the nations of the Gariwerd region in Victoria have six main seasons, known as *Kooyang* (eel season), *Gwangal Moronn* (honey bee season), *Chunnup* (cockatoo season), *Larneuk* (nesting bird season), *Petyan* (wildflower season) and *Ballambar* (butterfly season).<sup>15</sup> These seasons are also calendared by stellar variations and relay knowledge relating to climatic change, animal behaviour patterns and plant life cycles. For instance, *Kooyang* is the hottest season, indicated when the sky is most bright with stars and water on the land is scarce. It brings the hatching stage of the breeding cycle for many insects, including the labyrinth butterfly and gum emperor moths.

## TIMEKEEPING

Timekeeping is commonly anchored within oral traditions relating to Sky Country. Throughout the Indigenous nations, this has been done by reading Country. By tracking particular stars and constellations, especially at sunrise and sunset, and embedding these observations into story, seasonal, annual and ceremonial time can be accurately kept. Material items and expressions such as rock art,<sup>16</sup> stone arrangements and message sticks<sup>17</sup>



are believed to assist Indigenous peoples in the marking of time on multiple scales. Rock art is found all over Australia and has been practised by Indigenous peoples across the continent and its waters for millennia – according to a 2017 article, some artefacts found in a sandstone rock shelter on Mirarr Country in the Northern Territory might even suggest some 65,000 years.<sup>18</sup> Among many things, it is a way to measure the flow of time. Notably, for those responsible for maintaining it, it is a way to connect to the Dreaming and to the ancestors. Further, rock art could be used to store practical, useful information. The Wardaman peoples of the Northern Territory use rock art containing concentric circles to measure the seasons experienced throughout the year, using the Sun as a metaphor to do so.<sup>19</sup>

Another great example of keeping track of seasonal time is in the Gomeri story of Gawarrgay, the Celestial Emu Dreaming. Similarly, the story of the Seven Sisters, Miyay-Miyay (Gamilaraay), is a common tool for keeping track of annual and seasonal time. Both of these Dreamings are explored in Chapter 2. As recorded by anthropologist Dianne Johnson in her 1998 book *Night Skies of Aboriginal Australia: A Noctuary*, the Miyay-Miyay can be heard in winter, when thunder comes from the mountains as they bathe and play.<sup>20</sup> A related story described by astronomer Raymond Haynes also speaks of the seven sisters with long hair and bodies of ice:

Before leaving Earth they travelled into the mountains causing springs to feed rivers so there would be water forever. A young hunter, Karambal, fell in love with one sister and carried her off. Other sisters sent cold, wintry weather to force him to release her, but later relented and made their way into the sky in search of the summer sun to melt snow and ice. Thus the Pleiades appear in the summer each year, bringing warm weather. Afterwards they travel west and winter returns as a reminder that it is wrong to carry off women who belong to a totem forbidden them.<sup>21</sup>

In this rendition of the Seven Sisters, the seasons can easily be discerned based on the position of the sisters in the night sky. In South Australia, the Adnyamathanha people say the Pleiades sisters possess pouches filled with ice crystals that they release into the sky as they travel across it, producing frost.<sup>22</sup>

Another example of Indigenous timekeeping comes from the Yaraldi people of South Australia. In order to keep track during the day, they have seven distinct times as measured by the Sun: before sunrise, sunrise, after sunrise, middle of the day, afternoon, sunset and night.<sup>23</sup>

As evidenced by these techniques, First Peoples had multiple ways of keeping track of important seasonal and resource times throughout the day, seasons and year, many of which were learnt, or tracked, through knowledge of Sky Country.

## **MOON PHASES, CUSPS AND TIDES**

The Moon is the brightest celestial body in the night sky, its appearance constantly changing across its 29.5-day lunar cycle. These cycles are marked by the eight core phases of the lunar face, all of which are acknowledged and described in the astronomical traditions of many Aboriginal and Torres Strait Islander communities.

The two extremes in the lunar cycle are the full moon, when the face of the Moon that is directed towards Earth is entirely illuminated by the Sun, and the new moon, when the far side of the Moon is illuminated but the side facing Earth remains in the dark (Figure 3.6). In between these two phases lie three stages of partial illumination, known as crescent, quarter and gibbous. This property of the Moon allows an observer to know the direction that the Sun is in, even during the dark of night.

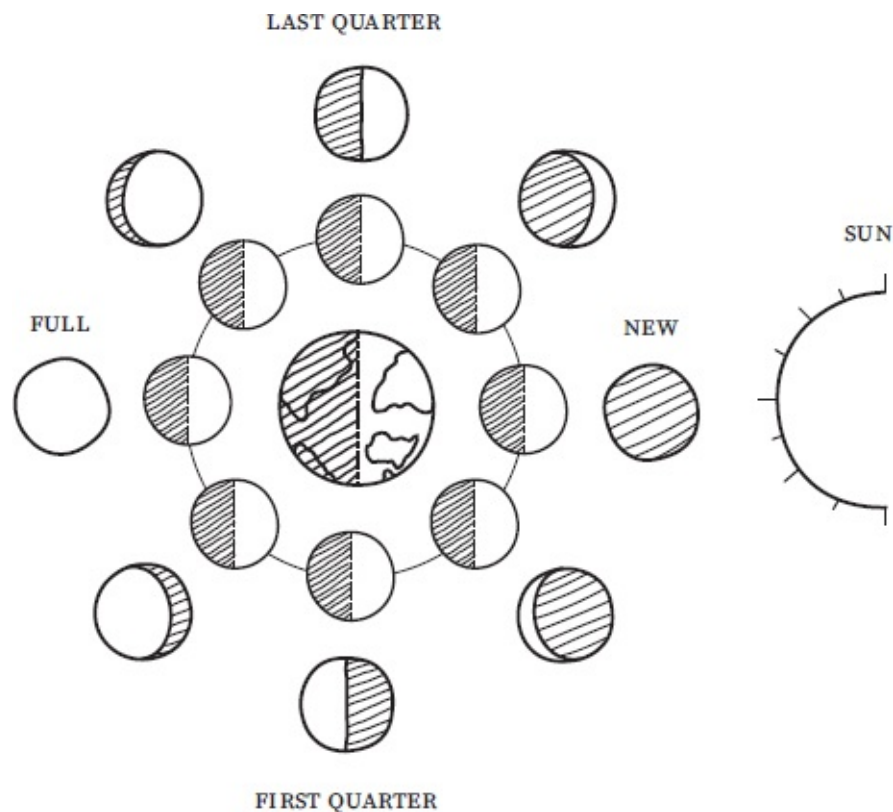


FIGURE 3.6: The position of the Moon relative to the Earth and the Sun throughout the lunar cycle (inner ring), and the corresponding lunar phases as observed from Earth (outer ring), at a condensed scale for clarity.

In Yolŋu traditions, the full moon is described as a fat, lazy man called Ngalindi. His laziness and gluttony are punished by his wives, who chop off bits of his body with an axe. This is said to describe the waning moon, as he is rendered into a fraction of his original self from his grand figure of the full moon. Ngalindi manages to escape the wives' attack by climbing a tall tree to follow the Sun, but is unfortunately mortally wounded. After remaining dead for three long days as the new moon, he rises again. Unfortunately for Ngalindi, he finds himself trapped in a vicious circle where he falls back into the same routine and fattens up as the waxing moon. He is once again attacked by his wives, and is doomed to repeat the cycle for eternity. This story reminds listeners of the values and taboos encoded in it, such as

greed, while highlighting the cyclic nature of the lunar phases.<sup>24</sup>

The phases of the Moon have several other applications that Aboriginal and Torres Strait Islander astronomers use to forecast weather events and seasonal change. The crescent shape phase, arguably the most common depiction of the Moon in popular culture, offers a good example of this. A lunar crescent occurs twice in the overall lunar cycle and is the phase when the Moon appears at its slimmest. When this occurs immediately after the new moon it is known as the waxing crescent, and when it occurs before the next new moon it is the waning crescent. It has two characteristically pointy ends that are known as the lunar cusps. Krystal De Napoli is working on a project at the University of Melbourne with Dr Duane Hamacher involving research with Aboriginal and Torres Strait Islander elders about the angle of the moon cusps and its links to seasonal rainfall.<sup>25</sup> In a recent article, Hamacher and Karlie Noon shared Meriam elder Uncle Segar Passi's teachings regarding the great significance of the cusps for Torres Strait Islander astronomers.<sup>26</sup>

Uncle Segar Passi describes how the orientation, or tilt, of the cusps is used to signpost the seasonal arrival of the wet and dry seasons for the Meriam people. The tilt is measured relative to the horizon. When the Moon – known in the Meriam Mir language as *meb* – is setting westward, it may be orientated and travelling such that its cusps are directed at an angle away from its line of travel. Alternatively, the cusps may be pointing directly up and away from the horizon, appearing as a bowl settling down onto Earth (see [Figure 3.7](#)). The variation in the orientation of the tilt is determined by the time of year and the latitude of the observer and is a consequence of the cumulative orbits of the Moon around Earth, and of Earth around the Sun across the year.

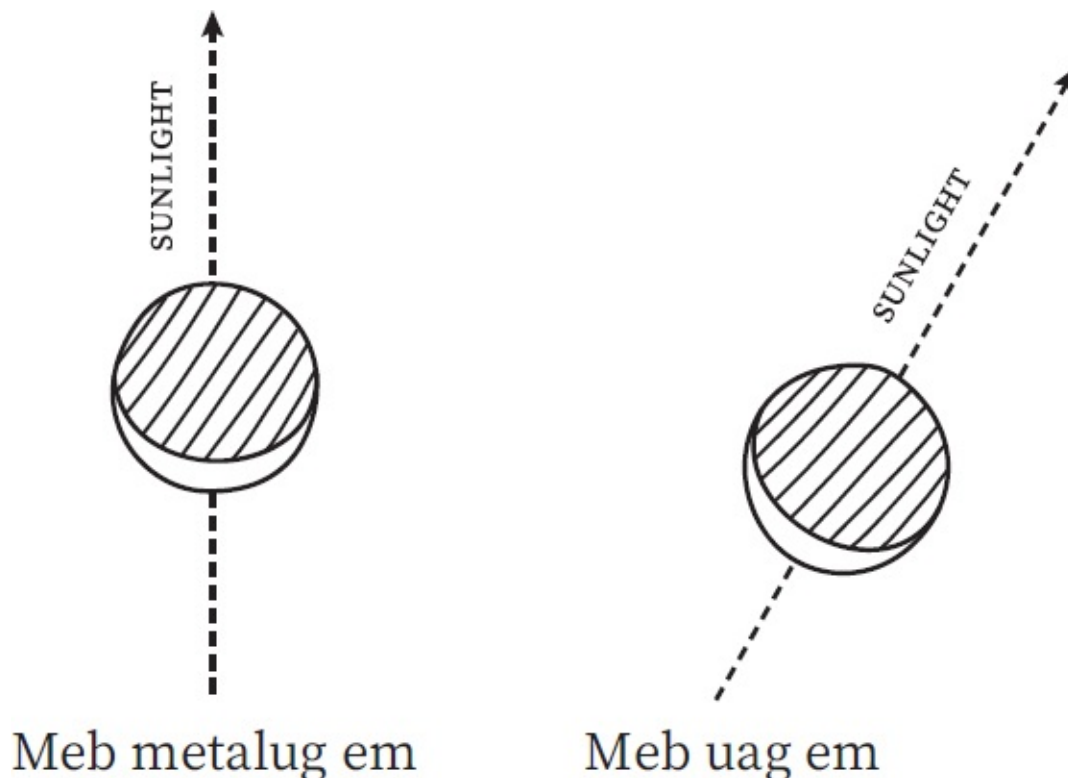


FIGURE 3.7: The observable angular tilt of the lunar cusps of a crescent moon, as described by

## Uncle Segar Passi.

Uncle Passi says that when the cusps are pointing straight up, known in Meriam Mir as *meb metalug em*, the dry season is upon them and they should expect ‘very fine weather’. Further, *meb metalug em* acts as a bowl that collects water, keeping its surroundings dry, meaning that the fine weather is often accompanied by choppy waters and cumulus clouds (fluffy clouds with flat bottoms). When the cusps are tilted at an angle relative to the horizon, the bowl is no longer sitting neatly atop the horizon and the water it once contained is now spilling onto the earth. Uncle describes how this orientation of the tilt, known as *meb uag em*, is forecasting the falling rains of Kuki (the wet season), which is characterised by strong trade winds and monsoons.

The cycle of lunar phases holds further uses for knowledge holders of the Torres Strait. Fishers forecast the suitability of different types of prey, depending on the phase of the Moon. Often, favourable fishing conditions are associated with the arrival of the quarter moon, which is said to be at a time when the ocean’s tides are low in amplitude and not churning. Churned water dredges up soil and sand that cloud the waters, giving them an opaque appearance that is not ideal for observing the potential catch.<sup>27</sup> Instead, during first and third quarter moons calmer tides, known as neap tides, are common. They occur at quarter moons due to the cumulative gravitational impact of the Sun and Moon on Earth. At this point in the cycle, the Sun and the Moon are positioned at a 90-degree angle, with Earth at the hinge (Figure 3.8).

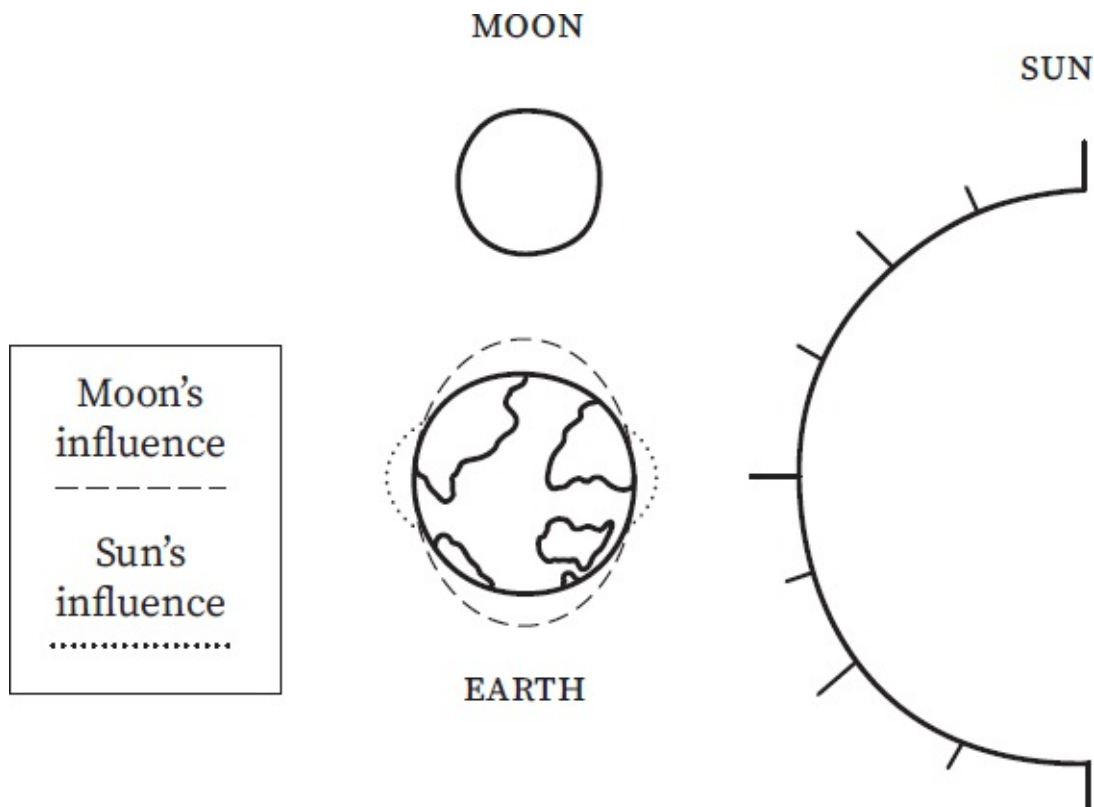


FIGURE 3.8: The cumulative gravitational influence of the Sun and the Moon on Earth during

a quarter moon phase, which results in neap tides. Scale exaggerated for clarity.

The new moon phase occurs at the stage of the Moon's orbit when it is lying between Earth and the Sun (Figure 3.9). The side facing away from Earth is illuminated, and the side directed towards Earth receives no light. If we simplify the Moon's orbit around Earth to a perfect circle where it navigates a full 360-degree orbit around our planet through its cycle, then we can designate the new moon phase as being the start of the cycle. This is when the Sun and Moon are both on the same side of Earth and sitting at an angle of 0 degrees relative to one another, as they are both in the same direction away from an observer on Earth. During this stage, Earth experiences the gravitational pull of both the Sun and the Moon from the same angle. At this time, high tides are at their highest and low tides are at their lowest.

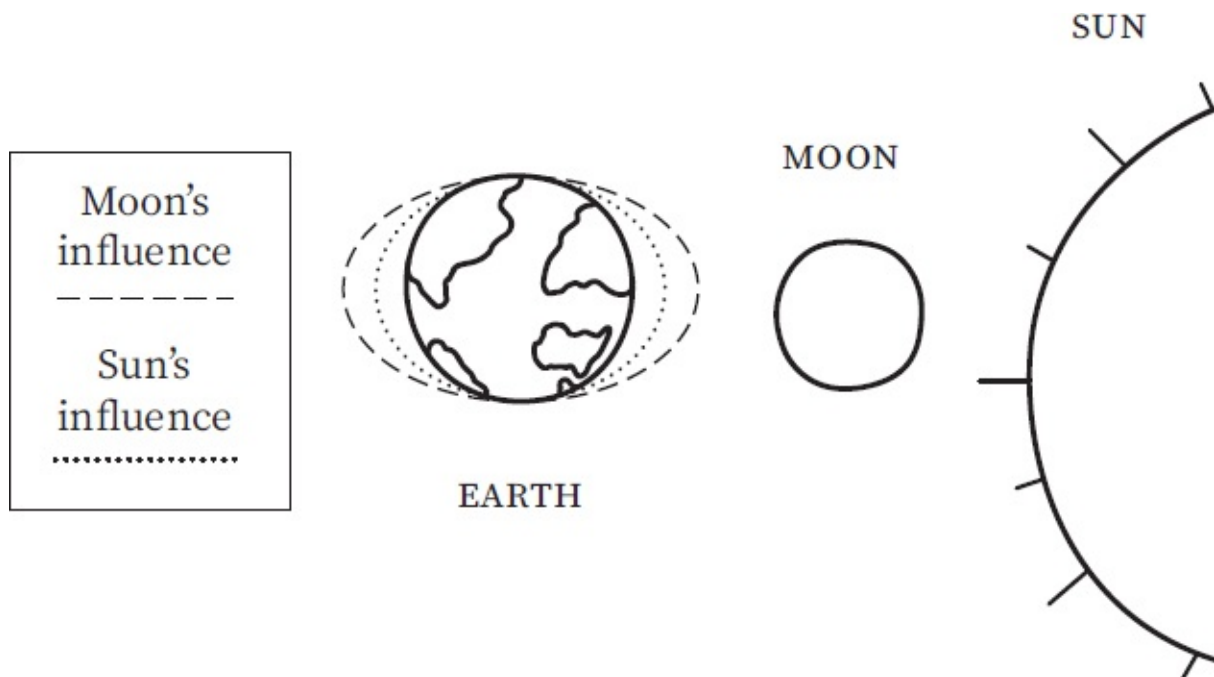


FIGURE 3.9: The cumulative gravitational influence of the Sun and the Moon on Earth during a new moon phase, resulting in high and low tides. Scale exaggerated for clarity.

Alternatively, when the Moon is in its full moon phase, it is sitting on the far side of Earth away from the Sun, catching all of the sunlight directed its way. Revisiting our 360-degree conceptualisation of the Moon's orbit, this is when the Moon is halfway through its orbit and is making a 180-degree angle with the Sun. Instead of the Sun adding to the tidal influence of the Moon, as in the case of the new moon, it instead cancels out some of its tidal influence.

There is a balancing act among the factors that lead to good fishing conditions. Although neap tides lead to clearer waters, Torres Strait fishers may prefer the full moon when hunting crayfish and turtles as its high luminosity illuminates the waters, leading to better observation of these animals.

Yolŋu traditions also describe the relationship between the lunar phases and the tides. When the tides are high, the Moon-Man, Ngalindi, fills with water as he rises at dusk, describing the full moon and its effects on tides. As the Moon loses its fullness, turning back

into a crescent, Ngalindi is said to be emptying of water and the tides drop. He will then fill again at the new moon, when it rises at dawn.<sup>28</sup>

## STAR MAPS AND NAVIGATION

Considering the depth and value of Indigenous sky knowledge, it is no surprise that Aboriginal and Torres Strait Islander communities have developed tools for safely navigating across our vast lands. Reasons for travelling across and outside Country include harvesting seasonal foods and resources, accessing different parts of Country, such as grindstones for baking, cooking and ceremonies, and trade. Trade was a significant feature in pre-contact Indigenous Australia and was a common reason for leaving Country, with tracks covering the entire continent (Figure 3.10) and beyond. This meant that travellers were required to observe and practise appropriate protocols when visiting other people's land. Message sticks and Songlines helped to communicate these protocols. Notably, Aboriginal peoples also have a significant trade history with the Macassan people of southern Sulawesi, Indonesia. The Macassan people would travel to the Kimberley in Western Australia and Arnhem Land in the Northern Territory every December to trade sea cucumber, signifying precolonial bilateral marine cooperation and management.<sup>29</sup>



FIGURE 3.10: A map of mainland Australia showing pre-contact trading routes, adapted from a hand-drawn illustration (McCarthy 1939).

As for inland Australia, goods such as sandstone, ochre, *pituri* (a smokable narcotic), tools, body adornments and food were all traded and shared with other communities.<sup>30</sup> One of the most extravagant examples of the trade networks is that of the Channel Country, at the borders of what are now Queensland, South Australia and New South Wales. The Mithaka people of the region have worked with researchers to uncover not only trade networks but villages, discovering evidence of *gunyah* (houses), food storage systems and large quarries where ochre, stone and quartz crystals were mined.<sup>31</sup> The Dieri people of the same region travelled to places 800 kilometres away for a specific colour of ochre.<sup>32</sup> Clearly, travelling such vast distances, particularly through such arid country, requires sophisticated navigational methods to ensure survival.

Aboriginal and Torres Strait Islander peoples have developed many different ways to navigate. Some travel strictly by day or night, across land or sea, depending on their Country and destination. In the desert, people often navigate by land features, which serve as mnemonics along the Songlines. Though many, if not most, use the Songlines to travel across their own Country, skies are needed to travel outside of their Country. For the Wardaman people of the Northern Territory, travelling by night is preferred in order to take advantage of the cool air and stars, which can be used as guides.<sup>33</sup> For those who travel across water, a Dreaming or Songline relating to a canoe constellation is common. In the Torres Strait, there is an impressively large and significant constellation known as Tagai, a Creator Being. Tagai's body is the constellation Scorpius, with the Southern Cross as his left hand and the Corvus constellation his right. The Tagai constellation aids in navigation in a variety of ways, such as the use of directional stars: Tagai's left hand points south, for example.<sup>34</sup> As explained on the website of Tagai State College, which is named after the Creator Being,

Tagai is also described by Elders as the 'heavenly clock'. Tagai directs the seasonal changes and his visibility in the night sky throughout the year tells Aboriginal and Torres Strait Islander people in the region how to adapt to the wind and tidal movements, and the best times to hunt, fish, plant and harvest. The Southern Cross is easily recognisable in the star formation that represents Tagai's left hand that is holding his spear. In his right hand, Tagai is holding the branch of the red-skinned fruit known as 'sorbi'.<sup>35</sup>

As told in Chapter 2, Yolŋu traditions describe Venus as the morning star, a female spirit who guides other spirits to their destinations. This is a Songline that incorporates Venus's journey across the Top End. It details many of the land's features, such as waterholes, on the terrestrial part of her journey. As such, the Venus or Barnumbirr Songline acts as an oral map for some Yolŋu clans. However, it is more than a cartographic map: it is also a cultural map laid down by the ancestors incorporating knowledge and lessons about the spiritual and the

ecological, as well as the rules and protocols of not only surviving but living properly. Each site links together to create the Songline and focuses on different lessons.<sup>36</sup>

Star maps were another technique developed by nations to aid travel. The Kamilaroi and Euahlayi nations used ‘patterns of stars to represent routes of travel on land’.<sup>37</sup> For example, each star in a constellation refers to a specific landmark on the ground, while the pattern as a whole indicates direction. The landmarks may be features such as waterholes, or indicators of where direction may need to be adjusted. As shared by Uncle Ghillar in a paper by Robert Fuller and colleagues, one star map describes a 600-kilometre journey from Goodooga, New South Wales, to Carnarvon Gorge, Queensland. Goodooga is represented by Gamma Sagittarii ( $\gamma$  Sagittarii), and the route goes via Dirranbandi (Sigma [ $\sigma$ ] Librae), St George (Girtab), Surat (Sargas) and Roma (Eta [ $\eta$ ] Scorpii) until it reaches Carnarvon Gorge (Zeta [ $\zeta$ ] Scorpii) (Figure 3.11).<sup>38</sup>

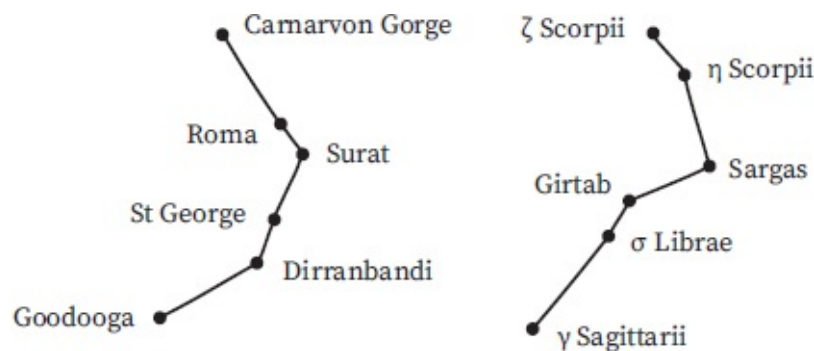


FIGURE 3.11: Rather than providing to-scale maps of the land, star maps relate to significant waypoints on journeys and often mirror preferred routes. This Euahlayi star map portrays a journey travelling northward from Goodooga to Carnarvon Gorge.

These stars do not serve as a to-scale map of the land, but reflect the easiest routes to traverse as they relate to specific land-based waypoints. The star maps are a valuable reference when teaching new learners about important routes of travel between communities. Their shape can be kept in mind whether one is travelling by day or by night. Being the easiest and most trusted ways of travel, the star maps set the foundation for what are now some of New South Wales’ and Queensland’s major road highways. The Goodooga star map described by Uncle Ghillar can be overlaid across the Carnarvon Highway, which connects Goodooga to Carnarvon Gorge; the traditional waypoints have become key towns and cities such as Dirranbandi and St George.



## DARK SKIES

Imagine that you are lying under unpolluted rural skies for the first time in your life. You have been blessed with ideal observation conditions: the skies are clear of clouds and the area is not affected by light pollution. There is no artificial glow in the sky drowning out the delicate celestial features above you, and the stars that you see are sharp.

Allow yourself the time to look up, take a breath and let your eyes adjust to the darkness encompassing you. Waiting is a crucial step in this observation routine. Our eyes detect light using two light-sensing cells, or photoreceptors, known as cones and rods.<sup>1</sup> Cones operate best in very bright conditions and allow the human eye to detect colours; rods are far more sensitive to light and operate best after we spend at least ten minutes adapting to the dark – although it takes approximately twenty minutes for our eyes to become fully ‘dark adapted’.

The brightest stars are apparent to you immediately – perhaps you recognise the familiar outline of the Southern Cross or catch a glimpse of the transit of a bright planet. Each minute you wait, the more your eyes adjust. Slowly, new stars become visible. Over time, it seems that in every previously dark spot you focus your eyes on, a new star is waiting to be found. The darker the conditions, the greater the quality of your observations. In the right setting, you will find that you are no longer looking only at the clusters of bright spots spattered across the sky, but are beginning to notice the rare regions where there is no light. In one section of the night sky in particular, you may notice that there are pools of no light, framed and illuminated by translucent space clouds that appear to tear the sky in two. You have found the Milky Way, known as the Sky River by many Aboriginal and Torres Strait Islander peoples.

For the Gamilaraay and Euahlayi people, the Sky River is called Warambul, and the dark patches represent flowing water while the surrounding stars are small fires and camps.<sup>2</sup> In a completely different area of Australia, the Yolŋu people believe that when they pass from this world they are taken to Baralku, the spirit-island in the sky where camp fires burn around the great river.<sup>3</sup>

Dark skies and the features within them play a significant role in many Indigenous knowledge systems. For an oral culture with a deeply and intrinsically interconnected knowledge structure, the skies are the melting pot and reference point for much of this

information. They are the stage upon which stories unfold. They inform us about the land below and guide us on where we are going, what we need, and who we are, were and will be.

For 65,000+ years, the history of this land has been mapped to features and events in the sky and carried through the generations by the power of language, song and dance. In the time preceding colonisation, there was no need to travel great distances to find a remote area that allowed the experience of the full, unimpeded beauty of the night sky – it was available wherever you found yourself. On a moonless night under pristine dark skies, the human eye may be able to detect anywhere from 2000 to 5000 stars unaided. In stark contrast, due to higher incidences of light pollution caused by unbalanced urban lighting, our modern metropolitan city skies offer visibility of a mere 100 or so stars.

It is not hard to understand that if even the brightest of stars are at risk due to the artificial lightening of our night sky, then fainter features like the Milky Way are entirely vulnerable. The Milky Way is already barely visible in the majority of metropolitan and suburban areas, and even in our rural towns. Other celestial features vulnerable to increased light pollution are the Magellanic clouds, a pair of faint dwarf galaxies that orbit the Milky Way. They are native to Southern Hemisphere skies, appearing as pale smudges of light that never set below the horizon to observers at latitudes of approximately 28 degrees south or more.

If you find yourself in blissful dark-sky conditions and straighten your arm upward, you can cover the larger of the two Magellanic clouds with a closed fist. The width of a human fist approximates a distance of 10 degrees across the sky – this knowledge is a useful tool for Aboriginal and Torres Strait Islander astronomers in measuring celestial distances. To communities in Yirrkala, Arnhem Land, the Magellanic clouds represent two sisters. The older sister resides in the Large Magellanic Cloud (LMC), and the younger sister within the Small Magellanic Cloud (SMC). Yirrkala lies 12 degrees south of the equator and observers there witness the older sister falling below the horizon in the midst of the dry season, leaving her younger sister to fend for herself alone in the sky. When the wet season approaches, the sisters reunite above the horizon, signposting the significant seasonal change the community can expect to experience.<sup>4</sup>

## **DARK SKY CONSTELLATIONS**

These vulnerable faint areas of the night sky are known by cultural astronomers as dark sky constellations. They are highly valued by Indigenous communities and are a unique way of viewing the sky, quite different to European constellations, which are constructed from groupings of stars. For Indigenous astronomers around the world whose astronomical practices have propagated for millennia prior to the introduction of artificial lighting to the natural environment, dark sky constellations remain a core part of their astronomical traditions.

Dark sky constellations are located in the pools of darkness that form when light from the Milky Way is obscured by gas and dust. As light from distant stars comes in contact with

these obstructions, the starlight is absorbed, preventing it from reaching our eyes here on Earth. These dark pools form in several areas of the sky, all well known and understood by Indigenous peoples. Each has its own meaning and purpose to different clan groups across our continent and around the world. However, the features are subtle, requiring not only the darkest skies but also astute observers. As such, they are quickly becoming extinct from view in locations affected by light pollution.

The International Astronomical Union (IAU) – a collective of approximately 12,000 astronomers from ninety countries that promotes and advances astronomy – formally recognises eighty-eight constellations that are familiar shapes made from stars, none of which are dark constellations. However, in areas not yet consumed by light pollution, these dark spaces are still observed and known.

It is within the depths of this darkness that familiar animalistic forms reside. Euahlayi and Kamilaroi astronomers observe Bandarr the kangaroo snuggling up underneath the Gawarrgay Dark Emu (see [Figure 2.1](#) in Chapter 2) on the banks of Warambul. They are not alone, as the two find themselves in the company of celestial crocodiles whose heads form from the belly of Gawarrgay between September and October. The crocodiles are said to have eaten the wives of Baayina, the creator being, at Coorigal Springs in Lightning Ridge, New South Wales. Baayina freed his wives by killing the crocodiles in a great battle, which in turn created the Narran and Coocoran lakes. Baayina demanded that the crocodiles stay on Earth to protect women's sacred ground and they were forbidden from going to Bulimah, Sky Camp. They can be seen in the waters of the Milky Way, going towards Bulimah but never making it. The story is one of death and resurrection and signals to the Kamilaroi and Euahlayi peoples that it is time to conduct initiation ceremonies.<sup>5</sup> Interestingly, crocodiles have been extinct in this region for over 40,000 years.<sup>6</sup> Sadly, access to these ancient depictions in our night skies is also now under threat, as discussed later in this chapter.

The animalistic features in the skies have different interpretations depending on which community has developed the knowledge. As these constellations often visually mimic the physical form of their earthly counterparts, similar interpretations of them are shared globally by other Indigenous astronomers. In central Brazil, Tupi astronomers see a very similar bird-shaped dark sky constellation in the Milky Way that overlays our Dark Emu. The shape represents their native bird, the rhea. Coincidentally, the rhea is not only also a large flightless bird, it shares a similar breeding cycle to the emu. Like Gawarrgay, the celestial rhea's head is also made up by the pool of darkness that is the Coalsack Nebula, with the stars of the Southern Cross described as holding the head of this enormous celestial beast in place lest it break free and guzzle up all of the world's water.

These features assist in understanding the behaviour of animals on the ground, learning about seasonal and environmental changes and long-distance navigation, and can also serve as a calendar for ceremonial events. As illustrated in chapters 2 and 3, the stars are crucial reference points for knowledge systems relating to astronomy, ecology, medicine, design, history and all things in between. As such, the skies can be thought of as being equivalent to a library for oral cultures, where each star is a book you can call upon to unlock the traditions

and knowledge associated with it.

## LIGHT POLLUTION AND ITS IMPACTS

Access to this knowledge is becoming increasingly compromised due to the growing impact of light pollution. Light pollution is insidious in that it has become so normalised in modern-day society that it largely goes unnoticed. We have become desensitised to the presence of light around us in unnatural settings. In metropolitan areas, it is accepted that the skies are often illuminated by an artificial glow instead of stars. Western society has become so used to the presence of light that the idea of darkness can provoke fear in many people. In contrast, Aboriginal and Torres Strait Islander peoples have been sleeping under the night sky, enjoying, memorising and living in harmony with its features and cycles since time immemorial. Traditionally, darkness was not feared by Indigenous communities, but valued as offering access to the night sky.

Some of this over-lighting has been driven by legitimate concerns for women's safety in public areas, with the belief that an environment with more lighting is a safer one. Recent research carried out by design company Arup with XYX Lab of Monash University suggests that it is not as simple as increasing the amount of light and that, in fact, overly lit areas feel more unsafe for women as they often lead into low-lit areas, leaving women incapacitated while their eyes adjust. Further, the colour of lighting is also an important factor, with findings suggesting it is important for lights to be as close as possible in character to daylight, so that objects can easily be distinguished.<sup>7</sup> Our streets are lined with lights to guide us home, but often they aren't just illuminating the footpath: instead, they unnecessarily extend their reach to the tops of nearby buildings and trees, which don't require their focus, while over-illuminating our eyes and leaving some people even more vulnerable.

The cause of light pollution is multifaceted, but it can be broken down into five main categories: over-illumination, glare, light clutter, light trespass and skyglow.<sup>8</sup> Often, multiple types of light pollution combine, resulting in bright night skies and little to no visibility of light outside of our atmosphere. These forms of light pollution are all largely avoidable, but they require multidisciplinary action for any progress to be made in restoring a healthy balance to our environment.

Over-illumination, the first form of light pollution, is the misuse of lights in the form of wasteful illumination. As described in our streetlight scenario, this form of pollution occurs when attempts to illuminate finite areas of land for a specific purpose lead to the unnecessary illumination of other landmarks. It also appears in cases of daylight lighting where streetlights remain on during daylight conditions and retail stores adopt superfluous lighting to attract customers.

Glare is the result of unshielded light spilling into the sky and scattering off nearby surfaces with a direct impact on the comfort of human beings occupying that environment. Astronomer Bob Mizon, co-coordinator of the British Astronomical Association's Campaign

for Dark Skies, separates glare into three further categories on an ascending scale of severity based on its impact on humans as a public-health hazard: discomfort glare, disability glare and blinding glare.<sup>9</sup> Discomfort glare is the least severe in the short term, but depending on placement can lead to impaired quality of sleep, and fatigue. Disability glare is where sight capabilities begin to be significantly impaired; it occurs when a pedestrian or driver is blinded by oncoming car headlights or by light that has unnecessarily scattered away from its intended target. Blinding glare is an incredibly dangerous level of light pollution that leaves the viewer with temporary or permanent vision impairment.

Light clutter is the excessive lighting of a given space beyond what is required – for example, an overly large cluster of streetlights in a small area. This form of light pollution often arises from businesses that utilise vibrant light displays to attract potential consumers. Unfortunately, it easily leads to the confusion and distraction of passers-by.

Light trespass, the fourth form of light pollution, is similar to most forms of trespassing in that it is the spillage of light onto a person's private property. It can come in the form of streetlights, a neighbour's outdoor lighting, or the headlights of passing cars.

Finally, there is skyglow, which can be described as the culmination of all the foregoing lighting missteps. Skyglow is the blanket of light that hangs above most city-dwellers at nighttime, resulting in a perpetual state of twilight. It is the result of undirected and uncontrolled artificial light that extends upwards and is reflected back down to us by our atmosphere. It is the reason that those living in metropolitan areas are restricted to seeing a mere 100 or so stars instead of the thousands they could have access to. An international study on 'artificial night sky brightness' led by Fabio Falchi in 2016 found that 80 per cent of the world's population now lives under skyglow.<sup>10</sup>

The loss of celestial features has happened so quietly that those who do not leave their city dwellings cannot recall what they are missing out on. Thankfully, the over-illumination of our skies and dulling of our dark nights are not inevitabilities that we must accept. By lighting our environment intelligently, consciously and minimally, we can reverse the impacts of this form of pollution far more easily than any other on Earth.

Concerns about dark skies extend not just to the loss of visibility of the animals in our dark sky constellations, but also to the harm being done to animals on the ground. Light pollution is having a significant negative impact on native fauna in Australia, with artificial light leading to a reduction in the reproductive output and quality of life of various native species.<sup>11</sup>

For millennia we have been able to look to the stars to guide all facets of our understanding of the world and the universe, including animal behaviour. The proper lighting of our skies and environment is imperative not just for Indigenous peoples and astronomers, but to preserve the accuracy and depth of our extensive knowledge systems and protect the holistic ecological systems within which we live. How can we look to the Dark Emu in the sky and hope for it to guide us on the emu egg cycle on the ground if artificial light is pushing an unnatural change in the terrestrial emu's reproductive lifestyle and overall collective health?

The presence of artificial white light illuminating our environment has been shown to significantly impact many native species, particularly migratory species that rely upon phenomena occurring as expected within their environments to signpost the beginning of their natural cycles. Migratory seabirds are particularly vulnerable to excessive artificial lighting along coastal regions, as the light can cause them to divert from their natural migratory routes and even to crash into illuminated human-made structures. Increased lighting also makes these birds vulnerable to abnormal instances of predation as they lose the veil of darkness they have evolved to hide within. This is inadvertently impacting the frequency with which they roost and their choices of roosting sites, and may lead to a reduction in their reproductive output. This reality is also experienced by adult marine turtles, who may be avoiding nesting on brightly lit beaches because their hatchlings are faced with disorientation and confusion when they make their vulnerable dash to the ocean.<sup>12</sup>

The theme of reproductive harm is becoming all too common in investigations of the impact of light pollution on animals. The Tammar wallaby, which is native to regions of South Australia and Western Australia, is facing active harm and alterations to its reproductive habits due to artificial lighting. The presence of unnatural light is causing a shift in the timing of its breeding season, resulting in the young being born at a time of year when their natural food resources are out of season and hence low in availability. Sadly, projections indicate severely reduced population sizes in the near future.<sup>13</sup>

Similarly, artificial lighting on our streets has been linked to sleep disruption in native birds such as the Australian magpie. The presence of artificial white and red light at night has been found to impact the REM sleep cycles of magpies, with notably worse outcomes experienced under the white light than the red light. White light is produced at higher temperatures than red light, and studies have found that, in comparison to red light, exposure to white or blue light at night is more likely to suppress melatonin and shift the circadian rhythm in humans and non-human species alike. Research suggests that a choice as simple as switching from white lighting to amber lighting may lessen the health impacts of light pollution on native birds. However, this is a species-dependent solution and is not enough to address the ecological harm of light pollution altogether and protect other affected species.<sup>14</sup>

Another native victim of our lighting missteps is the relationship between the mountain pygmy possum and the bogong moth. The bogong moth is a migratory species that is attracted to light and serves as a main food source for the possum. It has also served as a significant feature in the diets of Aboriginal nations across southeastern Australia, who have many different methods of consuming the once-reliable food source – from cooking them on a fire or grinding them into a flour and baking cakes to preserving and smoking them, which is said to give them an almond-like flavour.<sup>15</sup> For Aboriginal people located around the Australian Alps, the migration of the bogong moth signals the time for ceremony: at one time, hundreds, even thousands, of First Peoples migrated to the Alps to participate in the annual ceremonies.<sup>16</sup> The presence of artificial light in the moth's environment misdirects its natural migratory patterns, consequently reducing food resource availability for the mountain pygmy possum and harming both species' long-term survival as well as the ability for local

Aboriginal nations to practise culture.

If the health impacts of light pollution on our native species are evident, then it should be natural to assume that these rules exist for human health, too, right? There is evidence that the suppression of melatonin and the subsequent shifting of our natural circadian rhythm due to blue LED lighting may contribute to certain cancers and diseases. Research has found that chronic circadian rhythm disturbance leads to a decrease in tumour suppression and an increase in breast cancer development in mice.<sup>17</sup> Blue LED lighting has also been linked to photoreceptor damage in our eyes. The rods and cones are crucial components of our eyesight and colour vision with their ability to convert light into signals that are sent to the brain for processing.<sup>18</sup>

Another source of light pollution that is particularly relevant to Gamilaraay skies is that of gas flares erupting from natural-gas plants. Gas flares are an integral part of the operational and safety management systems for gas plants, meaning that wherever such a plant is erected, the flares are largely unavoidable.<sup>19</sup> The flares do not just impact astronomical observations with the excess light they emit but are symbolic of the ecological harm that gas plants bring to their surroundings.

In Gamilaraay Country, 20 kilometres from the New South Wales town of Narrabri, a natural-gas development project has been proposed. It has faced widespread protests in the past five years due to the ecological, astronomical and cultural risks it poses. The land for which the project is proposed includes the Pilliga Forests, on the sacred grounds of Gamilaraay peoples.<sup>20</sup> Knowledge holder Rosie ‘Bumble’ Armstrong Lang told us, on the topic of the Pilliga, that ‘It is important because it is where every plant exists for the Nation. It’s like our Garden of Eden. If we don’t protect it, we lose everything.’<sup>21</sup> The forests contain close to 300 sites of significance to the Gomeroi peoples, including camp sites, grinding grooves and ceremonial/burial grounds.<sup>22</sup> The construction of the plant will lead to the destruction of parts of the Pilliga Forests, inevitably causing cultural and ecological harm.

Other core concerns about the Narrabri gas project are that it may cause significant environmental damage, particularly to local surface water and groundwater sources, could impact the health of local residents, and is in a precarious position as it is situated in an area at risk of unmanaged bushfire threats. Traditional owner and activist Polly Cutmore has relentlessly opposed the proposal since its inception, stating that ‘The Pilliga forest and water is an important place for the Gomeroi people. We believe in the healing power of these waters and have historically used it for medicinal purposes. Our water is precious to us. We cannot allow further destruction and alienation of our Country and water.’<sup>23</sup>

Grassroots activists suggest that investing in a renewable energy source instead of gas would mitigate the risks posed by the plant. Despite the public backlash, the project was approved in September 2020 by the New South Wales Independent Planning Commission and in late November 2020 by the federal minister for the environment, Sussan Ley.<sup>24</sup>

Light pollution is not only an issue for Indigenous astronomers, impacting our stellar library and our observations as astrophysicists – it is an issue for our overall interconnected

knowledge systems. By pushing unnatural shifts in the balance of our ecosystem, we risk our knowledge, culture, health and the future of entire ecosystems.

## **MEGACONSTELLATIONS**

Another emerging source of light pollution that is proving to be among the biggest threats to the skies is megaconstellations. These are groupings of telecommunications satellites working together to provide internet coverage across the world. They are currently being deployed into Earth's low or medium orbit at a rate greater than we have seen in the past. Some of the world's wealthiest companies, including SpaceX and Amazon, are competing in a space race, with each trying to dominate Earth's outer orbit with megaconstellations and thus the market for internet connectivity.

Since 2018 and at the time of writing, Elon Musk's Starlink project has launched approximately 1300 satellites into Earth's orbit; it hopes to launch another 40,000 over the next ten years. The initial satellites each measured approximately 4 metres in length and weighed 200–350 kilograms. Another company, OneWeb, has launched nearly 150 satellites with the intention to launch another 6000. Amazon also intends to launch approximately 3000 satellites into multiple orbits around Earth. Even with this relatively small increase in artificial satellites (only 3 per cent have been launched to date), we are already seeing huge impacts. When news of these plans first became public, astronomers were concerned but did not have the scientific proof to back up their concerns or the opportunity to voice them. Now, the science is conclusive that increasing the number of artificial satellites will destroy dark skies.

In the March 2021 issue of a Royal Astronomical Society publication, a paper outlines the several ways in which mega-constellations interfere with ground-based astronomy, including radio interference, streaks appearing through imagery leading to a loss of information, and, most notably, increased light pollution.<sup>25</sup> The researchers conclude that we are experiencing a new type of skyglow caused by the increase in satellites. As these artificial objects orbit our planet, the Sun's rays hit them, reflecting and scattering sunlight throughout our atmosphere. Initial measurements indicate that this new source of light pollution is already increasing the brightness of our night skies by 10 per cent. This value has sent alarm bells ringing throughout the astronomical community. The upper limit of light pollution tolerable at observatories (set by the IAU in 1979) is 10 per cent of the natural skyglow: values higher than this render observations obsolete. Observatories and dark skies in general were already threatened by the numerous other sources contributing to light pollution, but the very nature of megaconstellations is to cover the entire planet, leaving no place untouched. They will drive dark skies to extinction if they are allowed to continue unregulated.

The effects of sending tens of thousands more satellites into our skies will be devastating not just for astronomy and for Indigenous peoples with cultural connections to the sky but to everyone living under the skyglow. The scientific community has not yet documented the



impact of megaconstellations on ecosystems. At the same time, the US Federal Communications Commission and the Australian Communications and Media Authority are approving more satellites to enter our shared sky.

Some companies have made attempts to reduce the impact of megaconstellations on skyglow. OneWeb has opted for fewer satellites at a higher altitude, which means the satellites will produce less skyglow while simultaneously covering a larger area.<sup>26</sup> Starlink appears to have little interest in high altitudes but has made attempts to reduce the luminosity of its satellites by painting them with anti-reflective coatings. Coating techniques have shown a reduction in reflected light by up to 50 per cent but they do not work for all wavelengths, meaning the satellites are still impacting ground-based astronomy.<sup>27</sup>

There are other issues to address regarding the impacts of megaconstellations. Already over 3000 working satellites are being used for commercial, military and civil purposes, with an estimated 20,000–34,000 pieces of derelict space debris also orbiting our planet.<sup>28</sup> With our atmosphere becoming more and more privatised and industrialised,<sup>29</sup> we risk not only our dark skies and the health of entire ecosystems but also our ability to leave the planet. The Kessler syndrome is a theoretical future in which one satellite collision could lead to a cascade of collisions that destroy the thousands of instruments in orbit,<sup>30</sup> which could create vast debris fields making it highly dangerous, or perhaps impossible, for anything to leave Earth, including us! Since the influx of megaconstellations, we have already seen an unexpected near-miss between a Starlink satellite and a European Space Agency craft that could have been devastating to observation satellites but, more drastically, makes clear the very real risk that a Kessler cascade could quite easily occur.<sup>31</sup>

We're overpopulating an already overpopulated space with little thought of the consequences. In the words of astronomer Aparna Venkatesan and her colleagues, 'The manner and pace of "occupying" near-Earth space raises the risk of repeating the mistakes of colonisation on a cosmic scale.'<sup>32</sup> Indigenous histories teach us the devastating consequences of the colonial agenda. As addressed at the start of this book, Country comprises land, sky and everything in between. There is no 'outer space' to Indigenous peoples, only a continuous, connected reality where coexistence is paramount. As captured by the Bawaka Country group, 'To hurt Sky Country, to try and possess it, is an ongoing colonisation of the plural lifeworlds of all those who have ongoing connections with and beyond the sky.'<sup>33</sup>

Indigenous culture, traditions and peoples also show us that there are different ways to achieve similar outcomes. Impacts can be minimised and the health of Country and community should always come first. Slowing down is one great lesson modern technologists could take from Indigenous communities. Indigenous astronomy is not just knowledge, it is the values, techniques and histories of the communities. By understanding that the world (and indeed the universe) is interconnected and relational, we see that nobody – not even humans – is immune to the consequences of polluting our skies. Further, by valuing the sustainability of our actions, we can create a world where we are not a threat to our own survival.

## PROTECTING OUR SKIES

The solution to light pollution is not to dramatically commit ourselves to the dark, but instead to invest in lighting our areas intelligently and with purpose. Any individual can take a handful of steps to properly light their surroundings, but the most meaningful change needs to be on a large scale in our public spaces. The National Light Pollution Guidelines for Wildlife released by the Australian Government's Department of the Environment and Energy in consultation with experts, including Karlie Noon, outline six steps to follow when designing best-practice lighting for outside spaces.<sup>34</sup>

They urge us to start with natural darkness. The intention is that artificially lighting a space should occur with purpose and that lighting limits should be kept in the designer's mind from the beginning. These limits would centre on how much light is necessary for that particular space, based on established standards for gauging when enough lighting has been achieved.

The next recommendation is to use adaptive or 'smart' controls for the lighting sources. These ideally enable flexible, instantaneous and remotely managed light and have the ability to switch off, dim and time the lighting. Motion sensor-activated lighting is perhaps the most obvious example that meets this recommendation.

Thirdly, the guidelines implore people to illuminate only the intended area by using directed lighting that is close to the ground. This includes the use of appropriate shielding, which in the case of a streetlight may be a cone that ensures all light emitted is being directed narrowly towards the ground without any spillage into the sky that would result in skyglow.

The guidelines then suggest that appropriate lighting is prioritised such that, within reason, the minimum amount of light needed to complete the task is all that is made available. A low-glare lighting source is strongly encouraged. People are advised to use non-reflective surfaces, and, finally, to use lights that reduce or filter out any harmful short-wavelength blue-violet light. These recommendations call for consideration at every level in a community.

The Australasian Dark Sky Alliance (ADSA), for which Krystal De Napoli is an ambassador, is a non-profit charity established in 2019 that is dedicated to educating the wider public and policy makers on the importance of dark sky conservation. Through collaboration with local councils, astronomers, health practitioners, ecologists, tourism representatives and lighting experts, ADSA seeks to strengthen the conversation surrounding light pollution, demonstrating that the solution to minimising excessive artificial lighting in our environment will require a multidisciplinary approach.

A society in which we emphasise the preservation of the dark skies is not an unachievable dream. It is already an everyday reality for people living under Kamilaroi skies in Coonabarabran, New South Wales – a small town at the edge of the Warrumbungle National Park. In 2016, the national park was officially designated Australia's first Dark Sky Park by the International Dark-Sky Association (IDA). The certification acknowledges that the park

lies under pristine dark skies that enable the human eye to observe precious dark sky constellations and light-vulnerable features that are impossible to view from light-polluted cities.

Inside the national park is Siding Spring Observatory, a renowned optical astronomy research facility boasting many fine pieces of observational equipment, including the Anglo-Australian Telescope and the Australian National University's 2.3-metre Advanced Technology Telescope. These have contributed immensely to our understanding of dwarf galaxies, dwarf stars and optical astronomy techniques. In order to directly monitor the health of the dark skies, critical light thresholds have been placed at the observatory. The park predominantly uses lighting techniques that reduce light pollution, allowing for a fully nocturnal-friendly environment that does not harm the eating, sleeping, hunting, migrating or reproductive tendencies of its inhabitants. The certification has served as motivation for Coonabarabran and its surroundings to follow best-practice lighting guidelines to preserve the dark skies, in a model that we hope to see adopted by the rest of the continent, and the world.

As for navigating our increasingly polluted atmosphere, many solutions are required if the communication monopolies of billionaires are to continue having free rein over our skies. Just as several companies have begun to consider mitigation tactics to avoid the increase in skyglow, all companies must be responsible for their contribution to an already polluted space. Given the near-misses that have already taken place and the estimated 20,000 pieces of space debris already floating in our atmosphere, orbital pollution reduction is required. Further, reducing planetary pollution – whether in Earth's orbit or on land – will produce better outcomes for all of humanity. If we are giving these companies access to these spaces, why shouldn't they clean them up? In a seminal 1995 book, *Orbital Debris: A Technical Assessment*, the US National Research Council described four ways in which space debris can be moved from Earth's cluttered orbit: forcing objects out of orbit with ground-based instruments such as lasers, reducing the lifetime of objects by accelerating their natural decaying process, moving objects to areas with less pollution, or actively removing them from orbit.<sup>35</sup> A minimally polluted atmosphere is possible with the right approach and know-how and, of course, money, of which these companies have plenty.

However, the issue of space junk is not just about removing it all – which couldn't be done even if we wanted to. Some pieces of space junk, like *Vanguard 1*, the oldest human-made object in orbit, have historical significance. In her recent book *Dr Space Junk vs the Universe*, Dr Alice Gorman highlights the many obstacles to the removal of space junk and says that decisions on what is to be removed should be made 'from an informed position. We need to know which objects do have cultural significance in orbit, from local, national and global perspectives. And we need to understand how their changing orbits may relate to collision risk.'<sup>36</sup> She further concludes: 'It will be a while before we see large-scale space debris removal. We should use this time to plan a cultural heritage management strategy that will be both effective and practical.'<sup>37</sup>

With all of these light-pollution mitigation options, there is one more crucial step that

must be taken by projects that aim to protect our environment. By having Indigenous people – not just Australian Indigenous people but Indigenous people from around the world – at the table and seeing them as stakeholders in the future of space exploration, sustainable living and the world more broadly, we can secure a future for all, not just for the corporations.

## **SPACE HERITAGE**

Indigenous and non-Indigenous Australians have significant heritage values related to the night sky and space. All Aboriginal and Torres Strait Islander stories about the sky exemplify this. The Celestial Emu is a part of our knowledge and culture, and a heritage in dire need of advocacy and preservation. In Chapter 2 we explored the oral traditions that relate land to sky for Australian Indigenous peoples, but sadly the visibility of the Celestial Emu is at risk with current and increasing levels of light pollution. Further, the story of Gawarrgay, like a lot of Indigenous heritage and other oral traditions, is intangible. How do we protect intangible things such as stories?

In 2003 the United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted the Convention for the Safeguarding of the Intangible Cultural Heritage, which aims to protect this heritage, ensure respect for it, raise awareness of its importance and ensure mutual appreciation of it.<sup>38</sup> Currently the UNESCO Intangible Cultural Heritage Lists contain at least seven entries related to knowledge of or celebration of Sky Country by various communities around the world – though none from Australia.

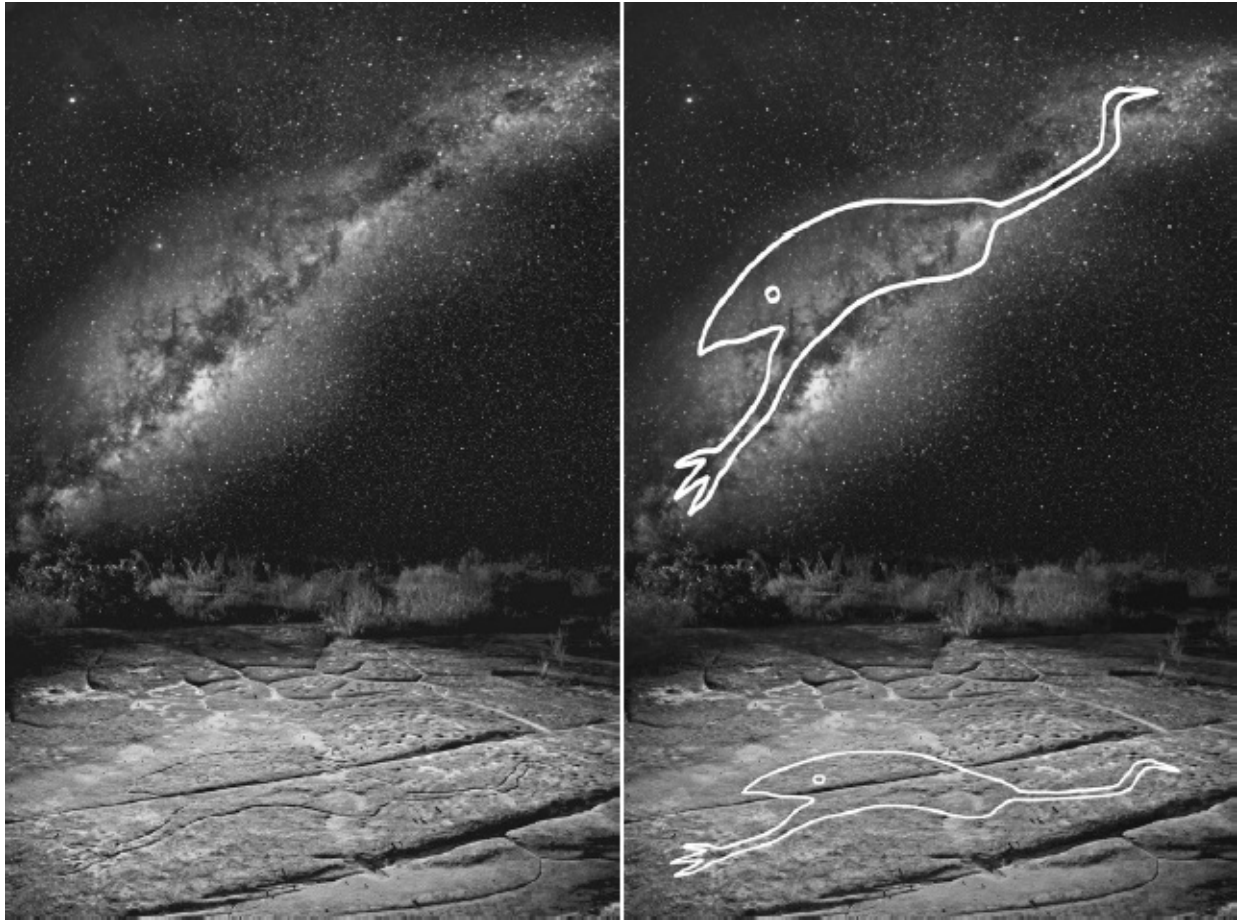


FIGURE 4.1: Emu engraving located in Ku-ring-gai Chase National Park, NSW. Its orientation matches that of the Celestial Emu dark sky constellation during the month of August.

Access to the site or object – as in actually being able to see features in the sky – is the first step. This knowledge is irremovable from the land and the sky. If the sky is not visible, how can we practise the traditions related to it? Preserving our dark skies all over Australia, not just in a few select places, is integral to protecting nocturnal animals and Indigenous traditions. Further, since Aboriginal and Torres Strait Islander knowledge often links to a physical place, it is a way that heritage can be physically protected. For the story of Gawarrgay, the physical place is the Milky Way, observed in the night sky from Earth. But there are places on Earth of particular significance to this story. One is the Ku-ring-gai Chase National Park near Sydney, which contains over 1500 pieces of rock art with many motifs relating to sky knowledge, including the Pleiades and the Celestial Emu (Figure 4.1). The Celestial Emu engraving is approximately 8 metres in length and aligns with the positioning of the Celestial Emu in the sky during the winter months, a time important for male initiation ceremonies.<sup>39</sup> This is of course only one example of the rich culture and knowledge contained in rock art in significant Aboriginal and Torres Strait Islander places.

Due to Ku-ring-gai Chase National Park's cultural significance and biodiversity, it was placed on the National Heritage List in 2006. Part of the *Environment Protection and Biodiversity Conservation Act 1999*, this protects the cultural value of the land. This distinction is important in preserving Indigenous knowledge and culture. For example,

protecting the emu rock art in Ku-ring-gai Chase National Park, and other places like it, would protect the value of having access to the Celestial Emu in the sky through tying an intangible oral tradition to a physical place. The location is also protected in the state heritage legislation of 1974, which broadly offers some level of protection to all Indigenous sites. By protecting the values of a place, that place itself is generally protected alongside the things associated with it, such as a story and accessibility.

The National Heritage List has many other great examples of protection of our culture and traditions, including the protection of physical places. One of the most exquisite listings is that of Quinkan Country in Queensland. This cultural landscape is an outstanding example of rock art and stratified archaeological sites that represent a span of Australia's history covering 30,000 years of occupation, and it is considered one of the top ten rock art sites in the world. The types of art found in this region include spirit figures called Quinkans, totemic animals and symbols relating to European colonisation. The site also provides evidence of a major cultural change that occurred in the mid-Holocene (7000–5000 years ago) when groups in the area became much more regionalised due to the development of cultural boundaries and increasing populations. The Australian Heritage Database entry for Quinkan Country recognises two elders from the region, the late Dr Tommy George and Dr George Musgrave, for educating 'the broader public and academia about Aboriginal art and culture in a number of genres ranging from children's books to academic archives that continue to provide a foundation for archaeological work and rock art'.<sup>40</sup> By protecting significant sites like Quinkan Country, we are preserving our cultures and histories into the future.

Again, it is through the linkage between intangible culture and physical places that our heritage will be protected. This is not unique to Indigenous people, it is applicable to all Australians. Recently applied to the Australian heritage space was something that has never been seen before: the protection of some of our scientific contributions to the world. Just like the intangible knowledge of Australia's First Peoples, scientific contributions from Australia are being included as a part of our National Heritage List. For the first time in Australian history, a physical place is being considered for national heritage listing due to its outstanding contributions to science. That place is known as Murriyang, or the Parkes Radio Telescope. It is commonly known as 'The Dish', which was adopted as the title of the 2000 movie that takes a look at the stunning 64-metre single-dish radio telescope and its role in assisting the transmission of pictures of the Apollo 11 moon landing to the world in 1969. (The movie was somewhat of a twist on the events that took place, leaving out the contributions of another Australian antenna, the Honeysuckle Creek Tracking Station, which actually produced the first transmissions of the landing and is listed on the Australian Capital Territory Heritage Register.) The moon landing aside, the contributions of Murriyang to the scientific community have been impressive, to say the least. As Melissa Price, the minister for the environment at the time, stated:

Since it was built, more than 50 years ago, it has showcased Australia's scientific ingenuity and expanded our knowledge of the universe. Established in the pioneering

years of radio astronomy, the Observatory's radio telescope was one of the first built as a movable dish. It served as a prototype for other telescopes around the world and contributed to major scientific advances such as the discovery of quasars – celestial objects which helped support the Big Bang theory.<sup>41</sup>

Similar, although less renowned, is the Heritage Near Me initiative around Molonglo Radio Telescope. This radio telescope, located just outside Queanbeyan, New South Wales, is a Mills Cross telescope that uses Earth's rotation to take radio images of the sky. The Heritage Near Me project is run by heritage expert Dr Alison Wain out of the University of Canberra, backed by a team of astronomers and heritage experts including Karlie Noon and Dr Alice Gorman. The project aims not only to protect the Molonglo Radio Telescope but to promote community engagement with this very cool piece of technology.

The Molonglo Radio Telescope was granted state-level heritage listing in late 2018 and was awarded a budget for the Heritage Near Me project. In the future, the team aims to facilitate public visits to the site so that students can conduct their own research using the telescope. The hope is that this will result in a pipeline of students wanting to enter the world of radio astronomy, a field of science to which Australia has made huge contributions – not only in recent years, but back in the mid-1940s, when Ruby Payne-Scott was one of the first radio astronomers, working with Joseph Pawsey at CSIRO.<sup>42</sup>

With the emergence of these new types of heritage listings comes an acknowledgement of First Nations culture. They exemplify what makes our nation and our many Indigenous nations unique. Whether it is our great creation stories, the scientific knowledge that allowed people to live sustainably and in harmony with this land for 65,000+ years, or our scientific and technological contributions that have shaped the way we understand our universe, our heritage is owned and shared by everyone.

# INTEGRATING INDIGENOUS ASTRONOMY

Integrating Indigenous astronomy into modern, mainstream knowledge systems, such as school and university curriculums and various entertainment formats, is a way to acknowledge Indigenous peoples' cultural and intellectual significance and conduct truth-telling about this continent's First Peoples. In order to integrate this special knowledge, the Archive from which much of the academic knowledge of Indigenous astronomy originates must be interrogated by researchers and appropriate knowledge holders to ensure information is correct. Notably, colonial biases, which have detrimentally affected representations of Indigenous peoples in the past and continue to impact communities today, should be redressed. Connecting disrupted communities back to the knowledge that was recorded from their ancestors and gate-kept within academia for centuries is another integral step towards working appropriately with Indigenous sky knowledge. In doing so, and in combination with the support of Western technologies and the Australian people through their respect and celebration of Indigenous peoples, we can gain a better understanding of humanity's collective fascination with and awe of Sky Country.

## REWRITING THE ARCHIVE

Today there is a plethora of traditional Indigenous knowledge available in the public domain. Much of this knowledge has laid the foundation for how Indigenous peoples have been perceived by the world since colonisation, and how Indigenous peoples are still studied and researched today. Many early Australian settler records include mentions of different traditions and customs being observed. Pastoralist and writer Edward Curr documented his time spent with Indigenous peoples in the late 19th century and wrote: 'It may perhaps be doubted whether any section of the human race has exercised a greater influence on the physical condition of any large portion of the globe than the wandering savages of Australia.'<sup>1</sup>

Curr took pride in his documentation and believed his accounts to be accurate due to his having lived with Indigenous people. To try to obtain an accurate view of Aboriginal peoples'



world, he would send questionnaires to white pastoral workers, stock owners and those he called 'bushmen', asking if they had noticed similar behaviours or cultural norms among different Aboriginal communities.<sup>2</sup> While his attempts at recording the lives of Indigenous peoples were commended at the time, settlers were not necessarily the best placed documentarians of Indigenous culture – and his derogatory description is indicative of the kind of outdated language that researchers have had to rely on. As historian Professor Samuel Furphy writes on the topic of Curr, 'Many collaborators had a clear motive to portray Aborigines as hopelessly primitive, as such a view justified (in their own minds) colonial land acquisition.'<sup>3</sup> Professor of Knowledge Management Karl-Erik Sveiby and Nhunggabarra painter, educator and custodian Tex Skuthorpe agree: 'What they saw they could not comprehend because they could not free themselves from their own cultural blinders.'<sup>4</sup>

More recently, Indigenous knowledge, traditions and ways of being have been viewed predominantly through the field of anthropology, which is defined by the *Cambridge Dictionary* as: 'the study of the human race, its culture and society, and its physical development'. The wave of anthropological research that emerged in the 20th century brought a more nuanced approach to views of Indigenous people, with a new awareness of the role of bias in documenting different cultures. This change in perception was brought about by German-American anthropologist Franz Boas, considered to be a founding father of anthropology.<sup>5</sup> In a 1901 journal article, Boas acknowledged the role of bias in conducting anthropological research:

In order to understand these clearly, the student must endeavor to divest himself entirely of opinions and emotions based upon the peculiar social environment into which he is born ... the more successful he is in freeing himself from the bias based on the group of ideas that constitute the civilisation in which he lives, the more successful he will be in interpreting the beliefs and actions of man.<sup>6</sup>

Following the increasingly widespread recognition of cultural bias within the field of anthropology, the early to mid 20th century saw increased interest in anthropological work on Indigenous peoples. With the devastation caused to Indigenous communities by colonisation, anthropologists formed a dire view of First Nations peoples, whom they believed to be on the brink of extinction – an approach known as salvage anthropology. This assumption justified anthropologists collecting as much tangible Indigenous culture as possible,<sup>7</sup> and many items were taken from their custodians in the imaginary battle against Indigenous extinction. The world was becoming obsessed with Indigenous people, especially Australian Indigenous people. As described by Greek-Australian anthropologist Andrew Lattas, they were seen to 'symbolise a primordial human origin'.<sup>8</sup> The early anthropologists believed Aboriginal and Torres Strait Islander peoples were dying out and began taking their material items, languages and bodies in an attempt to preserve their culture in time. But in doing so, they

were actively taking from living custodians. The legacy of salvage anthropology continues to impact Indigenous peoples, cultures and communities today.

Can any good be retrieved from these past practices? How do we conduct ourselves as researchers in a space that has historically caused harm? Since the late 1980s, various movements in the anthropology and archaeology space have attempted to decolonise the Archive – meaning actively acknowledging and removing the presence of white supremacy in works relating to non-white peoples and instead encouraging meaningful, respectful collaboration. Such efforts have looked outside the imperial confines of anthropology to seek a more accurate, diverse view of humanity. African American anthropologist Faye V Harrison explains:

Anthropology has now absorbed the early critiques of [scholars] who exposed the relation between anthropology and imperialism. While some believe that anthropology is so deeply flawed by its origins that it should be abandoned, these authors believe that an authentic study of humankind can be developed by drawing upon neo-Marxist political economy, interpretive and reflexive ethnography, feminism, and radical Black and Third World scholarship.<sup>9</sup>

In the 21st century, the academic corpus has grown to accept views that critique the various historical power systems at play. Goenpul academic, activist and author Dr Aileen Moreton-Robinson captured a fundamental observation in a 2004 paper: '[Aboriginal peoples] have often been represented as objects – as the “known”. Rarely are they represented as subjects, as “knowers”.'<sup>10</sup> Indigenous peoples' increasing access to educational institutions has contributed significantly to such debate in the Australian context, and to current representations and approaches in working with Indigenous peoples and knowledges. In Dr Moreton-Robinson's essay, her critique both acts as an example of Indigenous 'knowing' and gives a helpful frame for moving beyond past misconceptions – to see Indigenous peoples as 'knowers'.

Looking specifically at Indigenous astronomy, some of the first Western recordings of Aboriginal and Torres Strait Islander observations of the sky were produced by early anthropologist and settler William Stanbridge in the mid 19th century. Stanbridge documented practices of the Boorong clan of the Wergaia language group, noting that the name Lake Tyrrell (*Tyrill* in Wergaia) meant 'sky' and that they were known in the north-west Victoria region for their extensive astronomical knowledge.<sup>11</sup> Even the word *Boorong* translates to 'darkness' or 'night'. The extent of the Boorong clan's observations are still being understood, with the recent exploration of the recording of a star outburst in Boorong oral traditions.<sup>12</sup> Around the 1840s, Stanbridge documented that the Boorong people knew a large red star that they called Collowgullouric War (female crow), which they described as being married to a nearby star called War (male crow). These two stars are what we now call Eta Carinae ( $\eta$  Carinae) and Canopus, respectively. In 1881, Presbyterian minister Peter MacPherson documented the oral traditions related to Eta Carinae as a small red star, in

conflict with Stanbridge's documentation forty-one years earlier of Collowgullouric being a large red star.<sup>13</sup> During the time Stanbridge was engaging members of the Boorong nation, Eta Carinae was experiencing an outburst and was the second-brightest star in the sky. Outbursts occur when a star either runs out of fuel, causing it to go supernova and explode, or when it absorbs too much material from its environment, forcing it to let out a 'stellar burp'. Both the Stanbridge and MacPherson accounts tell us that the Boorong people recorded Eta Carinae's outburst and updated their knowledge systems as their observations of the star changed over time.

In recognition of the astronomical prowess of the Boorong people, Sigma Canis Majoris, a star significant to them, was officially renamed and formally recognised by the IAU in 2018 by its Wergaia name, Unurgunite. The renaming of sky objects to reflect cultures around the world is a significant step in acknowledging significant astronomical feats by peoples and cultures outside of the Western norm. Through such recognition, Aboriginal people are being reintroduced to the world as critical observers and excellent storytellers.

The modern recognition of the Boorong people's observations of the night sky is in stark contrast to earlier representations of Indigenous peoples, and exemplifies the importance of re-examining the past in a new light. In the past five years, many stars, asteroids, telescopes and places have been renamed with Aboriginal and Torres Strait Islander names. For Indigenous peoples, this is a small step. However, the increasing recognition of First Peoples' excellence is also shining a light on the mistakes of the colonial agenda. These small steps are integral for the truth telling of our collective history on this continent and taken together are a big step towards accurate representation of Indigenous peoples in the future.

## **WORKING WITH COMMUNITIES**

Acknowledging the history of Indigenous peoples' experience with researchers is vital when attempting to work collaboratively and respectfully with communities today. The Archive is primarily seen as a reliable snapshot of Indigenous life and culture pre-colonisation. In addition, as systematic attempts to repress Indigenous peoples from expressing or sharing their knowledge increased during the 20th century, information contained within the Archive became a source not just for academia but also for Indigenous peoples and communities.

Even so, what is documented in the Archive cannot be taken at face value. As discussed, early settlers and anthropologists had a range of biases when engaging with Indigenous peoples that affected what they saw and what was (and wasn't) documented. Further, early settlers were not trained astronomers, which means that inconsistencies occurred when they recorded astronomical knowledge. For example, in the records of self-taught early 20th-century anthropologist Robert H Mathews, 'Jupiter was a Kilpungurra man called Wurndawurdayarroa, who lived on roasted yams, hence got his reddish colour from the fire.'<sup>14</sup> However, in a study conducted by Robert Fuller in 2012 as part of his Master of Arts thesis, several Aboriginal participants from the area stated that they believed this story was from the

Murrawarri nation and refers to Mars, not Jupiter.<sup>15</sup> Of course, the earlier informants could have been correct and the later group incorrect. Regardless, this highlights some of the potential difficulties of using only colonial archives when discussing Indigenous knowledge and the importance of collaboration.

Clearly, early settler records can be problematic regarding what was observed and how it was interpreted. For this reason and obvious ethical reasons, it's very important that we do not repeat past mistakes by continuing to not work with Indigenous peoples when looking into their cultures. By working with them, we can begin to understand 'how our ancestors understood and related to the night sky, away from the white gaze', as captured by theoretical physicist and activist Chanda Prescod-Weinstein.<sup>16</sup> Working collaboratively and respectfully with Indigenous communities, in tandem with knowledge in the Archive, enables the process of decolonisation of the Archive to occur. Undoubtedly this is the ideal option for both researchers and communities. Decolonising begins when we stop treating the words of non-Indigenous people as fact and instead support Indigenous peoples in controlling their own narrative.

These types of professional relationships can take many years to build and require much meaningful community engagement and significant listening. Deep listening, or *dadirri*, is a skill that Indigenous people revere and celebrate. Teacher, activist and Ngan'gityemerri elder Miriam-Rose Ungunmerr-Baumann says:

It is perhaps the greatest gift we can give to our fellow Australians. In our language this quality is called *dadirri*. It is inner, deep listening and quiet, still awareness. *Dadirri* recognises the deep spring that is inside us. We call on it and it calls to us. This is the gift that Australia is thirsting for. It is something like what you call contemplation.<sup>17</sup>

When working with Indigenous peoples and benefiting from their culture, knowledge, labour or land, mutual benefit and respect should be expected for and from both parties. This not only extends to reimbursement and permissions but also to an appreciation of the individuality of the voices and opinions of Indigenous and non-Indigenous people alike. For researchers, organisations or governments, there are guides on how to collaborate appropriately and respectfully when working with Indigenous peoples. Specifically, researchers should obtain free, prior and informed consent (FPIC) when engaging with Indigenous peoples. Set out in the United Nations Declaration on the Rights of Indigenous Peoples, FPIC asserts that Indigenous peoples have the right to self-determination and control over matters that are about them or affect them.<sup>18</sup> Consent is required from the beginning of any engagement, with all relevant information offered by the Indigenous peoples freely, without coercion or distress. This is a way to ensure that there is 'nothing about us without us'. However, both parties must always have the right to not participate in any activity if mutual benefit and respect cannot be established. Positively, universities and organisations today largely require researchers and program managers to show evidence of

having FPIC or some level of consent from relevant Indigenous peoples as a part of their ethics process.

Trust and respect between Indigenous people and researchers can lead to phenomenal outcomes. There are a few great examples of works produced in this manner that examine the astronomical accomplishments of Indigenous cultures. One of the most outstanding is the collaboration between academic Dr Hugh Cairns and Wardaman law man, traditional owner and artist Bill Yidumduma Harney. In the late 1990s, Dr Cairns was helping a colleague when he met Uncle Yidumduma on his cattle station on Wardaman Country, near Katherine in the Northern Territory. The two men became friends, and one day Cairns had the urge to ask Uncle about the stars. Uncle Yidumduma said that Cairns was the first white man to ask him anything about the stars.<sup>19</sup> What followed was a respectful and prosperous relationship. Uncle explained that the stars told the Wardaman people everything they needed to know about time – the timing of ceremony, food, seasons, even just knowing what time it was when working at night as a stockman. The two men shared their knowledge, with Cairns explaining what he knew about the stars. His knowledge impressed Uncle, and they began to share more and more. This respectful relationship led to the best collaboration in Australian Aboriginal astronomy history and produced the book *Dark Sparklers*, which explores Wardaman astronomical knowledge in depth, including how sky knowledge is used and how the Wardaman people understand the sky with respect to the Dreaming – or what Uncle refers to as the ‘cosmoscape’. The book combines both the ‘white man’s’ knowledge of the stars and the Wardaman perspective, giving us insight into the relationship between the land and sky and ‘caring for Country like the Creation People did, the mountains, rivers, landscape, plants, animals ... for people to understand how to care for Country’.<sup>20</sup>

Working alongside communities is undoubtedly the most reliable and ethical way to learn about Indigenous peoples. It gives researchers the best shot at success and communities the respect they deserve. As Cairns states, referring to the early anthropologists,

They studied the rock art in Australia and interpreted some of the art as being about the sky, but archaeologists in Australia said we needed an Aboriginal informant and could not extrapolate from Europe or the Americas. Archaeologists here said there had to be Aboriginal informants before they would even consider the matter, even though early papers were written on the subject in the early 19th century. [These papers] told us the Aboriginal peoples knew nothing about the sky.<sup>21</sup>

The collaboration between Uncle Yidumduma and Dr Cairns was groundbreaking for the field referred to as Indigenous astronomy, and helped cement Indigenous knowledge systems as inherently scientific. Today we are starting to see mainstream recognition of the extent and depth of First Peoples’ extraordinary expertise, and *Dark Sparklers* has contributed significantly to our understanding of how Indigenous peoples connect to the sky.

Thankfully, with the growing awareness of Indigenous peoples’ sophisticated culture, and organisations being responsive to our ever-growing and diverse world, the issue of

appropriate acknowledgements is now being addressed. It is vital to make sure communities know what rights they have, and that they are deserving of acknowledgement and benefit sharing for any work conducted about them. Further, training universities and other educational institutions on how to appropriately engage with Indigenous peoples – that is, to not speak for Indigenous peoples or gatekeep their voices but to support appropriate engagement with them – is a process that is becoming normalised through ethics applications, supported by the ever-increasing work being done to support Indigenous agency and sovereignty.

## **ACADEMIA TODAY**

Interest in and recognition of Indigenous astronomy have blossomed over the past two decades, prompting academia to engage with it as a whole new field. Ethnoastronomy – the study of a culture’s interactions with astronomy – is studied and taught by anthropologists and astronomers alike. Several Australian universities, groups and people are leading efforts in the respectful recognition of Indigenous culture and increasing Aboriginal and Torres Strait Islander representation in ethnoastronomy, astronomy and STEM in general. Research can benefit communities as a means of maintaining appropriate cultural knowledge, assist them in repatriating their ancestral remains or asserting land rights, and give a platform for Indigenous understandings to be implemented into systems such as environmental management.

The Australian Aboriginal Astronomy Project is a community dedicated to increasing awareness of Indigenous sky knowledge. Currently very few of the active researchers are Indigenous, which highlights the urgency of getting more First Peoples into the field. Gamilaroi man Peter Swanton recently commenced postgraduate studies at the Australian National University, addressing representations of Gamilaroi astronomy and astronomers in the Archive. He will be one of the first Indigenous people to undertake higher-degree research in the field of Indigenous astronomy.

Another exciting area of research is considering the cultural competency of astronomy in general. Cultural competency is a way to analyse how capable a field, an organisation or a person/people are with respecting and incorporating perspectives and people from various cultures. Journalist, science communicator and creative director Carla Guedes completed a Master’s thesis in 2018 that explores how cultural competency can help non-Indigenous astronomers work ethically with Indigenous peoples, resulting in better outcomes for both sides.<sup>22</sup> Her work outlines what culturally respectful and beneficial outcomes look like for astronomical projects conducted on unceded lands. The thesis won a University of New South Wales Outstanding Academic Achievement award.

A tangible product of this groundbreaking work has been developing a measuring tool for organisations to use when working with particular language groups on their Country. As shown in [Figure 5.1](#), the tool helps measure culturally competent outcomes. On the upper end

of the scale, projects and organisations value and respect the contributions and rights of Indigenous peoples. Guedes explores how the billion-dollar Square Kilometre Array (SKA) project has demonstrated a good level of cultural competency. It is endeavouring to construct the world’s largest radio telescope, half on Yamatji Country in Western Australia and the other half in Karoo, South Africa. During the construction of the observatory, the SKA commissioned Indigenous peoples from both lands to share something from their respective cultures. The result was the SKA Shared Sky project, which saw Indigenous peoples from both countries contributing artworks that describe how they view the sky. The paintings from the Wajarri Yamatji and the people of the Karoo can be seen at [skatelescope.org/shared-sky](http://skatelescope.org/shared-sky).

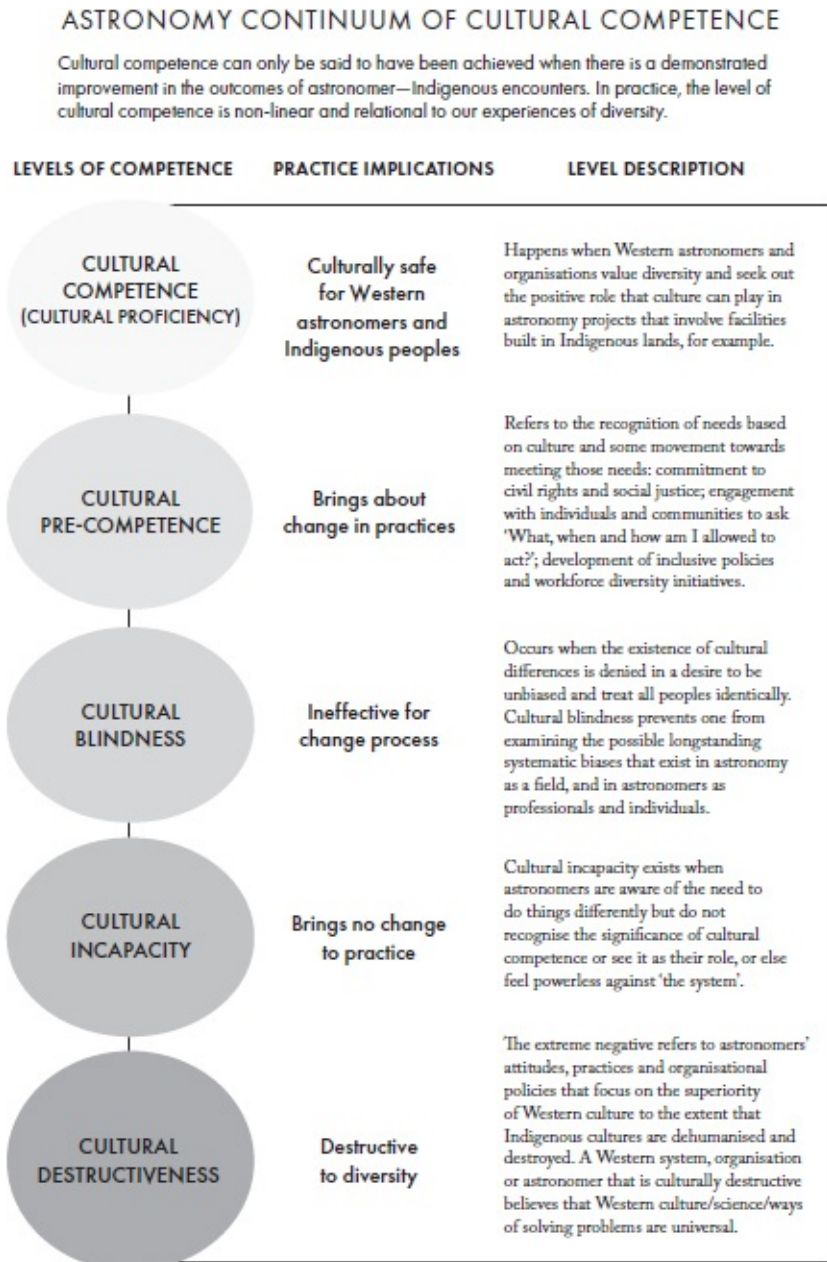


FIGURE 5.1: Cultural competency charts such as these, slightly adapted from Carla Guedes’s original (see p. 141), are invaluable resources in helping to assess and improve non-Indigenous astronomers’ interactions with Indigenous peoples and the resulting outcomes.

Analyses of how Indigenous and non-Indigenous people involved in the SKA project spoke about it mostly show that the process has been constructive. ‘Indigenous [people] have a very rich connection to the night sky and the sites, and we really want to explore that,’ says Mathieu Isidro, the deputy communications and outreach manager of the project. Wajarri elder Uncle Godfrey Simpson offered a welcome in response: ‘I’d like to say welcome to Boolardy and welcome to Wajarri country. Welcome! As Wajarri people we give our blessing for this project, the SKA project, to go ahead.’<sup>23</sup> These positive outcomes from both sides are a clear demonstration of what working respectfully and collaboratively with each other can achieve.

On the other end of the scale, organisations and projects are culturally destructive when they view Western culture as superior to Indigenous cultures. Guedes found a lack of cultural competency displayed by the Thirty Meter Telescope (TMT) project. This project aims to build one of the largest optical telescopes in the world on Mauna Kea mountain on Kaho‘olawe island, part of the sacred lands of the Kānaka Maoli peoples of Hawai‘i, and has proven to display culturally destructive qualities. Due to a lack of consultation and historical misuse of Kānaka Maoli land, the TMT project has resulted in many protests from the Kānaka Maoli people and ultimately led to the government declaring a national emergency in 2019. This declaration sadly saw the violent and unjust arrest of thirty-eight Indigenous people who were peacefully protesting to protect their sacred land. Kānaka Maoli educator and native rights activist Noe Noe Wong-Wilson states that ‘There is space for discussion about improving the way astronomy remains upon our mountain, but attitudes have to change. Astronomers look at us like we’re the bad guys, like we’re intruding on their space. It’s quite the opposite: they’re in our space.’<sup>24</sup>

For the Indigenous people of Hawai‘i, Mauna Kea is the god Wakea or ‘sky father’ and it holds great spiritual significance. The mountain currently houses thirteen other telescopes that were all built with minimal consultation with the original landowners. In 1965, the US military detonated 500 tons of TNT on the island, creating a permanent crater that resulted in the loss of the island’s groundwater and Kaho‘olawe becoming known as ‘the most shot island in the world’. The name of the new telescope, TMT, is eerily similar to TNT and understandably has caused significant pain for the Kānaka Maoli people who are still trying to defend their home from irreversible damage.

The harmful nature of the TMT project is clear in Guedes’s analysis of how Indigenous and non-Indigenous people spoke about it, which shows that almost 50 per cent of documented commentary on the project contained destructive words or phrases. Astrophysicist Sandra Faber, professor emeritus at UC Santa Cruz, says, ‘The Thirty-Meter Telescope is in trouble, attacked by a horde of native Hawaiians who are lying about the impact of the project on the mountain and who are threatening the safety of TMT personnel.’ Joshua Mangauil, a First Nations man of Hawai‘i, states: ‘Like snakes you are. Vile snakes. We gave all of our aloha to you guys, and you slithered past us like snakes.’<sup>25</sup> Such statements demonstrate the effects of not respecting Indigenous peoples or consulting appropriately with them when matters concern them and their land.



Engaging appropriately and respectfully with Indigenous peoples is essential for researchers and organisations working on and with Indigenous lands and cultures, and First Nations peoples must be able to participate in activities that involve them. On the power imbalances at play between science and native peoples, Prescod-Weinstein says, ‘What can change ... is our relationship with the current power arrangement and our relationships with each other.’<sup>26</sup>

In questioning such power dynamics and maintaining the principle of ‘nothing about us without us’, we have the opportunity to expand our perception of what scientific knowledge and scientists look like, while respecting people’s sovereignty. Further, it is an opportunity for both academic and Indigenous communities to sit at the table and come together as people of culture, cleverness and curiosity, not of differences. These are the opportunities and work of current and future researchers working in the fields of both Western and cultural astronomy.

## **INDIGENOUS ASTRONOMY IN THE CURRICULUM**

Australian schools and tertiary institutions are beginning to embrace Indigenous knowledge by including it in their curriculums. The inclusion of Indigenous-specific content has been led and partially funded by the University of Melbourne’s Graduate School of Education and Indigenous Knowledge Institute. So far the project has developed curriculum-linked resources across a variety of subject matter, including English, mathematics, science, humanities and social sciences, the arts, technologies, health, and physical education – all through an Indigenous lens.

Currently, Years 5 and 8 (spanning ages 9–14) have access to appropriate Indigenous astronomy via two educational packages, ‘Solar System’ and ‘Stellar Scintillation’. The Year 5 content explores the movements of celestial bodies in our skies as understood by the Wardaman people and Aboriginal people of the Great Victoria Desert.<sup>27</sup> The resources take a peek at planetary motion from a Wardaman elder’s perspective, including orbits, conjunctions (eclipses) and retrograde motion. Further, teachers and students learn various astronomical terms in language. In the ‘Stellar Scintillation’ resource, students learn how Torres Strait Islander peoples use starlight to understand weather and seasonal changes – specifically, how Meriam elders can make various weather predictions by observing the speed, colour and sharpness of starlight and its twinkle,<sup>28</sup> as discussed in Chapter 3. Through such oral traditions, the resources explore atmospheric turbulence, properties of stars, and the interactions between light and water molecules. Incorporating accurate and sophisticated Indigenous knowledge in the curriculum in this way offers students an understanding of First Peoples’ expertise, and inspiration for engaging with STEM fields.

Although efforts to incorporate Indigenous knowledges in university curriculums have been ongoing for a couple of decades now, the past few years have seen a striking rise in tertiary institutions looking to provide their students with access to these perspectives and

knowledge systems. Increasing the cultural capability of all tertiary graduates by 2020 was prioritised by Universities Australia in its *Indigenous Strategy 2017–2020* and may be responsible for the rise in content offered by universities across the country in the past twenty-four months.<sup>29</sup> The ability to work appropriately with and for Aboriginal and Torres Strait Islander people has become a desired attribute in Australian graduates and carries the expectation that regardless of their discipline, they should have the ability to work towards better outcomes for all Indigenous people.<sup>30</sup> The manner in which Indigenous sciences and perspectives are being included in the curriculum varies from one institution to the next and is occurring in tandem with the development of frameworks that guide the authentic embedding of these traditional knowledges. Many institutions around Australia are either offering or are in the process of creating dedicated Indigenous science subjects and courses. Notably, the Australian Research Council has added Indigenous sciences as a field of research.

As mentioned in Chapter 1, Monash University offers a second-year science course titled ‘Indigenous Science: Science through the eyes of Australia’s First Peoples’ that is co-taught by Krystal De Napoli. The course is the outcome of ongoing collaborative efforts between the William Cooper Institute and the Monash Faculty of Science along with external Aboriginal knowledge holders and community members, and is an excellent example of appropriate Indigenous knowledge integration into a university context.

The William Cooper Institute, led by Aboriginal woman and Pro Vice-Chancellor (Indigenous) Professor Jacinta Elston, oversees the development of targeted strategies to improve representation of Indigenous students in undergraduate and postgraduate studies, and conducts research by engaging with Aboriginal and Torres Strait Islander communities and knowledge holders outside of the university. It is fittingly named after Yorta Yorta man William Cooper, an Aboriginal political leader and activist in the 1930s who advocated for Indigenous representation in the Australian parliament and fought for human rights. The institute has been an invaluable and necessary force in the crafting of culturally safe and responsive courses at Monash.

Alongside De Napoli, the course benefits from the joint curation of content by Ngarrindjeri Assistant Lecturer and SCI2030 Unit Coordinator Andrew Giles, Yorta Yorta men Uncle Colin Walker and Josef Tye, Wurundjeri man Murrundindi, and Gunditjmara man Damein Bell, as well as representatives of the schools of Physics and Astronomy, Chemistry, Biological Sciences, and Earth, Atmosphere and Environment. The classroom always aims to prioritise Indigenous voices by ensuring that each class is taught by an Indigenous knowledge holder. The course is structured such that the first two weeks of the twelve-week semester are dedicated to cultural competency and the final two weeks focus on reconciling with the information and perspectives the students have been exposed to. As addressed in the early parts of this chapter, it is fundamental that the cultural, historical and social context for Indigenous knowledges and histories is decolonised and understood by the students engaging with the course. The content contained in the first two weeks offers perspectives from Indigenous voices, both those of local knowledge holders and from within the university. The

importance of this is ensuring that content is not created solely by people who happen to exist within the institutional academic community, which is an often-overlooked bias that was highlighted by Yuin academic Jade Kennedy and his colleagues in a recent article.<sup>31</sup>

In line with the values expressed in this book, the course aims to navigate away from the common Western educational pitfall of isolating scientific knowledge into individual fields, instead taking a holistic approach. Astronomy and ecology and other knowledges are not separated: in fact, the links between sky, land and water knowledge are emphasised. By rejecting the compartmentalisation of Indigenous knowledges, which often removes relational information and the applications of the knowledge, sophisticated and practical understandings can form. On discussing his motivations for designing the course in a holistic manner consistent with Indigenous values, Giles stated:

One of my biggest problems with modern Western science is the idea that everything has to be compartmentalised into this little box. But Indigenous knowledges, they're comprehensive. They don't compartmentalise into geography, geology, biology, chemistry ... It's all interconnected. Indigenous knowledge aims to put you in a framework that is connected with the society and Country you come from, and it teaches you how to respect it and care for it.<sup>32</sup>

Although it would be ideal to see courses like this one become available in all institutions across our continent, it is not appropriate to simply package the knowledge and present it as content. A holistic approach is not all that needs to be considered when incorporating Indigenous knowledges into higher education. If we wish to do this, we need a framework that guides the implementation while ensuring the knowledge is delivered in a manner that maintains its cultural and contextual integrity and associated protocols. As such, it has become a popular viewpoint that Indigenous perspectives cannot be authentically implemented into curriculums solely using non-Indigenous practices.

Jindaola is an educational development grants program centred on curriculum reconciliation that has been developed at the University of Wollongong and is described at length in the article by Kennedy and colleagues mentioned above. It is the result of a partnership between Aboriginal and non-Aboriginal academics, academic developers and Aboriginal communities. *Jindaola* is the Yuin word for 'goanna', which is known to the Yuin nation as a protector of knowledges who teaches about protocols and the appropriate practices that must be performed to maintain them. The name precisely represents the nature of the program – which is to guide the embedding of Aboriginal knowledge into the curriculum through a culturally appropriate framework grounded in Aboriginal methods and values.

The construction of a framework to guide authentic knowledge integration has been developed by the team of Susan Page, Associate Dean (Indigenous) of the Faculty of Social Sciences and director of the Centre for the Advancement of Indigenous Knowledges (CAIK) at the University of Technology Sydney (UTS); Michelle Trudgett, Wiradjuri woman and

Deputy Vice-Chancellor Indigenous Leadership at Western Sydney University (and former director of CAIK); and Gawaian Bodkin-Andrews, D’harawal man and associate professor at CAIK. The team members focused on meaningfully including Indigenous perspectives across all nine of their faculties at UTS, extending the reach of the perspectives beyond the creation of a standalone subject or course. Their research proposes that a standalone subject may offer content only to a small population of students, whereas embedding Indigenous perspectives into the curriculums across all disciplines and all years of a degree enables students to engage with applicable and tangible Indigenous perspectives and knowledge systems broadly, and directly highlights the systems’ application to each field. In a 2019 paper, Page, Trudgett and Bodkin-Andrews outline their framework for Indigenising the curriculum in a three-step process – Building, Connecting, Practising – that aims to embed perspectives early and rigorously into the overall curriculum.<sup>33</sup>

## **INDIGENOUS ASTRONOMY IN THE COMMUNITY**

The inclusion of knowledge can be realised in many ways outside the realm of higher education and is an area with endless opportunities for expansion. For Indigenous astronomy, there are several high-quality examples where traditional knowledge is integrated into places that are publicly accessible and immersive while remaining respectful and contextually relevant. They range from learning centres such as museums and planetariums to naming conventions and the use of Indigenous language.

Planetariums are a type of learning centre that engages audiences visually using creative and immersive projections of the universe. With the launch of ‘Skylore’ in 2018, Mount Coot-tha’s Sir Thomas Brisbane Planetarium became the first planetarium in Australia to feature a permanent exhibition of Indigenous astronomy. The exhibition was designed by Dr Duane Hamacher in collaboration with Wardaman elder Uncle Bill Yidumduma Harney, Yuggera elder Uncle Eddie Ruska, Meriam elder Uncle Alo Tapim, Euahlayi law man Uncle Ghillar Michael Anderson, and Turrbal songwoman Auntie Maroochy Baramba.<sup>34</sup>

Skylore covers a 13-metre-long curved wall detailing sky knowledge generously shared by the listed community members. As Aboriginal and Torres Strait Islander people have been demonstrated to be the world’s first astronomers, it feels sensible that our astronomical knowledges are embraced and celebrated in these relevant spaces. Ideally, this type of recognition will become commonplace in planetariums around the country.

A simple but powerful way of ingraining knowledge into public spaces is by incorporating the many surviving languages. Aboriginal and Torres Strait Islander astronomical knowledge systems are literally the world’s first, and yet they have hardly been championed on a local, national or global stage. Language is a powerful vessel of knowledge transmission and a first step for institutions to take in the process of correcting the global narrative about the history of astronomy.

As we discussed in Chapter 4, an example of successful community collaboration in

offering traditional names to place occurred through the renaming of the iconic Parkes telescope to Murriyang in Wiradjuri language. This process unfolded over two years of collaboration between Wiradjuri elders, CSIRO Parkes staff, the New South Wales Aboriginal Education Consultative Group and the North West Wiradjuri Language and Culture Nest.

One of the most powerful influences the International Astronomical Union has on the wider scientific community is its internationally recognised authority to designate names to celestial bodies and the geographical features on them.<sup>35</sup> In 2016, the IAU formed a group dedicated to the official naming of stars, aptly named the Working Group on Star Names (WGSN). Until then, stars had been officially recognised by their Bayer designation, where an object is catalogued by pairing the Latin name of the constellation in which it lies with a Greek letter indicating the object's appearance within the constellation, ordered from brightest to dimmest. Occasionally, popular names for objects are associated informally.

The Southern Cross is arguably the most well-known constellation in Australia, and it is an easily recognisable feature of the night sky. It appears on the flags of five nations – Australia, New Zealand, Brazil, Samoa and Papua New Guinea – and is a circumpolar constellation for most of Australia, meaning it doesn't go below the horizon. Even in metropolitan Melbourne, with its less-than-ideal observing conditions, the Southern Cross hangs above as an eternally patient aid in night-time navigation (see Chapter 2).

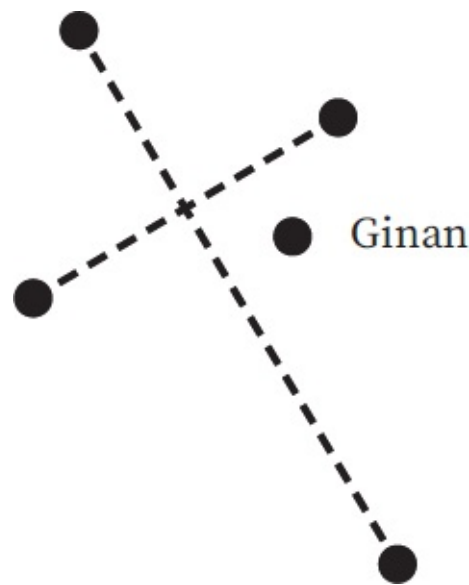


FIGURE 5.2: The Southern Cross (or Crux constellation) showing Ginan, the fifth-brightest star in the constellation.

The Southern Cross is composed of four stars that make a cross shape, and an additional off-centre fifth star. Using the Bayer designation system, this fifth star is called Epsilon Crucis (♆ Crucis). Epsilon is the fifth letter of the Greek alphabet and in the star's name indicates that it is the fifth-brightest star of the constellation Crux. In 2018, the star was officially globally recognised by the name 'Ginan', a word from the Wardaman language of

the Northern Territory (Figure 5.2). This came from the WGSN formally approving eighty-six non-Western star names for global recognition. Along with Ginan, three other Aboriginal star names are recognised, meaning they have the most ancient star names among those officiated. Two stars have been given the names Wurren (Zeta [ $\zeta$ ] Phoenicis) and Larawag (Epsilon [ $\epsilon$ ] Scorpii) from Wardaman traditions, and the third, Unurgunite (Sigma [ $\sigma$ ] Canis Majoris), comes from the Boorong people of Victoria.<sup>36</sup>

Ginan is a name offered by Bill Yidumduma Harney and is said to represent a dillybag that is filled with songs of knowledge, informing community on matters relating to ceremonial initiation. It is described in the book *Dark Sparklers*, which continues to serve as one of the most detailed dives into Aboriginal astronomy to date. The ceremonial traditions described by Ginan are also linked to those of Larawag, which operates as the signal watcher of ceremony. Wardaman oral traditions say that Larawag indicates when legitimate participants of ceremony are present, with the promise that initiation is safe to proceed.

Space archaeologist Dr Alice Gorman writes:

Of over 15,000 officially named places in the solar system (excluding Earth), it turns out that approximately 0.3 per cent are Australian Aboriginal words. They are found on four planets, Venus, Mercury, Mars and Pluto; four moons of Saturn; one moon of Uranus; and four asteroids. Some places, particularly on Mars and the asteroids, are named after similar features or relevant towns in Australia, which just happen to have Aboriginal names. Most, however, belong to Aboriginal ancestral beings related to the naming theme of the planet ... These [Indigenous names] are not forgotten 'gods and goddesses', like many of the classical names so common in the solar system, but very potent symbols of continuing Aboriginal cultural practices against the formidable array of colonialist alienation technologies.<sup>37</sup>

This indicates a significant appreciation of Aboriginal and Torres Strait Islander peoples' long history as astronomers but also an acknowledgement that the names need to be treated appropriately. It is important to note that this IAU naming convention does not invalidate or overwrite the names and systems attributed to these stars by other Indigenous communities, which are equally as important and distinguishable. It simply offers global recognition of the wealth of astronomical knowledge that belongs to non-Western communities globally, which historically has been overlooked.

Another example of the embedding of Indigenous knowledges into public spaces is the Starlore plug-in available for the open-source software program Stellarium, a free-to-use virtual planetarium that can be accessed directly from most smartphones and computers. Stellarium is a popular program for astronomy education due to its ability to simulate the night sky as viewed from any location at any point in time. It can be prompted to display labels and overlays for any celestial object or constellation and is highly customisable, allowing users to tweak the quality of the observation conditions to simulate a night sky free from the dimming impacts of the atmosphere and light pollution.

The Starlore plug-in offers content on the astronomical traditions of fourteen different non-Western cultures from around the world. Currently, two of these cultures are Aboriginal: the astronomy of the Boorong clan from north-western Victoria, based upon the works of William Stanbridge and John Morieson; and the astronomy of the Kamilaroi/Euahlayi nations, based upon the work of Robert Fuller. The descriptions begin by informing the user that this cultural knowledge is living knowledge that is still strongly connected to the respective communities despite the impact of colonisation. In the Kamilaroi/Euahlayi tab, users can select to see an art overlay that highlights the location of various features such as the Gawarrgay Celestial Emu and the Miyay-Miyay sisters of the Pleiades.

Lastly, one of the most important tasks in the Indigenous knowledges space is enabling knowledge and knowledge holders from a particular Country to share their knowledges with the Indigenous communities of that Country. This can occur in a variety of ways, facilitated by school groups and cultural leaders. For example, on Gamilaraay Country, a Yinarr healing gathering led by Rosie ‘Bumble’ Armstrong Lang occurs at least once a year, facilitating a space for Gamilaroi women to share knowledge and conduct women’s business. Other sharing opportunities occur at corroborees and cultural events such as Garma, the annual festival of traditional culture that occurs in Arnhem Land.

The significance of these forms of embedding knowledge is that they are in a format that is publicly available, free and accessible to a wide range of people who don’t belong to an academic institution. More of these approaches to inclusion are in development and will hopefully see greater public visibility in the future. For example, a Stellarium package that gives information on Wiradjuri astronomy is being developed by Wiradjuri artist Scott ‘Sauce’ Towney, palawa woman Tina Leaman and cultural astronomer Trevor Leaman.<sup>38</sup>

## **ASTROTOURISM**

Astrotourism is the idea of promoting geographical locations that offer exceptional sky viewing to stargazers. Astrotourism WA established itself in Western Australia in 2018, becoming the first of its kind in Australia. Its goal is to provide the best destinations and opportunities for stargazers to, well, stargaze. It is also on a mission to preserve the incredible dark skies of Western Australia by working with the community to reduce unnecessary light pollution. Founder and CEO Carol Redford explains: ‘Communities around WA are working to keep the night sky as dark as possible by reducing light pollution. While we’re protecting our night sky, we’re inviting visitors from around the world to share its beauty. At the same time, we’re growing our understanding of how stargazing brings people together.’<sup>39</sup>

Further, Astrotourism WA is finding meaningful ways to bring Aboriginal people into the stargazing scene, collaborating with Indigenous elders, guides and knowledge holders to share their stories under pristine Noongar skies. It has partnered with Beemurra Aboriginal Corporation at Yallalie Downs in Dandaragan to create astronomy tours from Western and Indigenous perspectives. Corporation chairwoman Madeline Anderson says, ‘It’s these

stories that we can not only pass on and share, but it's something that is part of who we are, it's part of our identity, and it gives us a sense of belonging and connectedness to the land.'<sup>40</sup>

Examples of astrotourism in other areas of the country are few and far between, but interest is growing. Recently, a company emerged in New South Wales called Blue Mountains Stargazing that aims to bring people together under the stars through storytelling. Indigenous, Greek and Western perspectives are included in its sky tour, with plans to have Pacific Islands speakers and understandings in the future. Similarly, the Dark Skies Downunder program based in Orange, New South Wales, offers tailored stargazing tours from Western and Indigenous perspectives. It is run by Trevor Leaman and primarily involves Wiradjuri descriptions of the sky, raising awareness of astronomical knowledge and Wiradjuri culture. Another exciting example of Indigenous-specific astrotourism is the collaboration between Tribal Warrior and National Roads and Motorists' Association (NRMA) that is bringing Aboriginal stargazing cruises to Sydney Harbour. The NRMA has devoted several of its boats to engaging the community with a side of the city sky they rarely get access to – a dark one. The cruises ran during the 2021 Sydney Solstice festival and are intended to be a feature of future festivals. Such programs are leading the way for astrotourism in Australia and celebrate Indigenous culture alongside Indigenous peoples.

Astrotourism in general, not just through an Indigenous lens, is an exciting and beneficial way for Australia to promote and utilise its natural resources. However, as we discussed in Chapter 4, such natural resources are at risk from multiple threats. If we cannot protect our dark skies, nobody will have the ability to enjoy or benefit from them. Now is an exciting time to acknowledge the significance of dark skies to all peoples across the continent and the world.

## **KEEPING KNOWLEDGE INTACT**

With so much ancient cultural knowledge entering the public domain after many years of suppression, how do we maintain that knowledge? We mentioned earlier in this chapter that Indigenous sky knowledge in the public domain often originates from a settler's interpretation of oral traditions captured during early contact. Before invasion it's believed there were up to 250 language groups with hundreds of distinct dialects.<sup>41</sup> According to the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS), today 159 languages are in use in varying degrees, and all of them are under threat.<sup>42</sup> Loss of language is only one of the many ways in which colonisation ravaged communities. Despite the enormous losses experienced since 1788, Aboriginal and Torres Strait Islander people still exist and modern linguistic research has shown that culture can transcend the loss of language.<sup>43</sup> The 2018–19 AIATSIS survey into languages found thirty-one Aboriginal and Torres Strait Islander languages being revived.<sup>44</sup> Additionally, two entirely new languages are emerging: Kriol and Yumplatok/Torres Strait Creole. Indigenous people and their cultures



are characteristically resilient and strong, as is the broader interest in them. So how do we ensure the knowledge is appropriately managed?

Several initiatives exist that focus on sustaining cultural knowledge. Importantly, their top priorities are maintaining and transferring knowledge to future generations while respecting protocols. AIATSIS is a national body that develops, preserves and provides access to a national collection of Aboriginal and Torres Strait Islander culture and heritage. Another example of responsive cultural management systems would be a First Peoples' Science Centre, as conceived by the City of Parramatta and described in a 2020 discussion paper by Wuthathi/Meriam lawyer Terri Janke.<sup>45</sup> The paper outlines the historical and current exploitation of Indigenous knowledge and emphasises the importance of having such a centre to support Indigenous cultural and intellectual property. Further, a First Peoples' Science Centre would assist in maintaining cultural knowledge already in the public domain and that held by community, with the appropriate protocols attached to it. Such a centre currently exists as a hope, but will undoubtedly soon become a reality. Perhaps, in line with the William Cooper Institute already mentioned, such a First Peoples' Science Centre could be named after a significant Indigenous scientific figure, such as David Unaipon, Ngarrindjeri scientist, author, inventor and storyteller. Unaipon received a Western education in the late 19th century and developed an interest in astronomy and physics, which eventually turned into a passion for perpetual motion, ballistics and polarised light. In the first half of the 20th century, he made ten patent applications for various inventions, including a design for sheep shears that is still used today. Recognition of our First Scientists can further help to ensure that our Indigenous culture remains the oldest continuous culture in the world.

As Indigenous science content continues to make its way into national curriculums and higher education spaces, the demand for accurate and informative teaching resources will grow. It is a fundamental necessity for educators to have access to reliable sources of information before presenting these concepts to students. If educators don't have direct access to trustworthy resources, they are at risk of engaging with curriculum changes in a manner that reinforces harmful stereotypes rather than challenging them appropriately. Understandably, inaccuracies such as outdated perspectives and misrepresentation of our cultures, histories and knowledge systems prevail, as the Archive was formulated without the agency of Aboriginal and Torres Strait Islander people.

Fortunately, this harm to Indigenous people and knowledge systems is being addressed and remedied with increased engagement in and management of the Archive. In 2021, the Australian Council of Deans of Science (ACDS) launched a public database of Indigenous science resources curated by Krystal De Napoli and Dr Angela Ziebell of Monash University in consultation with knowledge holders from across the country.<sup>46</sup> It aims to offer resources on a range of Indigenous science topics that have been developed with communities. Importantly, these resources do not perpetuate the harmful misinformation and language of some other resources in the Archive. The database also provides resources on cultural competency and teacher resources, including an introduction to Aboriginal pedagogies.

Across the waters in Aotearoa / New Zealand, Māori communities are also experiencing

increased interest in their ancestral sky knowledge. This interest has resulted in the emergence of an entirely new type of institution, Te Whare Tātai Arorangi o Tangotango rāua ko Wainui, the first Māori astronomy school and potentially the first modern-day Indigenous astronomy school in the world. Founded by Tainui astronomer Piripi Lambert and Ngati Awa elder Pouroto Ngaropō, it aims to train Māori communities in the ancient role of *tohunga kōkōrangī* (astronomers). The founders believe the school can ‘improve the health and wellbeing for all of their people’.<sup>47</sup> The entry-level courses are open to anyone who wants to learn some of the ancient tohunga kōkōrangī ways.

The introduction of similar institutions in Australia would raise the visibility of Aboriginal and Torres Strait Islander astronomy into the mainstream. The interconnected nature of Indigenous sky knowledges means that they are contextually relevant to natural cycles in the land upon which Australia exists, and engaging with them will inevitably lead to a more environmentally conscious population.

## UNDER FUTURE SKIES

Respecting and engaging with Indigenous peoples and knowledge is not just ethically preferable, it is imperative for the long-term survivability of every living creature on this land. The dominant culture has prioritised surplus over need, resulting in sickness in Country and communities. Indigenous knowledges show us that scientific endeavours do not have to be synonymous with destruction. In a time when we are looking to the solar system and the stars for humanity's very continuation, we must acknowledge that science does not have to be devastating. If we continue our unsustainable ways of living, our resources will eventually run out and so will our time here, or anywhere. Indigenous knowledges are alive and well today because of the sustainable practices they encourage, and Indigenous peoples want to share with those who are interested in listening. We know there is an obligation to care for Country. Improving connections with these communities and their expertise can help restore the health of Country for all peoples.

By acknowledging and implementing Indigenous knowledges, including land, water and sky knowledge, without excluding those who have held it for so long and shared it, we can have hope for the future of all beings living under our shared sky. Indigenous peoples all over the world teach us that sustainability does not come at the cost of knowledge or progress. What is more progressive than 65,000+ years of survival? And so, in the hope of many more millennia on Earth, we have written a letter from the not-too-distant future custodians of the planet to the current ones.

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*The year is 2044 and Country has never been healthier. The droughts are less severe, there are more fish in our oceans and rivers than plastics, bushfires are completely controlled by frequent cool burns, and our skies have been almost entirely cleaned of near-Earth pollutants and junk.*

*Don't get us wrong – things were looking really dire there for a while. Not just for a moment, not even just for one lifetime, but for generations Indigenous peoples,*

conservationists and ecologists have fought for the protection of Country. All Country: the land, the waters, the mountains, the animals and the sky. Clever people have known since forever about the underlying relational network that generates the phenomena we call life. These clever people also know how sensitive the network is to change.

It took a lot to get the mega-rich to release their grasp, but we were able to do it thanks to the teachings and practices of the world's First Peoples. It all started with the opening of Te Whare Tātai Arorangi, the first Indigenous astronomy school in the world, based in Aotearoa. The Māori peoples showed the world that Indigenous peoples were just as much owners of the sky as the billionaires were. Then Australia opened the First Peoples' Science Centre, giving communities access to and ownership of their culture. The world followed soon after. This was vital in connecting Indigenous peoples internationally and giving them authority over their own stories. With these stories, Indigenous peoples easily proved that their connection to the sky was indisputable, making them the original and rightful custodians of Sky Country. This was seen in the 2013 granting of sea rights to Torres Strait Islander peoples, recognising their authority over their Sea Country – legally proven using a sacred spiritual moon dance called Gedge Togia, which connects the Meriam and Mabuyag islands through shared Sky Country knowledge.<sup>1</sup>

Communities quickly got to work. The first thing to go was the incessant lightening of our skies. Smart lights were soon invented and installed around the world, low to the ground and shielded to protect nocturnal animals and reduce skyglow. Next it was time for space junk to be dealt with. It wasn't easy, but First Peoples are problem-solvers and they worked with great speed to de-orbit the majority of abandoned debris in Earth's orbit. This included the thousands of redundant megaconstellations that were largely destroyed in a great space-junk collision not long after they were all deployed. Some remnants that survived the re-entry into Earth's atmosphere are now housed in museums.

The quick results achieved by First Peoples in cleaning up the skies gave the world a renewed sense of hope, and many more immediately jumped on board. Committees were set up to do the same on the land, with all peoples represented at the table, with one goal: to take care of all living and non-living things. Earth is now entirely powered by renewable energies, and ecosystems are flourishing. A lot of damage was done, but we managed to turn it around before all was lost. First Peoples are equally represented on most development approval committees to ensure that development does not come at the cost of our sensitive natural systems.

Our institutions have also learnt a thing or two about holistic knowledge, and how the interface between Indigenous and non-Indigenous systems can produce new understandings of our world. The results have been groundbreaking in the fields of health, psychology, international relations and communications technology, to name a few. Notably, people no longer talk about colonising or terraforming alien worlds but are instead focused on 'treading lightly' so as not to disrupt the sensitive balances that might exist. These days, we look simply to observe and learn. Changing the goal from altering entire distant planets to delicately observing them has drastically improved our ability to actually get to them. Now

*that we are taking less with us, we can travel distances that were previously thought impossible. All that was needed was a slight change in focus.*

*Earth is now a place where knowledge is respected regardless of the race or qualifications of the person or community who holds that knowledge. Instead, the validity and usefulness of the knowledge is what is respected. Under the skies of the future, all peoples are custodians of Country.*

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– KN

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# IMAGE CREDITS

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# NOTES

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