Episode 3: Fire of Creation

GRADE 11/12 TEACHER'S GUIDE

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CONTENTS

Introduction . 3

Correlation to Pan-Canadian Science Protocol 4

Precis 4

Teacher Preparation . 6

Questions

- Before Viewing . 6
- During Viewing . 8
- After Viewing 9

Glossary 13

Script 15

INTRODUCTION

The Sacred Balance is a four-part video series in which David Suzuki explores our place in nature. In the third video of the series entitled **Fire of Creation**, David Suzuki explores our knowledge of sustainability and its relation to the cultural knowledge of indigenous peoples. This wisdom reveals the interconnectedness of life on Earth. The video consists of five sub-themes, each of which contains resources on the Sacred Balance website www.sacredbalance.com that complement the video. This guide provides teachers with suggestions on how to use the video and website resources in the science classroom.

Themes	Sacred Balance Website Resources		
	Bio	Articles	Games/Animations
Earth's Rotation: A Cosmologist's View		Carbon in Flux: Perspectives on the Carbon Cycle Cosmologist Brian Swimme on Watching the Sunrise	
The Place of Fire in Nature		The Place of Fire in Nature and Human Culture	Life Cycle of a Beaver Pond
Learning to Live in Balance with Nature		Tim Flannery on Learning to Live in Balance	
Biodiversity in Soil		Organic Wine Biodiversity Just under Our Feet	
Sustainable Agriculture in Bali: The Wisdom of the Water Priests	John Stephen Lansing	The Wisdom of the Water Priests A Computer Model of Balinese Agriculture	

Correlation to Pan-Canadian Science Protocol

LEVEL	SUBJECT	TOPIC
Senior Science	Grade 11-12 Biology	Reproduction and Development Evolution, Change, and Diversity Maintaining Dynamic Equilibrium Interactions among Living Things

PRECIS

The Fire of Creation begins with the sun filling the sky, bursting into the star-pricked blackness of space with a pyrotechnic spectacle of shifting, scorching images. This, Southern California cosmologist Brian Swimme tells David Suzuki and Tamo, David's grandson, is the way the cosmos began: in a single big bang, approximately 13 billion years ago, matter coalesced, and the stars turned on.

All life on Earth is forged in the furnace of the sun. This vast energy source, one million times larger than Earth, bathes us, from a distance of 93 million miles, in life-giving rays. Swimme considers each day s dawn as a cosmic act of generosity -- a vast giveaway of energy. We are all children of the sun, accumulating cosmic energies, transforming them into matter. Throughout the ages, human beings have revered this sacred flame. As David discovers on this journey, the findings of science amplify that reverence.

In Arizona, David experiences a controlled burn of a forest and learns how fire acts as a creative destroyer, taking life apart so that new life can appear. David goes to Australia to experience our ancient role as fire creatures with the Aborigines. They use fire to renew the land that feeds them. They see it as a sacred trust. They're the keepers of the flame, having learned over the millennia how to live within the energy cycle of the planet.
Soil is where the planet's energy cycle comes full circle, and death turns into life. The seed stirs in the ashes; the spark in the cell fuels growth; the plant reaches for the furnace in the sky. Long ago, human beings learned how to manage the energy of the soil. Now all six billion of us on Earth depend on this thin brown layer. In California, David is shown how solid rock, over thousands and millions of years, is transformed by life into the matrix for new life: nutrient-rich soil. In the fertile Napa Valley, he witnesses how newly introduced, natural farming techniques are working within the energy web of the soil and maintaining the productivity of the land.

Human beings have been part of the cycle of productivity for thousands of years at David's last stop -- Bali, Indonesia. Here, farmers honour the fertility of the land at the water temples and recognize the wisdom of traditional farming techniques developed over the centuries. When modern agriculture brought the Green Revolution to Bali in hopes of increasing the already highly productive system, the cycle was broken, and pests besieged the crops. Pesticides destroyed the life of the soil, and the harvests were lost. The work of anthropologist Stephen Lansing revealed how the water temples kept farming in harmony with the natural cycles, policy changed, and traditional methods were reinstated.
Human societies have learned over many generations how to use the generosity of the sun for their survival, passing on through myth and ritual those lessons for the generations still to come. We're all part of the energy web, embedded in the universe, and burning with the fire of creation.

TEACHER PREPARATION

- Preview the five-minute highlight video on the Sacred Balance website to familiarize yourself with the content of the video. Alternatively, read the script found at the end of this guide

- Explore The Sacred Balance resources on the website.

- Select appropriate biographies, webcasts, articles or games for students to explore before watching the video or to extend their knowledge after watching the video.

- Select appropriate before, during and after viewing exercises from this guide or adapt and design your own based on the resources here.

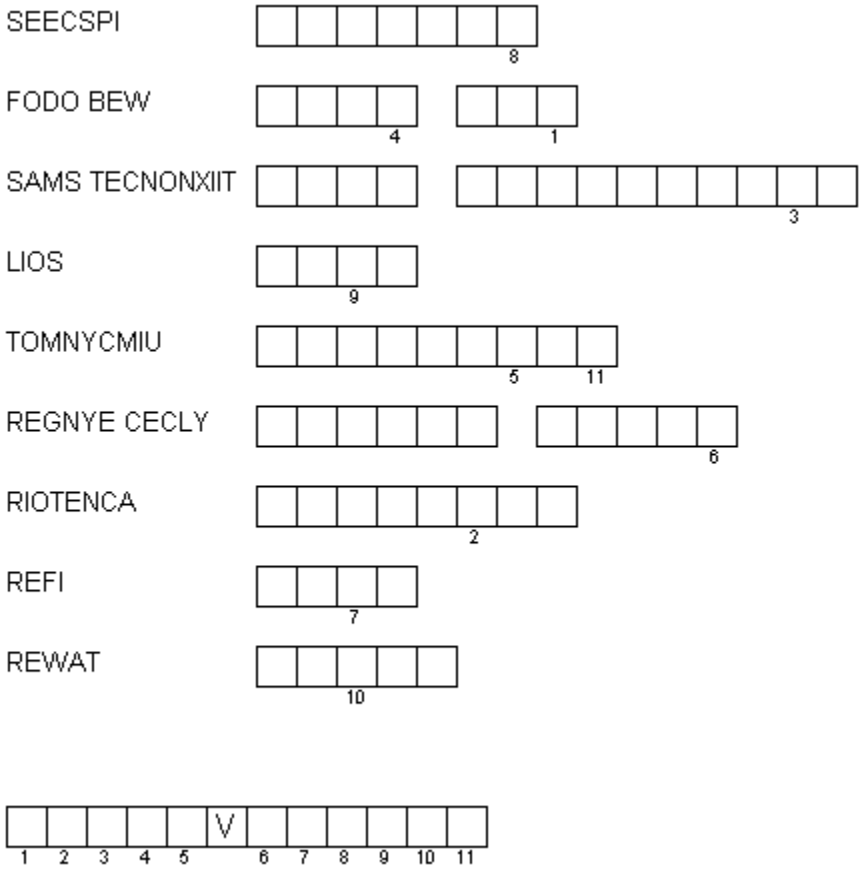
- Provide students with the opportunity to learn vocabulary from the enclosed glossary for sections of the video you would like them to see. The glossary consists of two parts: defined words to support the learning of science vocabulary and undefined general words that ESL/ELD students may not be familiar with.

- Photocopy critical sections of the enclosed script for students to read prior to watching the video. Alternatively, provide the sections to students after previewing the video, to free students from the need to take notes during the video.

BEFORE VIEWING

Fire Of Creation Double Puzzle

1. Unscramble each of the clue words. Copy the letters in the numbered cells to other cells with the same number. The final word is _____. What is the relationship between this word and all the other words?



Answers:

Unscrambled Words: species, food web, mass extinction, soil, community, energy cycle, creation, fire, water

Final Word: biodiversity

This is an opportunity for the class to explore biodiversity and how it relates to all the words in the scramble. This activity can thus serve as a discussion tool.

2. What is biodiversity and why is it important?

Biodiversity is the number and variety of species found in an ecosystem. Biodiversity allows life to respond to changes in the environment. All life is connected. We are not fully aware of all the relationships that exist among organisms. Removing organisms will affect in varying degrees all other organisms.

3. Visit The Sacred Balance website to play the online game **Climate Change Casino.**

a) What is the metaphor presented?
David Suzuki is using the metaphor of "gambling" when describing how we humans are dealing with climate change. In this gambling metaphor, humans may make short-term gains in terms of monetary profits. However, the environment loses.

b) What are your thoughts on this metaphor?
Students responses in regards to the metaphor will vary. If time permits, other metaphors can be generated as a class. A discussion of the limits and benefits of metaphors is appropriate here.

DURING VIEWING

In the video Fire of Creation, four of the people that David Suzuki interviews are a cosmologist named Brian Swimme, a fire historian named Stephen Pyne, a soil scientist named Elaine Ingham, and a paleontologist named Tim Flannery.

Read the quotations and highlight two to three key words or phrases that will help you remember the quote as you watch the video. Jot down some notes to help you remember the scene for classroom discussion after the video.

Quotes from the Fire of Creation:

Quote	Who says this?	What is happening during this scene?	Jot Notes
But the one science brings is the fire here; this burning is actually the sun. This is literally the sun s energy, through the power of photosynthesis.	Brian Swimme		
But about two hundred years ago, we shut fire up and put it to work. With furnaces and internal combustion engines, we built the modern world.	Stephen Pyne		
There would have been giant marsupials the size of rhinoceroses. There would have been goannas that were seven metres long and, you know, komodo dragons sort of blown up to a huge size. And giant turtles the size of VWs but with horns like cows.	Tim Flannery		
We re looking at, oh, probably about a hundred miles of fungi per gram of soil, per teaspoon of soil in here. When we look at one teaspoon of soil, maybe that much, we re looking at 40,000 species of bacteria. We re looking at probably 20,000 species of fungi in that one	Elaine Ingham		

AFTER VIEWING

1. According to Tim Flannery, the Aborigines' arrival in Australia, some 40 to 60 thousand years ago, precipitated a wave of extinctions that was the catalyst for an environmental meltdown from which the Aborigines made a triumphant recovery. Flannery believes their story is a parable for our times.

a) Summarize the story of the Aborigines and what happened in Australia 40 to 60 thousand years ago.

Tim Flannery summarizes in the following quote from the video:

It's very hard for us to know in the fossil record exactly what happened, but the hypothesis that I've developed, really, is that people come into this continent, and they have a profound impact. They seem to precipitate an extinction. Maybe a hunting-caused extinction; maybe they start changing the environment as well. It's hard to tell at this stage. But soon after that, all of the big marsupials are gone, and then the Australian vegetation itself starts to change. There must have been a period of massive wildfires that caused lots of extinction and lots of damage. And after that, the most incredible change of all happens because it looks like Australia's climate itself changes, and the continent starts to really dry out.

b) What is the parable between their story and our current story?

We too are living in a time of mass extinction. Industrial processes are transforming the environment. Our climate is changing due to our activities.

c) What ending do you envision for our story?

Student responses will vary. Many students may feel overwhelmed. To support students in their efforts to make a change, have them **Take the Nature Challenge** found on The Sacred Balance website.

2. Sometimes civilizations do not learn important lessons from their history. Research the story of Easter Island. What lessons does this story teach us? Should this story be made into a motion picture? Why or why not?

The story of Easter Island describes how a fertile land became treeless. Polynesian sailors who moved to the island around AD 800 completely exhausted the natural resources of the island through their activities. Slash and burn methods to clear the land and large consumption of wood to build monuments took their toll on Easter Island s nature.

3. Tim Flannery describes humans as future eaters. What do you think he means by this phrase?

Tim Flannery describing what he means by future eaters:

"As I started to look into the history of humanity around the world, I started to realize that we're future eaters; that's the only way I could put it. We are the species that has consistently been eating the resources that we require to persist in future. And that's a process that's been going on for 50 thousand years. But it's been accelerating. So today, it just has reached a maximum; it's reached a high point. I mean we're not just killing off big animals anymore; we're actually mining the planet's soils and water and clean air. And that is a very dangerous process. I can't see that the process is going to go on much further. Our species has to change in order to have a future."

4. Fire and beaver have been perceived as being destructive to human habitats. Visit The Sacred Balance website to play the game Life Cycle of a Beaver Pond and to read the article The Place of Fire in Nature and Human Culture. List ways in which fire and beaver are beneficial to the environment.

Fire	Beaver
Releases nutrients in the soil which are locked up	Creates ponds, which serve as habitats for many organisms
Promotes species that otherwise would not flourish	Initiates natural cycles, which renew topsoil and create diversity.

5. Visit The Sacred Balance website to read the article Carbon in Flux: Perspectives on the Carbon Cycle. Based on the article, write a short story or a poem describing the journey a carbon atom as it goes through the cycle.

Student responses will vary. Before students begin writing, as a class, debrief the article.

6. In 1987, Dr. Gro Brundtland, former Prime Minister of Norway, completed her very influential report, entitled Our Common Future. In 1989, Dr. Karl-Henrik Rob rtdeveloped a framework called The Natural Step. Research the use of the word sustainability in both these cases. Is there consensus on the definition? Find one other source in which sustainability is defined. Within groups, write a definition of sustainability that would be compelling for secondary students.

Answer:

Our Common Future did not really define sustainability; it defined sustainable development:

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs. The process of change in which the expectation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations." (WCED, 1987)

The Natural Step refers to the practice of sustainability:

"The practice of sustainability is about creating new ways to live and prosper while ensuring an equitable, healthy future for all people and the planet."

7. Research the role of bioengineering in food production. What kind of future will genetically modified organisms bring? What are the positive and negative impacts associated with this technology?

Student responses will vary. Many fear that genetically modified organisms will damage human health. Also, genes from modified plants may mix with plants that are not modified, thereby changing the genetic makeup of plants. Others argue that genetically modified plants will feed a growing population as new, hardier and more fruitful plants are designed.

8. David Suzuki asks: If we ve got out of balance now with the industrial combustion, where do we have to go now? What s the future for fire in our life? What are your thoughts on his questions?

Student responses will vary.

Glossary

clay	Clay is a kind of sticky soil with grains smaller than 0.002 millimetres in diameter.
combustion	Combustion is a quick chemical change where oxygen reacts with a pure substance releasing heat and light.
compost	Compost is fertilizer made from decaying organic matter, such as leaves and manure.
colorimeter	A colorimeter is an instrument that measures the concentration of a known constituent of a solution by comparison with colours of standard solutions of that constituent.
concentration	Concentration is a unit measurement of how much substance is dissolved in another substance.
cosmologist	A cosmologist is a scientist who studies the history, structure, and dynamics of the universe.
fauna	Fauna are a group of animals of a particular region or period.
fertilizer .	Fertilizers are natural and synthetic substances that include nitrogen, phosphorus, and potassium compounds, used to increase the capacity of soil to support plant growth.
galaxies	Galaxies are a large grouping of stars, gas, and dust making up the universe
germinate	Germinate means to sprout.
inorganic	Inorganic is matter that is not carbon based and does not originate from living things.
irrigation	Irrigation is a process used in agriculture to provide land with water by means of ditches, pipes, or streams.
nutrients	Nutrients are substances required for the healthy growth of organisms.
lichens	Lichens are a form of fungus that grows symbiotically with algae, resulting in a composite organism that characteristically forms a crustlike or branching growth on rocks or tree trunks.
nematodes	Nematodes are worms of the phylum Nematoda, which have unsegmented, cylindrical bodies and include parasitic forms, such as the hookworm and pinworm.
organic	Organic is carbon-based matter originating from living things.
protozoa	Protozoa are eukaryotic single-celled, microscopic organisms, such as amoebas, ciliates, flagellates, and sporozoans.
paradigm	A paradigm is a set of assumptions, concepts, values, and practices that form a way of viewing reality.
pesticides	Pesticides are chemicals used to kill pests, especially insects.

phosphate	Phosphates are chemicals that contain phosphorus compounds. They are salts or esters of phosphoric acid.
precipitate	To precipitate is to cause (water vapor) to condense and fall from the air as rain, snow, sleet, or hail or to cause (a solid substance) to be separated from a solution.
reagent	A reagent is a substance used in a chemical reaction to detect, measure, examine, or produce other substances.
species	Species is category of classifying related organisms capable of interbreeding.
silt	Silt is a kind of soil consisting of very fine particles bigger than the particles of clay, but smaller than the particles of sand.
vegetation	Vegetation refers to the plants of an area or a region.

The following non-science words may be new for students. Provide time for students to study and learn these words prior to watching this episode.

accumulate	embedded	ingenious	percolating
ascendancy	endow	innumerable	primordial
compaction	enshrine	inoculate	promotes
conflagrations	expansion	millennia	tapestry
constituent	impart	mosaic	vicious
democratic	incremental	palatable	virtuous
dependence			

EPISODE 3 SCRIPT

David V/O: It s dark . There are no familiar landmarks . It s easy to feel lost. Tonight my grandson Tamo and I are going to find out where we really are. Since time began, humans have looked up into the night sky and wondered Where did it all come from? . Where do we fit in? Tamo and I have come to southern California to meet a remarkable scientist -- cosmologist Brian Swimme. He brought us up to a telescope to look for the origins of the universe and for our place in it.

Brian: Telescopes to me are an image of what it means to be human. That might sound strange, but if you think about how much intelligence, how much work, how much effort had to go into the making of a telescope, you d have to say that all 50,000 or 100,000 years of Homo sapiens, all of that was required to assemble something so advanced as a telescope.

The galaxies send their light here. That light had been present every day of the entire human journey . It took all of these millennia of development simply to awaken to what is here now.

David V/O: What s here now, all around us -- the beauty and diversity of life on Earth. All this diversity, Brian told us, comes from the first moment of creation. A single, unbelievably intense pulse of energy -- the big bang.

Brian: As we understand it now, the universe flares into existence around 13 billion years ago as this super-dense concentration of energy, trillions and trillions of degrees hot and then quickly develops into the first atoms. And then suddenly, the moment comes when these atoms can join together to form the galaxies and the stars. Then the stars developed in their core all of the other elements of the universe. These elements then form new systems, star systems, such as our own sun and Earth and Mars and so forth.

David V/O: Then life began on planet Earth -- in a process that continues today. It s a truly amazing story. That moment of creation is still unfolding everywhere around us.

Brian: I always look for ways in which I can connect with the larger story. One of them for me is dawn.

David: Here it comes.

Brian: In that moment, just for a brief second, I remember that I am a member of Earth community going around a star. One star among 200 billion.

Ninety-three million miles the light has to come and already we re being warmed up by it. And what s amazing is to think about the sun being a million times as huge as the Earth. It s just this vast fire that enables all of life to take place here. So one way to think about the sun, every time you see it at dawn, is to think of it as an act of cosmic generosity. It s this vast giveaway of energy.

David V/O: The sun provides the energy for all life, death, decay and rebirth everywhere on the planet.

Everything lives, Brian told us, by eating the sun.

David: How do you like your bacon, Brian?

Brian*: I like it crisp.*

David: Good. Good Morning. Are you hungry?

David V/O: Now there s something really primordial about a fire, isn t there, Brian?

Brian: Yeah, yeah. I ve always been amazed by fire. Every culture had a way of relating to this mystery of fire, and all of them are interesting. But the one science brings is the fire here, this burning, is actually the sun. This is literally the sun s energy, through the power of photosynthesis.

There s almost nothing more important or more wonderful. Right here, we re seeing the energy that is carefully folded into the tree being released as this fire.

And then, the amazing thing is that this is our moment for entering into this flow of energy because right there in the eggs is the energy from the sun.

Tamo: So it s sort of like the sunlight gives energy to the leaves, which goes into the tree, which we chop down and burn to make our fire, and then which cooks the eggs, which we eat. So us, all humans, have a bit of sun in ourselves?

Brian: Exactly, that s exactly it.

Tamo: And is that what gives energy to us?

Brian: That s exactly what gives energy to us, precisely.

David: Now let s get some energy into your body. Are you hungry?

Tamo: Yeah.

David V/O: The sun is in us, released in our cells by a process of combustion. It s the energy of creation, taken up as sunlight, released as fire. Fire: it s an overwhelming force, one we ve learned to dread. We know what fire can do, once it takes hold. Every year, the conflagrations rage. Thousands of hectares of forest consumed, communities destroyed, lives lost.

News report: This fire grew from six hundred hectares to over fifty thousand hectares in just about four hours. Firefighters have not been able to get out ahead of it. It s moving too fast; it s very dangerous to get ahead of it .

David V/O: How can this be a creative force, part of the planet s cycle of life? I went to Arizona to learn what fire has to do with life. Stephen Pyne is a historian of fire. He s the first one I ve ever met. He took me into a forest as it was set alight. It s called a controlled burn -- a pretty unnerving sight. I m used to people stopping fires, not starting them. But Stephen Pyne told me this is fire s natural habitat.

David: Pretty hot flame here. So when you look at it like this, it looks like it's causing a lot of damage. What'll be the long-term consequences of this, this fire?

Stephen: Well, it is damaging but temporarily. It's part of the creative destruction, if you will, out of nature's economy.

David V/O: Over the centuries, he said, naturally occurring fire shaped this forest and kept it healthy - wildfires racing through the grasses, thinning the saplings, barely scorching the trees. Without regular fires, the forest becomes a tinderbox; it may burn to the ground.

Stephen: You know, it's freeing up a lot of nutrients that are stuck in these logs. There's not much to decompose it in an arid climate like this. A lot of critical ingredients and chemicals, they have to be freed. It shakes and bakes. It promotes some species and drives off others temporarily.

David V/O: Fire takes apart the living world, so that new life can appear. Stephen Pyne believes we humans have a very special part in this cycle.

Stephen: People are really a poorly endowed creature; I mean, we re not big; we re not fast; we have a poor sense of vision, smell, all these things. But then, we acquire fire and suddenly we become very powerful. Perhaps, too powerful. We have control over a really fundamental property of ecosystems and indeed of life. This is who we are as a creature: we re the fire creature. Other animals knock over trees and dig holes in the ground and hunt, but we re the creature that manipulates fire.

David V/O: Over the millennia, he told me, fire gave us safety, a hearth, even culture itself. And we treated it with respect, tending the sacred flame. But about two hundred years ago, we shut fire up and put it to work. With furnaces and internal combustion engines, we built the modern world. Now we ve lost touch with the sources of power. We think energy comes from a pump, instead of the sun. We re still fire creatures -- never more so -- but we re not part of any process of renewal. Every night, the industrial world reveals its excesses, burning off the planet s stores of energy, lighting up the night. Stephen Pyne believes we ve forgotten our role as keepers of the flame.

Stephen: We had certain knowledge about how fire worked in the world because we used it all the time. We had certain rules and rituals for guiding how we use it, when it was good, when it was inappropriate. But with industrial combustion, that seems to have gone. We don t have those guides; we don t have those codes; we don t have an understanding of how that interacts ecologically.

I would say basically that the planet now has too much combustion and not enough fire.

David: If we ve got out of balance now with the industrial combustion, where do we have to go now? What s the future for fire in our life?

Stephen: The future of fire. Part of it is simply to recover our lost understanding of what fire means in the world and what our particular role should be in managing it. To recover our senses as real fire creatures.

David V/O: Fire creatures -- playing our part in the planet s energy web.

Stephen: This was burned in the spring; it s already come back. The grasses thrive on it. And most of the wildlife that would feed on the grass likes that succulent, fresh growth. That s rich in protein; that s where the nutrients are; that s what s palatable. The old dead stuff, nobody wants to eat that.

David V/O: Life, death, and rebirth: the cycle turned by fire. Stephen Pyne says we re part of that cycle whether we like it or not.

Stephen: When our ancestors long, long ago seized fire, they made a Faustian bargain, and the control of fire, of combustion, is really the basis of our ecological ascendancy, for good or ill. And if we use fire well, we create a virtuous cycle; if we use it badly, we create a vicious cycle. And so, it s up to us to sort of reclaim that heritage, admit that bargain and use it well.

David V/O: One group of people on Earth still see themselves as fire creatures. The Aborigines of Australia believe they re the keepers of the sacred flame. When I flew into Arnhemland, a vast territory in northern Australia, the whole continent seemed to be burning. Over tens of thousands of years, the Aborigines have used firestick farming, as it s called, to shape the Australian landscape. Burning small patches of woodland, they make a mosaic of new grazing for the animals they hunt.

I came here to meet Jabani Lalara, the leader of a small group of Aborigines who live in eastern Arnhemland. I wanted to ask him why his people burn the bush. He told me that setting fires is the way they serve the land that feeds them. They see it as a sacred trust. Australia s soil is arid and infertile. Nothing decomposes quickly here, so nutrients aren t released to feed new growth. It takes fire to drive the cycle. Aborigines believe they re part of a continuous process of creation. Jabani told me about his people s relationship with the land. In a way, he said, instead of owning territory, they re owned by it, charged with performing the proper rituals, taking proper care. He took me through his country and told me a little of its sacred history.

David: Do you have a responsibility to take care of that land? Are there jobs you have to do?

Jabani: Yeah, big responsibilities to look after our land and because of its very important sacred sites.

The ancestor spirits -- stingray and sea turtle -- still live there in the sacred sites, keeping things going. People have to know how to play their part.

Jabani: I mean we can t throw it away, you know. We still have to teach our children.

David: And you re a rich man.

Jabani: Of course.

David: As long as you ve got the land, your traditions.

Jabani: I m proud of all that, you know? Because we share; all the people share.

David V/O: The corroboree was the high point of my stay with Jabani. The entire community gathered to share their traditional dances. First they decorated themselves with clay. Then they danced the stories about how people fit into their world. Each dance is part of a sacred text, a way of presenting myth and history. Traditionally, Aborigines see themselves as caretakers of the world around them, keepers of the

flame. It s an understanding that s under pressure in the modern world. But there s another strand to this ancient story, I discovered, which has lasted 50,000 years.

Tim: Fifty thousand years is a very long time, and over that time, people have become so intimately interwoven with the nature of Australia that they are they're embedded in a way that no other people in the world are, I think, in their environment.

David V/O: Tim Flannery believes that this deep connection has been a hard-won lesson. He s a biologist from the South Australia Museum in Adelaide who s been exploring the continent s ancient past. He took me up Injalak Hill, a sacred site in northern Arnhemland. And he took me back through thousands of years.

David: Wow it s just covered with paintings.

Tim: There s got to be thousands of individual paintings.

David: I ve seen a lot of them in North America but never like this.

Tim: This is one of the best sites in Australia.

David V/O: Layer after layer, laid down over the millennia, the paintings depict the living world of the Aborigines.

Tim Flannery told me that Australia was very different when they first arrived.

Tim: There would have been giant marsupials the size of rhinoceroses. There would have been goannas that were seven metres long and, you know, komodo dragons sort of blown up to a huge size. And giant turtles the size of VWs but with horns like cows. I mean, it was a pretty bizarre fauna, and there was a lot of big animals that are missing today.

David V/O: Fifty thousand years ago rainforests covered much of Australia. They cycled water, making clouds and rainfall, drawing coastal monsoons deep into the centre of the continent. So what happened? How did Australia change so much?

Tim: It's very hard for us to know in the fossil record exactly what happened, but the hypothesis that I've developed, really, is that people come into this continent and they have a profound impact.

They seem to precipitate an extinction. Maybe a hunting-caused extinction, maybe they start changing the environment as well. It's hard to tell at this stage. But soon after that, all of the big marsupials are gone and then the Australian vegetation itself starts to change.

David V/O: No longer grazed by large mammals, the forest became choked and vulnerable to fire.

Tim: There must have been a period of massive wildfires that caused lots of extinction and lots of damage. And after that, the most incredible change of all happens because it looks like Australia's climate itself changes, and the continent starts to really dry out.

David V/O: Wildfires altered the mix of vegetation, and that changed the climate. The arid landscape of modern Australia was born: sparse eucalyptus woodland, adapted to drought, swept by frequent fires.

Tim: Only slowly, I think, did aboriginal people learn to tame that fire, learn to burn and fight fire with fire, if you want. And it's that process that eventually led to what we call firestick farming or the very, very careful management of Australian environments using fire.

David V/O: In a sense, Aboriginal people farmed the landscape, releasing nutrients when they wanted to, releasing feed for the animals they hunted with a firestick rather than with a plough. But the process is every bit as intricate as traditional farming, is. It is a very, very complex thing, a system that evolved over 50,000 years.

Aborigines seem so much a part of their world. I was amazed to discover what a long hard lesson it s been.

Tim: A lot of people are shocked by the idea that aboriginal people may have lived in a destructive way in the past. But to me it's just, its part of being human, that's the nature of the species. What I see is 50,000 years of careful learning about the environment, of incredibly ingenious interactions to maintain life in a very, very harsh and difficult environment. And that's the great triumph of Aboriginal people to me.

David V/O: Fire creatures, learning how to live within the cycles of renewal. That s also part of being human. That s what they have to teach -- and we to learn. Soil is where the planet s energy cycle comes full circle, and death turns into life. The seed stirs in the ashes; the spark in the cell fuels growth; the plant reaches for the furnace in the sky. Long ago, human beings learned how to manage the power of the soil. We became creatures of the Earth. Today, six billion of us depend on this thin brown layer. Fire and water, earth and air combine into the matrix for growth. On a beach in California, soil scientist Elaine Ingham showed me the sacred balance that continually creates the soil.

Elaine: This rock will become soil through the action of weather, wind, rain and the micro-organisms that grow on the rock; the bacteria, for example, growing on this will break this down. The lichens, the moss will grow on those, the bacteria, the phosphate, fixed by those bacteria, and break it down into the constituent sand, silt and clay that we re looking at here. The bacteria grow in there, produce organic matter, and on that the fungi then start to grow, contribute more organic matter to the material. Then along come the protozoa and the nematodes, and they start that process of nutrient cycling, which turns this into soil.

David: But that plant looks like it s growing out of solid rock.

Elaine: Yeah, but you had to have just a little bit of soil caught in that crevice, and then the seed had to fall in there as well, and it s the nutrient cycling in that soil that allows that seed to germinate, start to grow, get the nutrients that it needs.

David V/O: From barren rock to mighty forest is a long, long journey. Life eats away at the raw materials and binds them into a living food web. Millennia must pass before the soil is ready to support a forest community like this one.

David: So this is a forest soil, which I guess has taken thousands of years to evolve.

Elaine: It certainly has. We have to slowly but surely develop this from the things we were looking at on the beach.

David: But this isn t soil. I mean this is stuff coming off the trees.

Elaine: That s right. That s the organic matter that s coming down to the surface of the soil, and the organisms are going to decompose this material, turn it into the organic matter, to build the rest of that soil structure that we re looking at. So let s take a little bit of a look in the soil, see what we can find.

David V/O: This food web in here has got just more diversity than almost any place else on Earth. Soil is where diversity really lies. We look above ground and we say, Ooh, look at all the plant species here. We go, Oh, there s ten, 15 different plants in here, high diversity. Doesn t hold a candle to what s here in the soil. We re looking at, oh, probably about a hundred miles of fungi per gram of soil, per teaspoon of soil in here. When we look at one teaspoon of soil, maybe that much, we re looking at 40,000 species of bacteria. We re looking at probably 20,000 species of fungi in that one

David: These are species, not individuals.

Elaine: Not individuals, because now when we go to individuals, we re looking at a thousand million individual bacteria split amongst 40,000 species. So it s a huge diversity that I m holding right there in the palm of my hand.

David: That s staggering. I would have to say that s a living organism -- that s alive.

Elaine: It s a community. You can sort of think of this as New York City. These trees wouldn t be here without this diversity, this food web structure in the only thing that keeps these trees alive and growing. This is the grandest cycling system that we have ever seen.

David V/O: Elaine is much in demand, helping farmers to maximize the health of their soil by working within the energy web.

Elaine: How are things going?

Kirk: Actually very well. We have had some good results in this block trying to address some soil compaction. And we are seeing some good improvement in soil structure .

David V/O: At Sinsky Vineyards in California s Napa Valley, she s working with the manager, Kirk Grace, to increase productivity without chemical input.

Elaine: Great earthworms too in here; look at all those organisms and the structure in there; that s marvellous.

Kirk: You can also see some of the compost that we have been putting on in the last few years too.

David: Kirk, there seems to be an awful lot of plant growing between the vines here; is that the normal situation?

Kirk: Well actually, we planted a cover crop here to help increase organic matter.

David V/O: More and more farmers are reducing their dependence on chemical pesticides and trying to breathe life back into the soil.

David: Now this is a compost that you use, right?

Kirk: That s right.

David: So when you spread this, is this essentially replacing the fertilizer that you add to the fields?

Elaine: Well it s not really replacing the fertilizer; you re doing other things in addition with the compost.

David: So in addition to providing that nutrient when you spray on your field, you re in effect inoculating your orchards with--

Elaine: All kinds--

David: Whole communities of creatures?

Elaine: That s right; the beneficial things that you want: to improve the soil quality, the health of the soil out in the field.

David: This is so different from the kind of, type of farming I am used to thinking about now. How is it for your people here to make that transition? Isn t it kind of scary to get away from the idea of using powerful chemicals that can do the job?

Kirk: The way we did it was incrementally. And because of that, success built upon success, and so it was actually a natural move.

David: Well give us an idea of how successful you ve been.

Kirk: Our productivity has stayed quite level. We ve watched flavours increase in the grapes. Something in winemaking that s very important is to get smaller berries and tighter clusters, so that the skins actually impart a lot of the flavour. And we ve been able to successfully do that through the methods that we re using -- quite successfully.

Elaine: It is a paradigm shift from going out and killing everything we don t want to encouraging, supporting all of the life we do want, so that we don t use pesticides, and we don t have to use high levels of inorganic fertilizers.

Elaine: Here s to the soil and the organisms that made it possible.

David: I ll drink to that.

David V/O: The marriage of sunlight and soil seems nowhere more blessed than on the island of Bali, in Indonesia. People here have a deep connection with the sacred cycles of creation. You can see at once, that Bali s a place of ancient and abundant fertility. They ve been growing irrigated rice here for almost two thousand years. I went to a village called Sebatu, to meet an anthropologist from Tucson. Stephen

Lansing has been visiting this community for more than 20 years. He s been studying the way people here define their relationship to the land.

Stephen: Ecologists think about ecology as a science, and of course, it is a science. The Balinese also think about how human ideas and emotions and how human society is connected to ecology, and they have a way of thinking about that that is utterly fascinating.

David V/O: They believe, Stephen explained, that the land s endless fertility is a gift from the gods. As farmers, they re touching the sacred source, the energy that creates life. Water carries the energy. Every village has its water temple where daily life is linked with the divine.

David: So where does this water come from, Steve?

Stephen: Well, the Balinese think it comes from the great Crater Lake in Mount Batur.

David V/O: Stephen took me to the water temple at Sebatu to show me the science behind the sacred.

Stephen: So when the rains fall, they recharge the lake then that recharges the springs. The island is dotted with innumerable springs -- like this one. This is the Spring Temple, built to capture that flow. The Balinese even call their religion [Speaking Balinese], which means the religion of holy water.

There are two things they notice and revere about water. The first, that it can make things grow -- you need it to make things grow. The second is that it can cleanse; it can wash away pollution. So in a place like this, which is where water is first emerging from the earth, so it s clean, pure water, so it can make things grow.

David V/O: This is powerful water. The Balinese believe that all water comes from Lake Batur at the foot of the sacred mountain. The rice goddess Dewi Danu lives in the lake, sending water down into every field in Bali. The water passes through volcanic rock that s rich in natural fertilizers, such as phosphate. That s what Stephen showed me in the water temple at Sebatu.

Stephen: So David, we ve been taking water samples from the spring for a while and rivers and also the ocean, just looking at what are the concentration of nutrients that are naturally present in the water because it is percolating through the volcanic soil. So here with this little spring sample, I have a little reagent, to do a phosphate test, and a little portable colorimeter.

David: Does it tell you how much is in there?

Lansing: Yeah. Basically, as the water changes, you get a reading on You know, the darker the water, basically, this will turn blue, and the darker the blue, the more phosphate in the water.

David V/O: Stephen s meter shows how rich the water is in the natural fertilizer provided by the ecosystem.

Stephen: So that s a very high concentration. So what it means is that there is enough phosphate flowing through the irrigation system to replace what the plants take out.

And because the rivers are flowing and the irrigation systems are flowing continuously you ve got a perfect little continuous delivery system replenishing the fertilizer on the fields. That s why you can plant rice endlessly, you know, century after century, without adding chemicals.

David V/O: The Balinese know they re part of a life-creating energy cycle that has fed them well for centuries. But in the 70s, the Indonesian Government tried to make a good thing better.

Stephen: In 1975/76 the Green Revolution had just begun. The Green Revolution means the introduction of western farming techniques, basically. It s high yielding plants that are designed to grow quickly and to take up fertilizer rapidly along with chemical fertilizer and pesticides. And so this came as a package to the Balinese farmers.

The farmers were told in the interest of national development take this new rice and plant just as fast as you can. If you can get at least three crops a year, great. Some of the old people said, well the trouble with that is according to our traditional system we schedule, you know, we carefully time when the water goes into the fields and when it doesn t, and there are reasons for that.

David V/O: After a couple of years of bumper harvests, those reasons started to become clear. Stephen Lansing s old friend Wayan Pageh is a farmer in Sebatu. He remembers what it was like 20 years ago when the pests began to appear.

Stephen: The Green Revolution s remedy for pests was pesticides. It s not just that the farmers were advised to use pesticides; they were forced to use pesticides. They were told they would be punished by the government if they didn t because the government would say if anybody doesn t use pesticides immediately as soon as any sign of pest appears then the pests will spread to other fields.

So within a year or two even the farmers pumping these pesticides into the field couldn t kill all the pests. The government then began to fly the island dropping pesticides from airplanes, and they succeeded in killing damn near everything.

Wayan: [Speaking Balinese]

Stephen: He says that everything is made by a creator and so by disturbing anything, by killing anything, you are disturbing part of the creation -- so you need to pay attention to the whole picture; essentially, he is saying you have to pay attention to the whole picture.

David: Wow.

David V/O: And that, Stephen told me, was the role of the water temple -- looking at the whole picture, applying wisdom accumulated over the centuries.

Stephen: In the middle courtyard of the temple, the farmers gather every month, and they make decisions in a democratic assembly on how they are going to plant.

David V/O: Agricultural activities are co-ordinated through the temple calendar, giving spiritual force to practical knowledge. The timetable is sacred. All the fields are flooded at once, driving out rats and

other pests. When the harvest is ready, the farmers collaborate to bring it in quickly. Ducks glean insects and grain in the stubble. Then the fields are flooded again -- and there s no place for pests. As Stephen Lansing explained it, the sacred calendar worked within the insect cycles, holding pest at bay.

Once the government understood this, they allowed the water temples to regain control. The island of Bali is regaining its place within the cycles that create and renew life. In Sebatu, everyone was preparing for the biggest festival of the temple calendar. Wayan and his extended family were busy organizing the offerings. They re giving back to the gods a portion of what they ve received.

Early next morning, Wayan called the people to the temple. The whole village came, wearing their temple clothes, bringing the fruits of the harvest. We humans have an extraordinary capacity to enshrine the knowledge we need for survival. We pass it on, and we honour it. It connects us to the process of creation that continually unfolds around us. Across time and space, through thousands of generations, we tell ourselves the stories. They teach us about life and death, about rebirth. They teach us where we live. Since the very beginning, we ve been dancing our place among the stars. On that mountaintop in California, my grandson Tamo looked out and saw the fires burning all around us. They re part of that first great pulse of energy that created the cosmos, and so are we. It s all a matter of perspective. That s what Brian Swimme explained to us that night.

Brian: Now if we look straight up at the stars -- here s an amazing thing, when we look up, we think of the stars as being above us; in a certain sense they are. But in space, there s no up; there s no down, really. We re on a planet; it s a round planet.

Tamo: And so there d be no left or right either?

Brian: There s no left or right, there s no up or down. It all depends on your orientation, where you are. So for instance, even though right now we think of the stars as being up; if we were on the other side of the planet, and we looked at the stars, we would actually be looking down, right? So we can actually do that here. As you look up, you can use your imagination. Imagine we re on the other, bottom side of the planet, and we re looking at the stars.

David V/O: We look out and see all the galaxies expanding away from us, but that s true, no matter where you are in the universe. Every place is right at the centre of that expansion. Everything is at the centre; everything is at its centre, and all of those centres are woven together. The universe is a tapestry in which every event, every being, is woven into the life and destiny and reality of every other being.

That s where my journey has brought me -- back to the beginning, into the centre. We re not lost at all. We re embedded in the universe, burning, like all life, with the fire of creation. Next time we explore a world of human connections. Linked to each other, close relatives of all life on Earth, we live within the sacred balance of the cosmos.