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STUDY GUIDE

ANIMATION OF THE EMU IN THE SKY BY MARGARET WHITEHURST

Deep in the Australian Outback, two children go on a magical odyssey of discovery to uncover the mysteries of the Universe through the world's largest radio telescope and its oldest living culture.

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CONTENT HYPERLINKS

THE EMU IN THE SKY BY MARGARET WHITEHURST

Twelve year old Max Winton and thirteen year old Lucia Richardson, leave the coastal town of Geraldton in Western Australia and head 300km east to the Square Kilometre Array, or SKA, in the arid heartland of the Murchison region. There they are met by Professor Steven Tingay who has been working on the SKA for 20 years. He shows them around the facility and tells them that the SKA is one of the world's largest ever scientific projects that will look deeper into space than ever before, back to soon after the Big Bang when the Universe was created, nearly 13.8 billion years ago.

After learning about the expansion of the Universe, the children step through a magical door and are welcomed to Yamaji country by artist and Yamaji elder, Charmaine Green. Charmaine leads the children on a journey across her country teaching them about the many Aboriginal language groups that exist across the continent and the fundamentals of Indigenous culture.

They learn that art is important to all Aboriginal people as a way of telling important stories and passing on knowledge. She introduces Max and Lucia to artist and Yamaji elder, Margaret Whitehurst. Margaret describes her painting, *the Emu in the Sky* and tells the story behind the painting. The Emu in the Sky sits in the Milky Way and tells the Yamaji when it is time to go egg hunting.

Margaret and Charmaine take the children egg hunting. They find some and blow out the yolks and eat it.

Charmaine and the children continue their journey where they meet Kevin and Barbara Merritt. Barbara is painting the Seven Sisters. Kevin describes the story of the Seven Sisters while animation illustrates the story.

We travel out to the stars making up the Seven Sisters also known as the Pleiades. There we learn the life cycle of stars which, once exhausted of fuel, can explode in a Supernova, scattering the elements for new life throughout the Universe.

Meanwhile back on Earth, Charmaine and the children meet with Glenda and Wendy Jackamarra. Wendy is painting the Jewellery Box or Jewel Box constellation. Glenda tells the story of the painting and how Wendy learnt about it from the scientists.

Out in space we visit the Jewel Box also known as the Kappa Crucis. We learn that the colours of the stars are caused by how hot they burn.

Finally, at night on a lit football field, the children are brought by Steven Tingay to once again meet with all the artists. He wants them to experience how he first saw the Emu in the Sky. The lights are suddenly turned off.

As the stars begin to appear the audience is invited to look for *the Emu in the Sky* and consider the notion that we all live under one sky, a shared sky.

MAX WINTON, MARGARET WHITEHURST, LUCIA RICHARDSON AND CHARMAINE GREEN FORAGE FOR EMU EGGS IN MULLEWA

About...

Lucia Richardson

Lucia is an Amangu girl with extensive familial connections throughout the Yamaji Nation. She has been dancing from the age of 3 years which highlighted her natural acrobatic and contortion skills.

Over the past 8 years, Lucia has been performing at various community events in her hometown of Jambinu (Geraldton). Her goal is to become a student of the National Institute of Circus Arts (NICA) and once she graduates, she aims to travel the world with Cirque de Soleil.

Max Winton

Max Winton is a sports mad teenager from Geraldton WA. A regular in school choirs & productions, which carried over to his participation with the Creative Works Youth Theatre under the guidance of Paula Wilkinson. He was part of their 2019 production of Cinderella before auditioning and winning his role in Star Dreaming with Prospero Productions.

He's a lover of all things nature, having spent most holidays camping & fishing around the Midwest & south west regions. Most of Max's spare time is taken up with playing basketball & soccer both at a local and representative level, most recently making the regional state U14 Soccer team.

Professor Steven Tingay

John Curtin Distinguished Professor Steven Tingay is the Executive Director of the Curtin Institute of Radio Astronomy (CIRA) at Curtin University in Perth and leads the Curtin University node of the International Centre for Radio Astronomy Research (a Joint Venture with The University of Western Australia).

Prof. Tingay was named Scientist of the Year at the 2020 Western Australian Premier's Science Awards. He is an expert in astronomy and astrophysics, in particular radio astronomy. His areas of expertise encompass building and using radio telescopes, as well as astrophysical interpretation. Tingay likes designing challenging and novel experiments to answer fundamental questions about the Universe.

Prof. Tingay has been at Curtin University since 2007, when he founded CIRA (now with an ERA ranking of 5 in "Astronomy and Space Sciences" and "Electrical and Electronic Engineering").

Before 2007 Tingay was at Swinburne University of Technology, CSIRO, and the NASA Jet Propulsion Laboratory in Pasadena. He has a PhD in Astronomy and Astrophysics from the Australian National University and an Honours degree in Physics from The University of Melbourne. Recently Tingay was on secondment in Italy for 18 months, as Director of the INAF Instituto di Radioastronomia in Bologna and Head of Section II of the INAF Science Directorate. Tingay is the Director of the Murchison Widefield Array (MWA) project. He has authored or co-authored over 270 papers in international refereed journals and has attracted over $110m of research funding since 2007. Tingay's team leads Australia's participation in the SKA work packages to design, deploy, and test the 130,000 low frequency antennas and electronics.

Charmaine Green

Charmaine is from the Wajarri, Badimaya and Southern Yamaji peoples of the Mid West of Western Australia. She has lived and worked in Rural Western Australia (Mid West and Pilbara) most of her life and which the Aboriginal sector industry as a community development practitioner and social science researcher. Charmaine is also a self taught visual artist and published poet who writes and paints about her country and culture.

Her poetry has appeared in *Antipodes, Artlink Magazine, Cordite Poetry Review, The Kenyon Review* and *The Lifted Brow*, as well as in the anthologies *The Fremantle Press Anthology Review of Western Australian Poetry, Inside Black Australia: An Anthology of Aboriginal Poetry, Ora Nui: A collection of Maori and Aboriginal literature, The Penguin Book of Australian Women Poets* and *Those Who Remain Will Always Remember: An Anthology of Aboriginal Writing.*

Charmaine has developed a contemporary artistic style giving special importance to line work which she believes represents the style of work done by her ancestors in the Murchison and Midwest Region.

Charmaine has a strong sense of place linking her to country and likes to reflect this in her artwork.

Margaret Whitehurst

Wajarri visual artist Margaret, was born on Billabalong Station in the Murchison, Western Australia. She is the second of seven children. Her childhood was spent swimming and fishing in the Murchison River and attending Tardun Mission School.

Her inspiration comes from the works of other Aboriginal artists and her Auntie Olive Boddington. She came to painting later in life, studying art at Geraldton TAFE through Wila Guthurra, and had only been working as an artist for short period prior to joining Yamaji Art Centre. Margaret's paintings are a mixture of traditional and contemporary Aboriginal styles and techniques, each telling a story about the Murchison, her ancestral lands and her childhood. These include the types of bush food found on her ancestral lands.

Margaret is the mother of seven children herself, she is an industrious and prolific artist. Her current works are reflections of Yamaji country.

Margaret now lives in Geraldton Western Australia; she is represented by Yamaji Art Centre.

Barbara Merritt

Badimaya Artist Barbara Merritt was born in Carnarvon in the 1950s, and grew up her Ancestral country in Mount Magnet and then later in Mullewa. Her father was a shearer who worked on outback stations and her mother worked at the hospital and raised a close family of ten. Barbara has fond memories of weekends hunting out in the bush with her family; this was continued into adulthood and states that painting the land where she comes from is her biggest influence.

Barbara always wanted to be an artist when she was young but being a mother of seven children came first. Now that her children are grown, Barbara has fast become a very active Artist in the Community. Barbara's journey started at Wila Gutharra and studying at Geraldton TAFE before joining Yamaji Art Centre.

Barbara has been involved in NAIDOC celebrations at local schools and input into public art projects such as Murals at Lake Indoon, Geraldton PCYC sharing her knowledge. With always more than one painting on the go, Barbara paints about the Knowledge and Traditional stories passed down by her Elders.

Barbara is known as the Queen of Colour and enjoys painting light hearted stories with bright colours to create an uplifting feeling in today's depressive society. Her paintings are an explosion of bright colours using Traditional and Contemporary Aboriginal styles and techniques.

Wendy Jackamarra

Wendy has been painting for about 15 years and is exploring traditional and contemporary art styles and enjoys painting at Barndi Nyarlu Arts in Mullewa.

Wendy paints about her family and connection to country often drawing inspiration from the colours of the country with many of her works showing the earthy tones of the red country to the blues of the sky and ocean and pinks, yellows and blues of the wildflowers.

"I paint about my country, my feelings and community issues."

Wendy lives in Mullewa with her family.

The Director – Perun Bonser

Perun Bonser is an Indigenous (Ngarluma) writer/director based in Perth. Perun has been a Directors' Attachment on *The Heights* season 1 (ABC) and *Thor Ragnarok* (2017) and has completed the 'Directing Actors' masterclass at AFTRS.

Perun is currently directing two features: *Star Dreaming* (Prospero Productions) and *Dying Young* (Joined Up Films). Perun developed *One of the Good Ones* with his partner Sukhjit as part of Impact Australia 2020.

Perun has written and directed several short films including *The Shore* (ABC), *Blight* (ABC), *Shadow of Displacement* (ABC), *Fighter* (NITV), *Invisible Light* (ABC) & *Unspoken* (ABC) which have been screened at Sydney Film Festival, ImagineNATIVE, Hot Docs, St Tropez International Film Festival to name a few. Perun has co-written/co-created an ABC series *Aussie Rangers* as well as a feature doco *Noongar Footy Magic.*

The Narrator – Ernie Dingo

Some of Ernie's most recent television shows include *Mystery Road, Squinters* – and his regular television program *Going Places With Ernie Dingo.* Other television includes *Redfern Now – Dogs Of War, Who Do You Think You Are* and *DNA.*

Ernie Dingo has earned enormous respect as a performer capable of extraordinary versatility. His talents as an actor, television host, reporter and comedian have made him one of Australia's best known and most loved performers, recently starring in the successful feature film *Bran Nue Dae*.

In 1979, Ernie was offered the lead role in the play Kullark in Perth. His subsequent theatre work includes a national tour of Jack Davis' *The Dreamers*, a US tour of *State of Shock* in 1985 (which also played in Sydney and at the National Playwrights' Conference in Canberra in 1984), *Bran Nue Dae, Tourmaline*, a visit to Poland with the Gardzienile Zubrycka

Theatre Association as part of a Foreign Affairs cultural relations program in 1987 and working as a stand-up comic at Sydney's Trade Union Club.

Ernie's first major television role was in *Tudawali* (1987) for which he received an Australian Film Institute Award nomination for Best Actor in a Television Drama. He accepted on behalf of the production a Special Jury Prize at the Banff Television Festival in Canada.

His numerous other television credits include *The Cowra Breakout* (1984), *Dirtwater Dynasty* (1987), *Clowning Around* (1991), *A Waltz Through the Hills* (1987), for which he won an AFI Award for Best Actor in a Television Drama, the comedy series *Fast Forward* (1989), *The Flying Doctors* (1992), *Heartland* (1994) and the lavish Barron Entertainment production of *Kings in Grass Castles* (1996) based on the novel by Dame Mary Durack.

Ernie's film credits include *Dead Heart* (1996), *The Fringe Dwellers* (1985), *Crocodile Dundee II* (1987), *Tommy Tricker and the Stamp Traveller* (1987), *Capuccino* (1988), Wim Winder's *Until the End of the World* (1990) and *Mr Electric* (1993).

He was with the top rating Seven Network program *The Great Outdoors* since it began in 1992. Ernie also was the host of *The World Around Us* on the Seven Network from 1998 until 2001, and has fronted numerous other Seven productions, including two Olympic specials and Melbourne's Comedy Gala. His most recent television productions are *Outback Wildlife Rescue* and *No Leave No Life*.

Ernie is a passionate advocate for his people and is vigilant about the portrayal of Aboriginals in film and television. He has won numerous awards and accolades and in 1997 was declared one of Australia's Top 100 "national living treasures".

In 1990, Ernie was awarded the General Division of the Order of Australia by Her Majesty the Queen. In 1994, he was voted "Aboriginal of the Year" by the NAIDOC Committee and "Personality of the Year" by the Australian Caption Centre. In 2004 he was again recognised for his work when he was awarded the Deadly Award for 'Outstanding Contribution to Film and Television'.

He was awarded the 1999 People's Choice Award for 'Favourite TV presenter' – his fellow nominees in the category were Ray Martin, Daryl Somers and Bert Newton.

Curriculum Links

Star Dreaming is suitable for students undertaking:

- **Year 1-6 Humanities and Social Sciences**
- **Year 1-6 English**
- **Year 1-6 Visual Arts**
- **Year 5-10 Science (with applications in Senior Science courses)**
- **Year 7-10 Design and Technologies**
- **Year 7-10 Media Arts**

with further links to Year 5-9 Mathematics and the Cross-curricular priority of Aboriginal and Torres Strait Islander Histories and Cultures.

While many activities across this Study Guide are specifically intended for certain subjects or year levels, as indicated with each header, these tasks can be modified to suit different cross-curricular purposes as the teacher sees fit.

As a curriculum resource in Humanities and Social Sciences, *Star Dreaming* is primarily relevant to the Inquiry and Skills component of the subject. The questions of Indigenous history allow students to develop their understanding of the History strand of Knowledge and Understanding, while tasks relating to the continent of Australia tie into the Geography strand of this component.

The activities found under the 'Indigenous Storytelling' heading centre largely on English and Visual Arts curriculum links, though elements of these curricula can be found in other sub-activities in this Study Guide. There may also be some applications to Humanities and Social Sciences that can be explored across these activities.

As a curriculum resource in Science, *Star Dreaming* is primarily relevant to the Earth and Space Sciences strand of Science Understanding. Investigations and observations suggested by the program also allow students to develop their Science Inquiry skills. There are further applications linked to Senior Physics, particularly in Unit 3 in topics such as 'Developing understanding of planetary motion' and 'The Square Kilometre Array'.

The activities found under the 'Fulldome Photography' heading centre largely on Design and Technologies and Media Arts curriculum links, though also incorporate some Science descriptors. As a curriculum resource in Design and Technologies, *Star Dreaming* is relevant to the Knowledge and Understanding strand. In Media Arts, the program provides the opportunity for students to explore technical and symbolic elements in the context of a Fulldome documentary. Note that while most activities can be commenced after viewing the film, 'Fulldome Photography' is best introduced beforehand.

Teachers are advised to consult the Australian Curriculum online at https://www.australiancurriculum.edu.au/ and curriculum outlines relevant to their state or territory for further information.

FILMING AT THE SKA

Great Southern Land

Year 1 – 6 Humanities and Social Sciences; Aboriginal and Torres Strait Islander Histories and Cultures

"Australia, the oldest continent on the planet."

So begins *Star Dreaming,* an exploration of the history, geography and culture of the Australia and the infinite sky expanding above it. Narrator Ernie Dingo goes on to explain that Australia is "also the home of the world's oldest living culture: sixty-fix thousand years of knowledge, past, present and future."

Yet *Star Dreaming*'s gaze is not firmly fixed on the past. Later in the documentary, we visit Murchison, a bioregion in the mid-west of Western Australia. The ancestral land of the Yamaji people, Murchison is also home to the Square Kilometre Array (SKA) – "the world's largest radio telescope."

Star Dreaming conjures the ancient past of Australia as a continent and as a centre of culture, while also paying witness to modern Australian innovations like the SKA. For this activity, your class will do the same.

Form a small group of four students from your class. Discuss and assign the following roles to your group members. While all members will contribute to aspects of the task, you will have additional responsibilities based on your role:

- **Leader:** the group leader will ensure that their group is on task and that other members are doing their jobs.
- **Scribe:** the scribe will be in charge of recording any notes and preparing the presentation (in whatever form it takes)
- **Timekeeper:** the timekeeper will ensure that the group is on track to complete their task in the time allowed by your teacher
- **Presenter:** once your presentation is complete, the presenter will take the primary role in presenting their findings (though all group members should participate!)

Once you have assigned your role, your teacher will assign you one of the following three topics to investigate:

Why is Australia considered the "oldest continent on the planet?" How did Australia develop as a continent and how do we know its age?

What makes Indigenous Australians the "world's oldest living culture?" How do we know this, and how does Aboriginal and Torres Strait Islander culture compare to other ancient cultures?

What makes the SKA "the world's largest radio telescope?" How long has it been the world's largest? Compare it to other radio telescopes across the world.

In your group, consider and research your answer to these questions, preparing a short presentation that you will share with your class. Your presentation can be in a format of your choice – with your teacher's permission – but should include a visual component; for example, a poster, brochure, video, slideshow presentation or even a performance element.

The following sites may aid your preparation, but you should complete your own research:

- **"Australia: The Land Where Time Began": https://austhrutime.com/venerable.htm**
- **"DNA Study Finds Aboriginal Australians World's Oldest Civilization": https://www.history.com/news/dna-study-finds-aboriginal-australians-worlds-oldest-civilization**
- **"The SKA Project": https://www.skatelescope.org/the-ska-project/**

MULLEWA

MAX WINTON, LUCIA RICHARDSON, CHARMAINE GREEN, GLENDA JACKAMARRA AND WENDY JACKAMARRA IN BUNDYBUNNA

Indigenous Storytelling

Year 1 – 6 English; Visual Arts. Aboriginal and Torres Strait Islander Histories and Cultures

Star Dreaming introduces its audience to a range of talented Aboriginal artists. We meet Charmaine Green, Wendy Jackamarra, Barbara Merritt and Margaret Whitehurst, painters and poets whose art encapsulates Indigenous history while exploring contemporary issues.

These artists are continuing a tradition of Aboriginal storytelling that spans millennia. As young Amangu woman Lucia Richardson explains,

"My people like to tell stories as a way of passing on knowledge by using painting, dances and having a yarn around the campfire."

In that spirit, this activity will begin with your class in a **yarning circle.** Yarning circles are drawn from Aboriginal and Torres Strait Islander culture and are a way of communicating effectively and respectfully. A yarning circle, as described by the Queensland Curriculum & Assessment Authority[1], operates as shown in the panel on the right.

MARGARET WHITEHURST

A yarning circle is usually initiated or hosted by an individual — a teacher, a student, or a visitor.

Yarning circles can take a number of formats but the following guidelines generally apply when initiating a yarning circle.

1. ***Sit in a circle:*** Participants sit in a circle and are encouraged to actively listen to others' views. Participants should understand that they are all considered equal within the circle and that there is no hierarchy.
2. ***Introduce the group:*** The host invites participants to introduce themselves and share something about themselves.
3. ***Introduce focus questions:*** Yarning circles can be undertaken for many reasons. The host introduces the purpose of the yarning circle or the focus question to participants.
4. ***Share ideas and thoughts:*** The host encourages participants to take turns to talk and to promote reciprocal sharing and learning. Time can be allocated for participants to write or draw their thoughts after each person speaks. The host could provide butcher's paper in the middle of the circle for participants to record their thoughts, or hold the circle outside so participate can draw their thoughts in the dirt.
5. ***Reflect:*** Resolve any actions or issues identified by the yarning circle, or agree to follow up in future yarning circles.

KEVIN AND BARBARA MERRITT PAINTING SEVEN SISTERS

The focus questions of your yarning circle conversation will relate to your knowledge of **Indigenous Australian art and storytelling.** Your teacher will guide the conversation, asking clarifying questions to help you and your fellow students share what you know about how Aboriginal and Torres Strait Islander culture is expressed through storytelling and art. Some questions you might want to consider are:

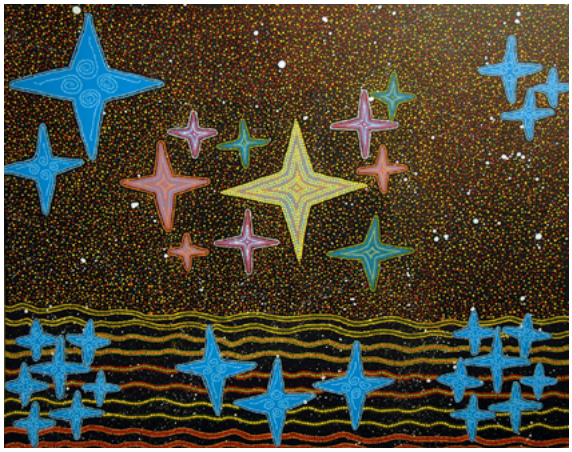
- How does Australian Indigenous storytelling differ from Western storytelling (if at all)?
- What do you know about Indigenous cultural stories and beliefs?
- What do you picture when you hear "Aboriginal art"?
- How is Indigenous Australian art important to Aboriginal and Torres Strait Islander people? Did it have a purpose – and does art need to have a purpose?

After completing the yarning circle, you will individually find your own piece of Aboriginal or Torres Strait Islander art. This could be a painting, a poem or a story. (You're encouraged to complete this as homework in your own time, though your teacher may provide class time for this.) Some websites that may help you locate an appropriate artwork are listed below:

> **Japingka Aboriginal Art**, https://japingkaaboriginalart.com/
> **Kate Owen Gallery,** https://www.kateowengallery.com/
> **Kullilla-Art Dreamtime Stories,** https://www.kullillaart.com.au/dreamtime-stories/

Share your artwork with your class. Your teacher will select some example artworks and lead a discussion around that art.

MARGARET WHITEHURST, CHARMAINE GREEN, LUCIA RICHARDSON AND MAX WINTON IN MULLEWA



CLOCKWISE TOP LEFT: SEVEN SISTERS BY BARBARA MERRITT • THE JEWELLERY BOX BY WENDY JACKAMARRA • MAX WINTON, CHARMAINE GREEN, MARGARET WHITEHURST AND LUCIA RICHARDSON

If the artwork is a painting, you might want to consider what visual elements the artist has used: Long brushstrokes or short? What sort of shapes and colours have they used? For stories and/or poems, reflect upon the kind of language that's used and the message the story might have. In both cases, reflect upon how it makes you feel.

After analysing some of these artworks, run another yarning circle considering if your feelings and knowledge of Aboriginal and Torres Strait Islander art has changed – or not – after researching and discussing these artworks.

Finally, research the art of one of the artists featured in *Star Dreaming:*

- **CHARMAINE GREEN**
- **WENDY JACKAMARRA**
- **BARBARA MERRITT**
- **MARGARET WHITEHURST**

Write a short (100 – 200) word response discussing the features of the artist's work (or one of their artworks), considering how it relates to your understanding of Australian Indigenous art, the techniques used and how it makes you feel.

Star Stories

Year 1 – 7 English; Science; Aboriginal and Torres Strait Islander Histories and Cultures

Indigenous Australians are sometimes described as the first astronomers; for instance, from the *BBC Earth* article "Australia's first astronomers"[2]:

> The Yolngu people in Northern Australia explain how the tides work: as the moon rises through the ocean, it alternately fills and empties with water, making the sea level rise and fall. This explains why the tides are synchronised with the moon, and why tides are higher at full moon and new moon than at a quarter moon, because then the moon isn't filling up as much. If this idea seems a bit different from the modern scientific explanation involving the gravitational pull of the moon, bear in mind that, pragmatically, it works. It enables a Yolngu elder to predict the timing and height of the next tide. Contrast that with the explanation by Galileo, the father of modern science. His interpretation, involving the motion of the Earth around the sun, was not only totally wrong but also failed to explain the connection between the ocean tides and the moon. Unlike the Yolngu explanation, his theory had no predictive power.

The final sentence of this paragraph is important; to be an astronomer is, after all, about more than gazing into the night sky and naming constellations. Astronomy is a science, and scientific theories are founded on their ability to collect observations and hypotheses into *predictions.* So when, in *Star Dreaming,* Max and Charmaine muse that Aboriginal Australians might be the world's "oldest astronomers", there's evidence to support that!

CLOCKWISE TOP LEFT: MARGARET WHITEHURST IN MULLEWA • MAX WINTON, PROF STEVEN TINGAY AND LUCIA RICHARDSON IN GERALDTON • MULLEWA

THE EMU IN THE SKY BY MARGARET WHITEHURST IN MULLEWA

The Emu in the sky– or *Yalibirri Ilgari* – as introduced in *Star Dreaming* is an example of this, used by First Nations people to tell when to collect Emu eggs – and when not to – long before contemporary calendars existed.

- Watch the TEDx Talk "Look up! There's an emu in the sky: Duane Hamacher at TEDxNorthernSydneyInstitute" on YouTube, located at https://www.youtube.com/watch?v=KViPueei7TE, from 6:15 to 10:35 (or, if you wish, the entire video which runs just under 15 minutes). Astrophysicist Dr Hamacher explains the astronomical and geographical significance of both the Emu in the sky and the story of Tagai.
- Research the Emu in the sky and how it was used by Aboriginal Australians. Use your findings to complete the table[3] below.
- Why did the location of the Emu in the sky throughout the year aid Indigenous Australians in hunting eggs? Consider the emu's breeding habits and the seasons.
- In a small group, complete a short summary (a brochure, video or report) summarising the historical, cultural and astronomical importance of the Tagai story.
- Discuss as a class the claim that Indigenous Australians are the "world's oldest astronomers" and whether or not you agree with this statement – and why.

YOU CAN COMPLETE THIS PAGE IN ACROBAT

YOUR NAME

MONTH(S)	LOCATION OF THE EMU IN THE SKY	FEATURES OF THE FOREST HABITAT THAT THEY RELY ON

What's the Frequency?

Year 5 – 9 Science; Mathematics

One of the key figures we're introduced to in *Star Dreaming* is Professor Steven Tingay, the Executive Director of the Curtin Institute of Radio Astronomy. As part of his role, Professor Tingay works with the Square Kilometre Array; as he explains to Max and Lucia, he's "a radio astronomer, which means that [he studies] the universe by looking at radio waves that are created by objects in space."

If you picture astronomers, you probably either think of astronauts – undertaking the increasingly rare practice of venturing outside the Earth's atmosphere – or perhaps someone bedecked in a lab coat gazing through a telescope lens into the night sky.

Indeed, much of science's knowledge of our universe comes through what we can *see* through telescopes in the visible spectrum of light. But radio astronomy – the study of electromagnetic radiation outside the spectrum of light detectable by human eyes – presents another frontier of knowledge to help us understand what lies beyond our Earth.

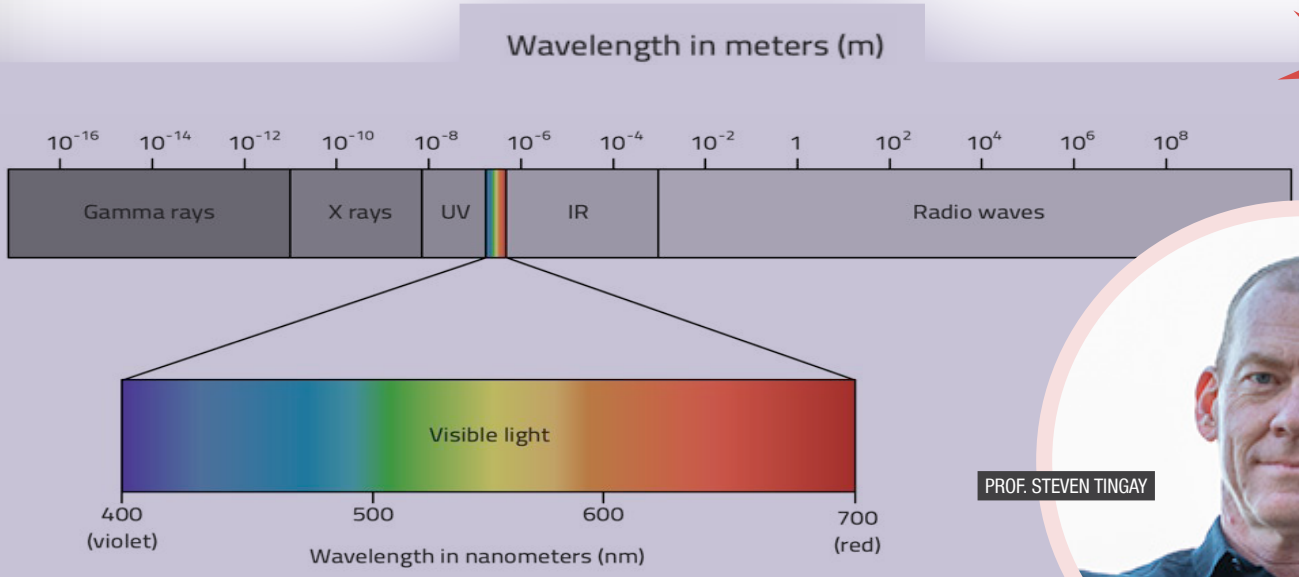
Star Dreaming explores radio astronomy, teaching us that "astronomers use telescopes to collect the full spectrum of radio waves" and that, in the spectrum of electromagnetic radiation, "visible light to humans makes up only a tiny percentage." In this activity, you'll investigate this spectrum and how it helps contribute to modern astronomy studied by scientists like Professor Tingay.

The below diagram represents the electromagnetic spectrum. Using the NASA resource "Tour of the Electromagnetic Spectrum" at <https://science.nasa.gov/ems/01_intro> and your own research, answer the following questions individually:

ANTENNA AT THE SKA

- What is an electromagnetic wave?
- What is the wavelength of electromagnetic radiation and why is it important?
- What is the frequency of a wave and how does it relate to its wavelength?
- Describe each of the following sections of the electromagnetic spectrum, identifying its behaviour, wavelength range and applications (in science and/or nature):
  - **Radio waves**
  - **Infrared waves**
  - **Visible light**
  - **Ultraviolet waves**
  - **X-Rays**
  - **Gamma Rays**
- How are electromagnetic waves affected by the Earth's atmosphere?
- What electromagnetic waves are emitted by celestial bodies (planets, stars, etc)?

After answering these questions individually, discuss your answers with a partner. Then discuss as a class how you think electromagnetic radiation might be relevant to astronomy; specifically, radio astronomy.



PROF. STEVEN TINGAY

YOU CAN COMPLETE THIS PAGE IN ACROBAT

YOUR NAME

	AVG DISTANCE FROM EARTH (M)	AVG TIME FOR LIGHT TO REACH EARTH
MERCURY	9.17×10^{10}	
VENUS	4.14×10^{10}	
MARS		4 minutes and 20 seconds
JUPITER	6.29×10^{11}	
SATURN		1 hour and 14 minutes
URANUS		
NEPTUNE		

Note: these values are average distances as planets will be varying distances from the Earth at different points in their orbital cycle.

All electromagnetic waves travel at the speed of light, which is three hundred million metres each second – or m/s in scientific notation. As this speed, typically represented by the pronumeral , is constant, we can use the formula or its other forms to calculate how long electromagnetic radiation takes to reach us from other planets.

- Use this rule to complete the table above (note that *both* measurements are missing for Uranus and Neptune – you'll need to research these yourself!)

Read the following archived article from NASA regarding an important breakthrough in radio astronomy: "How One Night in a Field Changed Astronomy", https://www.nasa.gov/vision/universe/solarsystem/radio_jupiter.html

Then answer the following questions, conducting your own research as required:

- What did Bernard Burke and Kenneth Franklin discover, according to the article?
- Franklin is quoted as saying, "Our identification of Jupiter as a radio source is not based directly on reasoning, but more on luck." Evaluate the accuracy of this statement; it is true, or a modest exaggeration?
- Why was Burke and Franklin's discovery significant?
- What's an advantage of radio astronomy compared to other measures of observation?
- How did Burke and Franklin's discovery affect the future of radio astronomy?
- What do we know about our solar system thanks to radio astronomy since this event? *(This is a big question, so try to keep your answer to one paragraph!)*

L–R: FILMING AT MULLEWA • FILMING AT RUNDLE PARK

FROM TOP: MAX WINTON, PROF STEVEN TINGAY AND LUCIA RICHARDSON IN GERALDTON • SHARED SKY BY SEVERAL DIFFERENT ARTISTS

An Expanding Universe

Year 10 Science; Senior Physics

Radio telescopes such as the Square Kilometre Array help astronomers to learn things about our universe – and not just how our universe exists now, but what it *was* like and what it *will* (likely) be like.

We're given some insight into this across *Star Dreaming.* Our narrator explains that,

"When we observe the most distant galaxies, we see them as they were over 13 billion years ago, soon after the Big Bang."

While Professor Tingay offers the dispiriting observation that,

"It will take billions and billions of years, but as the theory goes, there may come a time when space will have expanded to the point that we won't be able to see distant galaxies anymore."

Each of these statements stem from scientists' understanding of our universe as expanding since the Big Bang. *Star Dreaming* credits the development of this theory to the following scientists:

- ALBERT EINSTEIN
- ALEXANDER FRIEDMAN
- HENRIETTA SWAN LEAVITT
- EDWIN HUBBLE
- GEORGES LEMAÎTRE

Create a timeline of important developments associated with idea of an expanding universe, including the contributions of these scientists and **at least three other scientists from your own research.** Your timeline should include key events and brief explanations of each that led to our current conception of our universe.

After completing this timeline, choose one of the following topics:

- THE BIG BANG
- COSMIC MICROWAVE BACKGROUND RADIATION
- HUBBLE'S LAW (AND COSMIC REDSHIFT)
- THE COSMOLOGICAL HORIZON
- THE HEAT DEATH OF THE UNIVERSE

Write a research and fully-referenced report (of approximately 1000 words – check with your teacher) on your chosen topic. Your report should include:

- A definition of your topic, that can be understood by a layperson
- A brief history of your topic and how it was discovered
- The relationship between your topic and radio astronomy
- The consequences of your topic for our understanding of the universe
- The relevant of your topic to modern science and technology

Fulldome Photography

Year 7–10 Media Arts; Design Technologies

Star Dreaming is not only a showcase for the wonders of the natural world and the sky above us – it also showcases modern camera technology through its immersive Fulldome photography.

Fulldome is a video-projection format that, as suggested by its name, is displayed in a dome format. It is an excellent showcase for non-narrative films that allow the viewer to explore and be immersed by their environment: whether expansive wilderness, the depths of the ocean or – as in *Star Dreaming* – from outback deserts to the expanses of infinite space.

Research the history and technical qualities of Fulldome photography to answer the following questions:

- When and where did Fulldome photography first originate?
- What sort of Fulldome films are shown at the venue where you viewed *Star Dreaming?*
- How does Fulldome projection operate?
- What are the advantages of single-projector Fulldome systems as opposed to multiple-projector Fulldome systems?

Fulldome presents a unique challenge for filmmakers in that the audience is given free rein to look wherever they wish, rather than being restricted to a flat, finite screen. While this facilitates an immersive atmosphere, it also risks the audience missing crucial information.

While watching *Star Dreaming,* take careful note of how director Perun Bonser controls the audience's attention. At what points are your eyes drawn to the natural focus at the front of the dome? When do you find your attention wandering to the outskirts of the dome? Is this intentional, or incidental?

The following is an excerpt of the documentary's script. Draw a storyboard of this scene, indicating clearly what you want to depict, where you expect the audience's attention to be drawn and how that will be achieved. Think carefully about how you might represent a three-dimensional space in two-dimensional storyboards.

STEVEN: Imagine this dough is the universe. The currents in the dough represent the matter in the universe from which the stars and galaxies will evolve.

STEVEN (VOICEOVER): 13.8 billion years ago, the universe was in a very hot, dense state. It then began to rapidly expand, mind-bogglingly fast. Faster than the blink of an eye, the universe expanded to be a billion-billion times bigger.

LUCIA (VOICEOVER): Not so much a big bang, but a big expansion.

STEVEN (VOICEOVER): Exactly. And it's still expanding today. We're steadily getting further and further away from other galaxies.
It will take billions and billions of years, but as the theory goes, there may come a time when space will have expanded to the point that we won't be able to see distant galaxies anymore.

LUCIA (VOICEOVER): We won't be able to see stars anymore?

STEVEN (VOICEOVER): We'll still be able to see the stars in our galaxy, the Milky Way ...
... but many of these stars will burn up and end their lives in that time.

LUCIA (VOICEOVER): Sounds depressing!

STEVEN (VOICEOVER): Well, the way I look at it is that we're lucky to live at this moment of our universe's history where stars and galaxies shine all around us, telling us stories about science ...
... the lands we walk ...
... and about ourselves.
It's a time we must make the most of.

MAX WINTON, MARGARET WHITEHURST AND LUCIA RICHARDSON BLOWING EMU EGGS IN MULLEWA

Endnotes

1 https://www.qcaa.qld.edu.au/about/k-12-policies/aboriginal-torres-strait-islander-perspectives/resources/yarning-circles Teachers may also want to access the following resource for further information on yarning circles: https://www.scu.edu.au/media/scueduau/academic-schools/-gnibi-college-of-indigenous-australian-peoples/About-Yarning-Circles-A-Guide-for-Participants.pdf

2 https://www.bbcearth.com/news/australias-first-astronomers

3 Adapted from http://www.aboriginalastronomy.com.au/wp-content/uploads/2018/05/Star-Stories-of-the-Dreaming-Guide.pdf

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