Episode 1: Journey into New Worlds

GRADE 11 - 12 TEACHER'S GUIDE

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INTRODUCTION

The Sacred Balance is a four-part video series in which David Suzuki explores our place in nature. In the first video of the series entitled **Journey into New Worlds**, David Suzuki explores the sciences of chaos and ecology and the related wisdom of indigenous knowledge to reveal the interconnectedness of life on Earth. The video consists of eight 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 Resources		
	Biographies	Articles	Games/Animations
Human Impact on the Earth	David Suzuki	Human Impact on the Earth	Climate Change Casino
Nature of Science		Portrait of David Suzuki as a Young Geneticist Views from a Director of the Human Genome Project	The Anatomy of DNA
An Astronaut's Reflections	Julie Payette	An Astronaut's View	
Importance of Land to Cultural Identity	Giindajin Haawasti Guujaaw	A Native View of Humanity's Place in Nature	
Relationship between Salmon and Forests.	Thomas Reimchen	Why the Forest Needs the Salmon	
Social Behaviour of Ants.		What Ants Can Teach Us	A Computer Model of Ant Behaviour
Chaos of Heartbeats	Ary Goldberger	To Hear the Heart as Music	A Song of the Heart
The Gaia Hypothesis	James Ephraim Lovelock	James Lovelock on His Gaia Hypothesis	

Correlation to Pan-Canadian Science Protocol

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

Précis

In the past half-century, science and technology have worked wonders -- healing disease, extending human lifespans, cloning life forms, communicating instantaneously with the other side of the globe. But along with all this progress, there have been terrible costs: environmental, social, and spiritual. In Journey into New Worlds, the opening episode of The Sacred Balance, David Suzuki travels to Arizona, England, Massachusetts, and to the Pacific Northwest rainforest in search of a new vision of the Earth and our place on it -- a world view we once had but seem to have forgotten.

David Suzuki looks back on the promise and limitations of Isaac Newton's reductionist science, sharing a personal journey that began with his work at the forefront of genetic research in the early sixties through to his ecological epiphany on British Columbia's Queen Charlotte Islands. There, as a biologist and environmentalist hoping to save the forest from clear-cutting, he realized he had it all wrong. He was looking at the problem by isolating it, by breaking it down in bits and pieces, losing sight of the context, ignoring the rhythm. A Haida leader named Guujaaw showed David another way of thinking in which human beings are inseparable from the forest and the rest of the natural world. It's a spiritual understanding: the Haida are the world they inhabit. And that, suggests David Suzuki, is what we've been missing in our scientific world view.

In the course of his odyssey in this episode, David learns how biotechnologists in Cambridge, Massachusetts, see the future of genetic research in the Human Genome Project, and he hears Canadian astronaut Julie Payette's remarkably poetic perspective on planet Earth. He discovers the amazing story of how salmon actually create the forest they spawn in, and he travels to Arizona to learn how life organizes itself into living systems from the cell to the biosphere. He travels to Harvard and is given an ECG by cardiologist Ary Goldberger, who has developed the technology to play the music of David's heart. On Canada's west coast, David participates in the biggest totem pole raising in a century; then, he's off to England to meet British chemist James Lovelock and discuss his vision of the self-regulating, emergent nature of Earth and the interconnectedness of all living things.

Today, many scientists are finding ways to look at wholeness, relationships, interconnection, and they are studying a world that is endlessly diverse, constantly changing and communicating. The newest science explores the world the Haida know in their bones. In this opening episode of The Sacred Balance, David Suzuki begins a personal journey -- an exploration of science and spirit that rediscovers the human place in nature. Thoughtful, revelatory, eye-opening, brain-opening, David's experiences leave the viewer with a sense of wonder for life in all its diversity and magnificence.

TEACHER PREPARATION

Point your web browser to the Curriculum Guide page at http://www.sacredbalance.com/science. Watch the available online video excerpts from The Sacred Balance television series. Alternatively, read the script found at the end of this guide.

Explore the many online resources (articles, games, animations) available on The Sacred Balance website at http://www.sacredbalance.com/.

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.

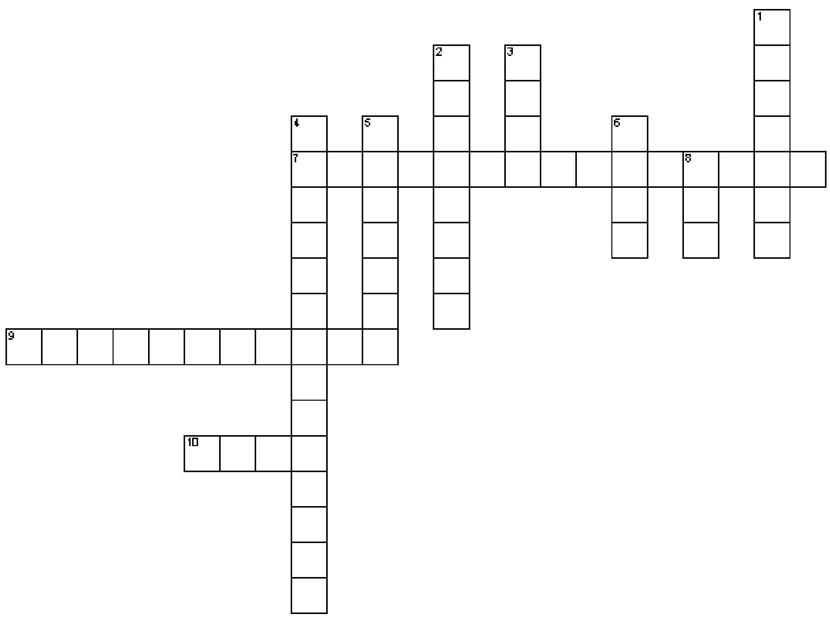
Photocopy critical sections of the enclosed script for students to read prior to watching the video. Alternatively, provide the sections to students after previewing the video, to free students from the need to take notes during the video.

BEFORE VIEWING

DNA CROSSWORD PUZZLE

1. Fifty years ago, James Watson and Francis Crick revealed to the world the structure of the DNA molecule. Studying the anatomy of this molecule accelerated developments in the field of genetics. Without knowing the structure and properties of this molecule, the Human Genome Project would have been impossible. Learn more about this fascinating molecule by visiting the animation [The Anatomy of DNA](). Using the information from this site, complete the following crossword puzzle.

THE ANATOMY OF DNA



Across	Down
7. responsible for the helix shape of DNA 9. links with phosphates at both its 3' and 5' carbons 10. one of the sub-units making up DNA that contains nitrogen	1. nitrogenous bases containing double rings in their structure 2. the code C stands for 3. the number of types of elements found in DNA 4. the bonds that allow long chains of DNA to form 5. the base pair of thymine 6. the number of types of nitrogen bases possible in a DNA molecule 8. abbreviation for the molecule deoxyribonucleic acid

Answers for Crossword:

Across:	Down
7. hydrogen bonding 9. deoxyribose 10. base	1. purines 2. cytosine 3. five 4. phosphodiester 5. adenine 6. four 8. DNA

2. Visit www.sacredbalance.com to explore the articles related to the following scientists: Ary Goldberger, Tom Reimchen, Eric Lander, Brian Goodwin, and James Lovelock.

Choose any two of the scientists, and briefly explain how their views and research support David Suzuki's new vision of our world as expressed in the following quote from Suzuki.

> "Each of us is shaped by a web of constantly changing relationships, reaching from the nucleus of the cell to the world around us.
> It's a very different idea of who and what we are."

Answer: Student answers will vary. The following is a sample model response that you may share with your students.

Sample Response for James Lovelock:

James Lovelock believes that the Earth is one organism. An Earth that is comprised of multiple complex relationships between abiotic factors and biotic factors is what he envisions. This is the idea behind his Gaia hypothesis. This web of relationships he describes is regulated by feedback systems much like the way our own bodies are regulated.

Suzuki also describes a web of constantly changing relationships that each of us is shaped by. He recognizes that humans, being living things, are also part of Gaia and thus are also regulated through the same feedback system. This is a different idea. Western views have generally separated humans from the rest of the living world. Lovelock and Suzuki are advocating that we change this view to one in which we place ourselves within Gaia.

3. There are different perspectives on the future of our world. Five commonly held visions of the future are presented below.

a) Read them carefully and reflect on your own views of the future.

1. Business as usual: There is nothing new under the sun. The world has problems, always did and always will. We will always have challenges but nothing that we can't work through.

2. Deepening crisis: Our world is in deep trouble. It might be because of a nuclear war, a major famine, a breakdown of law and order, or an environmental crisis. Life will never be the same again.

3. Governmental intervention: Authoritarian leadership is required to save our society.

Our government needs strict control to prevent population growth and to stop pollution.

4. Technological innovation: Science and technology have improved nutrition. Consequently, humans are living longer. Investing more in scientific research and technological development will solve our current problems.

5. Sustainable society: It is necessary to rethink our mechanistic and fragmented view of the world. A more holistic and ecological perspective is required so that a more humane and sustainable society is possible.

UNESCO, 2002. Adapted from "Teaching and Learning for a Sustainable Future"

b) Consider global climate change, acid rain, and city smog. For each of these environmental issues, which vision of the future best matches your own perspective? Explain.

Issue	Your vision of the future for the issue	Explain
Global climate change		
Acid rain		
City smog		
Loss of biodiversity		

DURING VIEWING

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

Quote	**Scientist**	**What is happening during this scene?**	**Which visions of the future do you think this scientist holds? Explain briefly.**
"What an achievement. Billions of letters in the DNA text have been written down in order -- the entire text of a human being."	Eric Lander		
"So the open ocean and the insects and the birds are linked in a series of an incredibly beautiful set of interactions in which there's no separation at all between the community of the open ocean and the community of the forest."	Tom Reimchen		
"The essence of healthy function is adaptability, the ability to cope with an environment that's going to play tricks on you."	Ary Goldberger		
"And it began to come into my mind at that moment, and I remember it very vividly, that if our atmosphere is so extraordinarily different, so reactive -- and yet it stays constant for millions of years -- something must be regulating it. And since I knew that these gases all came from living organisms, it must be life that's doing the regulating."	James Lovelock		

AFTER VIEWING

1. Studying our genetic code piece by piece, geneticists have sequenced the human genome.

a) Construct a timeline starting in the 1950s, the beginning of the DNA revolution, to present time. Along the timeline indicate hallmark moments in the history of the DNA. Include at least seven events in your timeline.
Answer: Students responses will vary. The following is a list of key events that students may have on their timelines.

1953 the double-helix structure of DNA is published by James Watson and Francis Crick

1969 first gene is isolated at the Harvard Medical School

1970 a gene is made from scratch by University of Wisconsin researchers

1983 polymerase chain reaction technique, invented by Kary Mullis, allows rapid DNA segment reproduction

1984 genetic fingerprinting is developed by Sir Alec Jeffreys at the University of Leicester

1990 Human Genome Project, an international effort to sequence the human genome, began

1997 researchers at Scotland's Roslin Institute clone a sheep named Dolly from the cell of an adult ewe

1998 research teams are successful at growing embryonic stem cells

2003 Human Genome Project is completed

b) According to the timeline you have constructed, what has been the most significant development? Share your timeline with a partner. How are your maps similar? How are they different? Working together, identify the advantages and disadvantages the DNA revolution has brought to science, technology, society, and the environment.
Answer: This exercise is a reflective one. Comparing timelines allows students to learn from one another as well as to verify key events. The advantages and disadvantages of the DNA revolution can then be part of a larger class discussion.

2. Describe the similarities and differences of the spiritual way of learning about the world with the scientific way of learning about the world.
   Answer: Student responses will vary. Drawing Venn diagrams will be useful in the comparing and contrasting of the two ways oflearning. Both the scientific and the spiritual way of learning are equally valid and necessary.

3. Did the video change your vision of the future? In what way? What information or scenes in the video lead you to change your view?
   Answer: Student response will vary.

4. What are the goals of the David Suzuki Foundation?
   Answer: Details of the goals of the foundation can be found at http://www.davidsuzuki.org.

5. The David Suzuki Foundation financially supported the research on the bear-salmon relationship of Tom Reimchen. Describe how the foundation might influence Tom Reimchen's research.
   Answer: Student responses will vary.

6. Many plants in temperate climates co-ordinate their fruit production with the autumn bird migrations. The birds are dependent on the plants' fruit for food, and the plants, in turn, are dependent on the birds for two reasons: to disperse the seeds and to partially digest the hard coating on the seeds, allowing germination to occur.

a) What is the scientific name for the relationship between the birds and the fruiting plants?
   Answer: The relationship between the birds and the fruiting plants is a symbiotic relationship. Particularly, it is mutualism since both organisms benefit from the relationship.

b) Use the Internet to locate further examples of this kind of relationship.
   Answer: Student response will vary.

c) What is the relationship between the bear and the trees in the video?
   Answer: Mutualism. The trees benefit from the fertilizing power of the bears' waste products. The bears need the trees to provide shelter.

7. Describe Eric Lander's biotechnology laboratory and the research he is engaged in. What are the potential benefits that result from this kind research? What are the potential costs?
   Answer: Descriptions of the lab and the research can be found in the video as well as the article Views from a Director of the Human Genome Project. Students may note the complexity of the science and the technological innovations, which make the project possible. In regards to the latter question, student responses will vary when describing the potential costs and the benefits of the Human Genome Project.
8.
   Based on his understanding of the complexity of rhythms of the heart, Ary Goldberger believes: "The essence of healthy function is adaptability, the ability to cope with an environment that's going to play tricks on you.." Why does David Suzuki find this so important?
   Answer: Goldberger's work highlights the need for variability in a healthy heartbeat. Similarly, on a larger scale, the Earth needs to maintain biodiversity (variability and diversity of living forms) to ensure healthy ecosystems. The rhythmical beating of a healthy heart is analogous to the natural rhythm of a healthy planet.

9. Eric Lander is the director of the Whitehead Center for Genome Research. Comparing the human genome to a classic text, he states, "The next decades, probably the next century, is going to be taking this classic text and learning how to appreciate what's in it and learning how to design experiments that start with that base."

   This is his vision of the next steps in the DNA revolution. What is your preferred vision of the future?
   Answer: Student answers will vary. Incorporate the five commonly held visions of the future first introduced in the pre-activities. This futuring question is a building block for the next science fiction writing activity.

10. Write a short science fiction story of the preferred vision of the future that you hold that relates to the DNA revolution. Complete the template below prior to writing your story.
    Answer: Give students the template as a guide to developing their story. Preview the templates before students start writing. This is also an opportunity for a cross-curricular activity between science and English. A sample template is provided on the next page.

TEMPLATE FOR SCIENCE FICTION STORY

Creative Title for Sci-Fi Story: ____

Description of problem to be solved:

Words describing the setting of the story:

Futuristic changes you are adding and their impact on the story:

Describe your character physically, emotionally, and mentally:

In your sci-fi story, your main character will face an event, which will change his/her emotional, spiritual, moral, and/or physical self. This main event will be tied with your futuristic changes. What will be this event in your story?

GLOSSARY

Word	Definitions
astronaut	An astronaut is a person who works on the crew of a spacecraft.
biologist	A biologist is a scientist who studies life.
biophysicist	A biophysicist is a scientist who studies parts of nature where biology and physics overlap.
carbon cycle	The carbon cycle is a repeating sequence of changes in which carbon moves between the atmosphere, oceans, and living organisms due to processes like photosynthesis, decomposition, and respiration.
carbon dioxide	Carbon dioxide is a gas that is colourless, odourless and incombustible. It is formed during respiration, combustion, and organic decomposition.
carbon sequestration	Carbon sequestration is the long-term storage of carbon in ecosystems. For example, carbon is sequestered in fossil fuels, long-lived trees, soils, and shells.
cardiologist	A cardiologist is a medical doctor who studies the structure and function of the heart.
climatologist	A climatologist is a scientist who studies weather and climate.
cod stocks	Cod stocks are populations of fish on the east coast of Canada. The cod stocks have decreased by 99 per cent. This has affected many communities that depend on cod stocks for their livelihood.
colony	A colony is a group of the same kind of animals, plants, or one-celled organisms living or growing together.
DDT	DDT is a chemical substance that can be used to control harmful insects. However, DDT does not easily break down in the environment; it bioaccumulates through the food web and poses a risk to humans and wildlife.
diversity	Diversity is variety or multiformity: "Charles Darwin saw in the diversity of species the principles of evolution that operated to generate the species: variation, competition and selection." (Scientific American).
DNA	DNA is an acronym for a chemical substance that carries the genetic information in the cell: deoxyribonucleic acid.
dragonfly	A dragonfly is an insect that has large wings and a large head with big eyes and a long body. Newly hatched dragonflies live in the water and eat tiny insects.
element	An element is a substance composed of only one type of atom. Elements cannot be reduced to simpler substances by normal chemical means.
environmentalist	An environmentalist is a person who believes that the environment needs to be protected from destruction and pollution.
evolution	Evolution is a process of change in the genetic composition of a population over a long period of time.
evolutionary adaptation	An evolutionary adaptation is a change in the structure or habits of a species or individual that improves its chance to survive.
growth rate	Growth rate is a measurement showing how fast a quantity changes over time.
homeostasis	Homeostasis is the ability of an organism or cell to maintain internal conditions by adjusting its own processes.

larvae	Larvae are newly hatched and insects. Larvae usually go through a stage called metamorphosis, which really changes how they look and function.
marsh	A marsh is an area land that is between water and land.
methane	Methane is a gas that is odourless, colourless, and flammable. Its chemical formula is $CH_{4.}$ It is used as a fuel and as a source of hydrogen for many other organic compounds.
molecular biologist	A molecular biologist is a scientist who studies the formation, structure, and function of molecules essential to life, such as DNA and proteins.
NASA	NASA is an acronym for National Aeronautics and Space Administration.
nitrogen	Nitrogen is an element that makes up almost 80 per cent of air. It is also found in many minerals and proteins. It is important in the manufacture of many chemicals, such as ammonia, nitric acid, TNT, and fertilizers.
nucleus	A nucleus is part of a cell that contains the cell's hereditary material and controls its metabolism, growth, and reproduction.
nymph	A nymph is a stage of life of an insect that looks like the adult form but is smaller and does not have fully developed wings.
oxygen	Oxygen is an element that makes up just over 20 per cent of air. It is also found in many compounds, such as water and iron ore. It is important in many chemical reactions, such as plant and animal respiration and combustion.
pathology	Pathology is the scientific study of disease and its causes, processes, development, and consequences.
physiology	Physiology is a branch of biology that studies the processes and functions of an organism.
swamp	A swamp is an area of land that is filled with a lot of water.
technology	Technology is the application of science, especially to industrial or commercial objectives.

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.

aboriginal	crucial	mock-up	sacred
anarchy	diversity	monotonous	sequestered
assemble	excessive	obliterated	splendour
blueprint	execution	phenomenal	turbulent
broadcaster	genealogy	radically	ultimately
coherent	literally	regulate	variability
collective	marginal	responsive	virtual reality

EPISODE 1 SCRIPT

David V/O: Sometimes, you don't know where you are or what's going on. This is a sacred ceremony, performed in a huge shopping mall by monks from Tibet. When two worlds intersect like this, it makes you give your own a second look. What kind of world do we live in?

David: I can't wait. You ever been to one of these before?

Tamo: Once.

David: Once.

David V/O: My grandson Tamo sometimes shares his world with me. It's amazing.

David: Oh Wow! So how do we know where to start? Where should we start?

Tamo: That game over there?

David: OK. Let's go.

Tamo: Ever seen the movie "Star Wars"?

David: Yeah.

Tamo: Episode two? That's it -- you're the pod racers. Yah -- go in that one.

David: OK.

David V/O: Tamo's like a tour guide in a strange new land, showing me the shape of the future.

Tamo: oh my god, oh my god … ahhhhh!!

David V/O: He's an expert in a virtual world, and it's a lot of fun. But it doesn't hold a candle to the real thing. Sometimes, I think we all live in a kind of virtual reality. Who knows what time it is in here, what the weather's like outside? Inside a mall, it's always summer, and everything's in season.

But once in a while, you catch a glimpse of an entirely different universe.

Tamo: What's going on?

David: These are Buddhist monks from Tibet, and they're using that coloured sand to paint a mandala.

Tamo: What's a mandala?

David: Well, it's their attempt to describe the world, as they know it. You see, this is a palace for their Buddha. And you can see the temples and the walls and the gate … and this comes from a very ancient tradition.

David V/O: They see a sacred world where everything's connected, held together by spirit. What do we see? A world we've built for ourselves with science and technology. It's a vision of power. We're in charge, taking what we need, set apart from the rest of the planet. But I think we all know there's something missing. And there are terrible costs. We need to find what I have come to call The Sacred Balance. As a scientist and a broadcaster, I've spent many years talking about our impact on the planet.

News bites: Climate experts are almost certain that this will be the hottest year … northern cod stocks are so low that the federal government … there are strong suspicious that the common weed killer 2,4-D …

environmentalist and many scientist say if we don't cut carbon dioxide emissions … there's a hole in the ozone layer.

David V/O: I want to tell Tamo a different story, show him where we humans really live.

David: C'mon, let's go.

David: Good eye, Tamo -- holy cow! Let's hope he doesn't fly away.

David V/O: This is where everything begins and ends -- the natural world. You get out here, and you see how everything hangs together. And you feel part of it -- you feel in touch with something sacred. When I was Tamo's age, I spent every moment I could knee-deep in a swamp.

David: So, why don't you go ahead and see what you can get -- just swoop through that. You can bump the bottom. That's it. OK, what's in there? Oh! You got a fish. Good one.

Tamo: No, it's not a fish, it's a …

David: What is it? Oh it's a dragonfly larva, a nymph! Yah. Oh, that was great.

Tamo: Oh, I got it ... Oh no … somehow it jumped out of my hand. Come back here. Got it. Man, this is a slimy bugger.

David: Let's see. Oh it's a nice one.

Tamo: That was a good chase -- good chase.

David: I didn't think you'd get it.

Tamo: I got it. It jumped right out it "eeeee," and then "eeeeee."

David: He's a big one, eh? Looks like an old shrivelled-up man.

Tamo: Like you!

David: Like me.

David V/O: In a marsh or a swamp, there's as much diversity as there is in a tropical rainforest. It's just that everything is tiny. In a swamp, if you look carefully, it's teeming with moving things, creatures that are as weird as anything you'd see in a science fiction film. There's a world there that is, it really is, mind-boggling.

We're biological beings. But we've somehow forgotten we belong to the natural world. I think science has been partly responsible -- at least, the kind of science I was trained in. I wanted to go on learning about nature. But as a scientist, I had to take nature apart. We took the world into the laboratory and studied it piece by piece. That's the scientific method. My old lab belongs to a new generation now. But visiting here takes me back to how I was in the sixties. What a time it was for young scientists. We were going to solve all the problems … cure disease, redesign life, conquer time and space.

Movietone News: From the inauguration of the first jetliner service, it's the beginning of a new era in air travel. In effect, the size of the world has been halved by the Comet.

David V/O: We did the science; then, we built the technology. It's such a powerful process; you forget you only know a tiny part of the whole picture. Looking back, I'm amazed at how much we achieved … and how little we understood.

News bites: … where DDT and special sprayers, sections of the city are literally fogged with the insecticide.

David V/O: Science has taken us a very long way … and promised to take us even further. The moon itself was a first step in a journey to the stars. Out to the stars, deep into the cell, those were the two great frontiers. I went into genetics when life's deepest secrets were emerging. Fruit flies taught us almost everything we knew. It's amazing what a beautiful creature it is. But in those days that wasn't what I saw. It was just a bag of genes for me to work on. Somewhere in the excitement of scientific research, I lost that sense of awe and wonder that I felt in the marsh as a boy. I looked straight through the organism, searching for its secrets. But that was just the beginning of the journey. Thirty years later, I'm setting off again. Science has changed a lot since I left the lab, and it's showing us a very different picture of the world. It's starting to describe a sacred balance. Molecular biology today, it's astounding. Every one of the 30,000 human genes has now been decoded. I came to the Whitehead Biomedical Institute in Cambridge, Massachusetts, to meet Eric Lander.

Eric: Hi.

David: Hi. Glad to meet you finally.

Eric: Very glad to meet you finally.

David: Thank you for taking the time to do this.

Eric: A pleasure, a pleasure.

David: You know, I haven't been in a lab like this … Well, I've never been in a lab like this.

Eric: Well, there aren't that many labs like this.

David: Tell me what it's doing. What is this doing?

Eric: In some sense this is not so different than the molecular biology lab of 20 years ago. It's just that that big device there with steel pins and a camera and all that would be a sterile wooden toothpick that you'd use to pick up the individual colony.

David: And one person would be doing it.

Eric: So, you know, about 70 million toothpicks later, you'd have collected all those. But the concept, of course, goes back to the invention of DNA sequencing more than 20 years ago. But the execution, now, that's exciting.

David V/O: What an achievement. Billions of letters in the DNA text have been written down in order -- the entire text of a human being.

Eric: Evolution has been putting down notes in this book for three and a half billion years. It's a classic, which contains, in many ways, the wisdom of three and half billion years of evolutionary adaptation. But we are amateur readers of this book. It's as if we got the keys to this amazing library, and we're going, and then we're pulling down these great volumes; there's all this stuff there. And we say, "wow, isn't this cool!" But of course, we're kindergarteners reading this stuff.

David V/O: And yet, if you ask how do we assemble an organism out of these parts, we've got only the barest clue as to how that happens. What we've really done is we've defined the problem for the first time. There is a lot more there than we know, but the work of much of the next decades, probably the next century, is going to be taking this classic text and learning how to appreciate what's in it. And learning how to design experiments that start with that base. We expected a blueprint revealing all of life's secrets. Instead we found a living library. Each of us is shaped by a web of constantly changing relationships, reaching from the nucleus of the cell to the world around us. It's a very different idea of who and what we are.

News bites: 654321…and lift off on Space Shuttle Discovery, the first spaceship to dock at an orbiting international space station.

David V/O: This was our other great journey, but the view from space has changed as well since we first went to the moon. Today's astronauts seemed to be looking in a different direction. I met astronaut Julie Payette at the Johnson Space Centre, in Houston.

David: So Julie this is a mock-up of the real thing, is it? I mean is it all done to scale?

Julie: It is actually a scale mock-up. This is to really show what the cargo bay looks like, but when we train in this particular facility we really use the front part of the cockpit and the mid-deck.

David V/O: Building 9 in the Johnson Space Centre -- it's where you practice how to spend days or months in space.

Julie: There are a number of things that strike you. Here I am, going at 28 thousand kilometres an hour around the Earth, with it passing by at my feet. It's very big at your feet because you're only 400 kilometres above, but at the same time, it appears to you as one entity; it's unique. It's one planet … clear to you; it's very round; it's one planet. So you're awed first by the splendour, by the beauty of the planet. And then you look down, and you realize that this one planet is the only thing we have.

Every time the sun comes up and down and for us going round the Earth once every hour and a half, 16 times a day. And every time you see it very well -- that thin, thin, thin layer just above the surface. We're way above that thin layer. And that's the atmosphere of Earth. That is it, a few tens or dozen kilometres. That is it. Below that is life, and above that is nothing. It's vacuum.

David V/O: One planet wrapped in air, water, and life. That's what we're part of. We humans have known about our link to the planet for a very long time. But these days, we mostly hear about it from aboriginal people. I first encountered this idea on Haida Gwaii, the Queen Charlotte Islands, off Canada's west coast. It took me a while to grasp it, but it's changed my life. Haida Gwaii is the home of the Haida people, and it's become like home to me.

David: Got a job for me?

Guujaaw: Holy Christ! Still alive.

David: Good to see ya! Hey, you're supposed to be finished by now.

Guujaaw: No, no.

David: Or is this a different one?

David V/O: It was Guujaaw who first opened my eyes to our connection to the Earth. Now he's a close friend and mentor, the head of the Haida Nation. Six new totem poles were going to be raised as part of a huge celebration of Haida culture.

Guujaaw: You know, as you understand the way totem poles work -- its all about identity, the identity of the clans, the identity of the people.

David: And the history, then. Because the history is your identity.

Guujaaw: Yeah, the history and the relationship to the land.

David: You know, I think I can do that job Guuj!

Guujaaw: You think so? Well I do happen to have another brush. You want to try?

David: Yah.

David V/O: I first came here to do a television story about logging on Haida land. As a biologist and an environmentalist, I thought I knew what was at risk if this forest was lost. But Guujaaw had a different sense of the forest's value.

David: You know, Guuj, when we came in to do that show on Windy Bay and I asked you what difference does it make if they cut the trees down, what would happen to you? You remember what your answer was?

Guujaaw: Oh, I said that we would become like everybody else.

David: You're saying that being Haida is more than just each individual, that the land, the air, the water, the fish -- everything -- is what makes the Haida a special people.

Guujaaw: Yeah, as in any other people, in their part of the world, would develop a relationship to the environment around them. And a culture would evolve that would reflect that.

David: You see, I keep saying that in the environmental movement we are acting like the environment is something out there and we are here. But you are saying it in a radically different way.

Guujaaw: Yeah, we're part of this environment; this is our source. You know, we eat plants; we eat the animals; eventually, we're made up of the very elements of the Earth that everything else is made out of. Every inspiration that we get is of the sights and the smells and the things around us.

David: And when you say inspiration, you mean literally taking a breath in, breathing in the stuff that comes off these trees and the plants --

Guujaaw: Yes. You know, this is our home, eh? And that's what we're familiar with. You know, the rain, every part of it is what we are.

David V/O: Like other traditional cultures, the Haida dance their stories, the myths that speak of their place on Earth. Guujaaw described a world in which we are the air we breathe, the place we live, the food we eat. Science is beginning to explore the same relationships. My journey took me to a world the Haida know well -- the coastal temperate rainforest in Northern British Columbia. I met biologist Tom Reimchen there. He's made an amazing discovery: the forest is made out of fish. Tom came here to study bear predation on spawning salmon, the great wave of life pouring up the rivers and streams of the west coast. Every year, fish that have been feeding and growing far out in the Pacific bring a banquet to the forest.

Tom: We have approximately 30,000 pinks in the system now and about five thousand chums. Bringing in these unbelievable nutrients that they have sequestered from afar. It's really a spectacular wonder of nature. It represents probably only a fraction of what came in a hundred years ago.

David V/O: The salmon bring the forest to life. You can see the relationship between the size of the salmon run and the numbers of predators. The more fish there are, the more gulls, ravens, bears and so on. Tom discovered just how far this relationship goes. Instead of feeding in the river or on the banks, the bears often carry their catch a good distance into the forest. And they eat only the choice parts of the fish.

Along the Pacific coast, thousands of bears spread hundreds of thousands of salmon -- and with them the nitrogen each salmon has absorbed in the ocean, the nitrogen the forest needs to grow.

David: Gee, there are salmon carcasses everywhere, Tom.

Tom: Yah, they occur most at the 200-metre band adjacent to the stream. Here's one.

David: That one looks fresh.

Tom: This is the pink salmon. Female. What I will do is … if I can first get you to weigh this; then I'll do a few notes here.

David: OK, it's about 1,800 grams.

Tom: OK, thank you.

David: So basically, this is like a chunk of fertilizer that's come from the ocean and is going to spread around the zone.

Tom: Absolutely. Three percent of that is nitrogen, and that's what the vegetation is taking.

David V/O: Tom and I track the nitrogen through the forest.

David: OK, it's getting harder. How far do I go, Tom?

Tom: Well, you're maybe at 1930 now. You want to go all the way in. About each one of these turns is approximately a year, and we should be able to get back to about 1850.

David: Oh, wow, there's a phenomenal growth rate down there.

David V/O: The growth rings vary with the size of the salmon run. As the runs decline so does the growth of the tree -- and the forest community.

Tom: We have relatively slow growth from the present back to, oh, approximately 1950 in this region. Then you notice, as we continue earlier than that, the much larger growth rings, and that continues down 1930, '20, to the early parts of the century when the tree was a seedling…. So it grew very well for 50 years and then has settled off. So this is a history, a library of information present in each of these rings.

David V/O: The growth rings show that the salmon build the forest, weaving a world of thousands of species across time and space.

Tom: That nitrogen is taken up by the vegetation. That vegetation is now consumed by the insects or by birds. And again, this nitrogen derived from the middle of the ocean is gradually cycled through these many species and into a wider area. So the open ocean and the insects and the birds are linked in a series of an incredibly beautiful set of interactions in which there's no separation at all between the community of the open ocean and the community of the forest.

David V/O: Ever since Isaac Newton's time, we've kind of looked at the universe as if it's a giant machine, a kind of a clockwork mechanism. And what Newton thought was, if we could look at the components of that clock, the cogs, the springs, the wheels, then we could eventually put them back together and get an understanding of the entire universe. That's called reductionism -- you reduce your vision to the smallest component of any given system….

And reductionism has been a very powerful way of gaining insights into bits and pieces of nature. But it doesn't begin to tell us how those bits and pieces come together, how they form this integrated world.

To study those relationships, you need a different way of thinking.

I met biophysicist Brian Goodwin in Bandolier Park, near Santa Fe, New Mexico. He's studying living systems -- parts combining into a whole. He told me something new always emerges -- something greater than the sum of the parts, for example, the Anasazi people, who lived here in these cliffs long ago.

Brian: They were agriculturalists and hunters, and it was fairly marginal agriculture, so they didn't have a lot of produce, and out of that, they created this extraordinary, productive, creative society with art, architecture, religious ceremonies and rituals. It's not as if you have kings and queens that are telling people what to do. They're simply coming together, doing their thing and then this creativity emerging out of the desert. Quite an extraordinary phenomenon.

David V/O: Together they achieved far more than they could have by themselves. Brian told me that's how life works. Parts organize themselves, creating patterns of collaboration you couldn't have predicted from studying the parts alone, like birds turning and wheeling in graceful unison or like cells combining to create a bird or a butterfly. We walked through the park looking for an anthill, so that Brian could show me the living system he's been looking at closely.

Brian: So let's just have a look at the anthill and get an idea of how these guys are self-organizing into a nice, nice coherent whole.

David: All right, so what can we learn from theses guys?

Brian: This nest goes down several feet. And there'll be two or three thousand ants in this colony. As they get older, they do different jobs. When they're young, they do this nest maintenance work. They bring out the debris from inside and dump it on the middens. Then there's another one that does cleanup work around the outside. It's this beautiful self-organizing activity. Nobody's in charge. The queen doesn't tell them what to do. So these guys haven't got fixed roles. They know what to do when. You can't say they are programmed. They are not automatons.

David: They're not machines.

Brian: No, they're quite fluid in their activities.

David V/O: If they're not programmed, how do they combine to do the work in the nest? Brian explored the question by computer. Whenever an active ant touches an inactive one, it springs into action. That's the process. A blue square is a resting ant; touched by an active white square, it lights up and sets to work. The more ants, the more action. You can see the graph of activity across the grid. When there aren't many ants, the place is chaotic. But as you add more ants, the activity increases. Then at a certain density, a distinct rhythm appears, and the whole colony begins to act as one. Order emerges from disorder, a collective rhythm from random individuals. Brian gave me a new view of the living world around me. Everywhere you look, parts come together; patterns develop, something new appears. Cities, factories, ecosystems, organisms, this is no clockwork world. A kind of responsive flow keeps everything alive. Even my heart, Brian told me, finds its own shifting harmony.

Brian Goodwin sent me to see Ary Goldberger, a cardiologist at Harvard with some very surprising ideas about health.

Ary: It appears that health represents a remarkable balance between excessive order on the one hand -- things being over structured -- and complete randomness on the other where , in essence, there would be physiologic anarchy. The healthy systems like to be there. They don't sit still. They are always kind of fidgeting. They are always ready for everything.

When people listen to a healthy heart, what they hear is something that sounds quite regular; it's either the lub-dub, lub-dub or they are looking at a cardiac monitor that's showing something that seems to be ticking off impulses much like a clock. But in fact, when you look at the way the heartbeat is actually changing in a very subtle way, what you see is this extraordinarily complex variability. It was to us an amazing surprise to see that the resting heartbeat was, in fact, as complicated as anything that we were able to find elsewhere in nature.

If you measure the beat over many hours, you discover that the heart's rhythm is constantly changing.

Ary: I'd like to show you a little game, a physiologic game that we developed in the laboratory, and what we're going to see is the pattern that your heartbeat makes if you were just basically sitting around.

David: This is just a resting heart?

Ary: Yeah, is that a surprise to you?

David: It is!

Ary: Yeah, this tracing here is very different from what you might suppose if you --

David: Completely!

Ary: -- came from the tradition of homeostasis. If you're resting, and you're quiet, this should be a straight line or something approaching it. So one of the ways we have of trying to convey what healthy physiology is all about is to take this sequence and to translate it, to transpose it, or to map it into a sequence of notes. And so the question is: what does your heart sound like? What is the music of the healthy heart?

[Music]

David: That was wonderful; that's a normal heart?

Ary: That's a normal heart, and what we're going to see here now is a very different pattern. This is the heartbeat tracing from the patient with heart failure, and what you see here is actually quite different from the healthy. Now things actually look more organized; they look, in a sense, more periodic. Now let's play it and see what this sounds like. [Music]. So which would you prefer to listen to, the healthy heart or this?

David: Boy, what a contrast.

Ary: So very repetitious, very monotonous, and the sicker and sicker people get, the more the variability collapses, and ultimately, you may end up with one note repeating itself. So in the sickest pathologies, you can literally go from this very musical, tuneful dance, which is the healthy heartbeat, to what becomes a one-note marching band.

[Siren]

Ary: The essence of healthy function is adaptability, the ability to cope with an environment that's going to play tricks on you. You don't know what's going to happen next. So having this sort of bubbly type of turbulent-like dynamic, which has all these different frequencies, all these different responses built in, gives you an advantage.

David: So as long as you're playing a symphony in your chest, everything's fine.

Ary: It's the old story about a song in your heart, but literally, that is, in fact, the case.

David V/O: We're not Newton's machines; we're part of an incredible series of living systems that spans the Earth. I visited James Lovelock in the west of England. He's a chemist whose work has been a revelation to me. Almost 40 years ago, he perceived the largest living system of them all -- the one that has kept the planet fit for life since life began.

Jim: To begin the story, I was a science fiction addict. I had been since a kid. I really loved it. And when they started exploring space, it seemed to me almost a dream come true. And I'll never forget the day I had a letter from the director of space flight operations of NASA inviting me to join in with their first moon landing expeditions, to be one of the scientists responsible for analyzing the surface. You know, to me, it was just like a love letter; it was one of those really exciting events of a lifetime.

David V/O: While he was with NASA, he joined a group of scientists searching for signs of life in the solar system. He wondered how we could detect life on another planet without going there. He focused on the planetary atmospheres. What he found changed the way we see our world.

Jim: When you look at the atmospheres of our three planets, Earth, Mars and Venus, they're enormously different. Mars and Venus, which are dead, both have atmospheres that are dominated by the gas carbon dioxide, which is what you'd expect from the distribution of elements. But when you look at the Earth, it's a totally different matter. We have methane and hydrocarbon and oxygen, and they're reacting all the time, burning like a cold flame in our atmosphere.

If you were a Martian astronomer, so to speak, looking at the Earth to detect signs of life by atmospheric analysis, it would shout back at you, "we're a living planet and there's no question about it." All sorts of things would come back immediately from the atmospheric composition.

And it began to come into my mind at that moment, and I remember it very vividly, that if our atmosphere is so extraordinarily different, so reactive -- and yet it stays constant for millions of years -- something must be regulating it. And since I knew that these gases all came from living organisms, it must be life that's doing the regulating. So now, I had my idea: a system on the Earth that could regulate the climate and the chemistry.

David: That all came together in that, just … wow, what an exciting moment.

Jim: That afternoon. It was an exciting moment.

David V/O: James Lovelock saw the planet as a living entity. He saw how the totality of life on Earth creates and maintains the conditions for life, cycling the crucial elements -- earth, air, fire, and water. It was a new vision for science but one with deep roots in human tradition. He named this planetary entity Gaia, after the Greek goddess who first drew the world from chaos, breathing life and form into matter. We walked up to a local church, talking about life and death and the carbon cycle that keeps it all going.

Jim: This is a wonderful place to illustrate the great cycle of carbon where the carbon dioxide comes in from the air, brought down by the rain, and is taken up by all the living things around us, the grass and the lichens growing on the rocks. That's what takes the carbon from the air.

David: And we can see it right here.

Jim: We can see it right here on this old tombstone. It's only about 150 years old, if I'm right, and already the lettering is beginning to get obliterated, showing how the lichen, these patches of white, are chewing away just to get their nutrients out.

David V/O: Like all life, we're part of Earth's chemistry, put together and taken apart by the great cycles of Gaia. For Jim Lovelock, that's a very comforting thought.

Jim: I put my trust in Gaia. I know that we have the most beautiful planet, something worthy of our worship and worthy of our respect. And in the end, I'm quite happy that there's no hereafter in the religious sense. I know that all the elements, all the chemicals in my body will go to mingle with the air and the ocean and the other living things.

David: And you'll still be there in a very profound way.

Jim: There in the living planet.

David V/O: My father, he interpreted that when you die the atoms that make up your body don't vanish and disappear. Essentially, you're just reabsorbed by everything else. So you're reborn again in these other life forms. So he told me before he died: "When you see the fish flash in the water or hear the wind sigh through the trees, you'll know that I'm there." And I believe that very, very strongly.

After all, where did we come from in the first place? We came out of the natural world, and we go back to it.

I'm profoundly influenced by my First Nations friends. And I like the way that they see our relatedness to all other life on Earth. The Haida Nation is celebrating its history -- raising six totem poles over a week. One of them was carved by my friend Guujaaw. It's the biggest pole raising in a century. My family has been adopted by the Haida, and I feel honoured to be here and share their celebration. Just like any other community, a public celebration here has its protocols. Clans and villages set aside their differences -- families reconnect. Each pole commemorates one of the lost villages of Haida Gwaii. All depict how people belong together and to the life around them. Each one is a map, a history, a genealogy, and a set of stories.

Since time began, humans have believed that they're related to the living world around them, that the Earth is alive and powerful. They've known that everything is made of the same stuff -- earth and air, fire and water, sacred elements crucial to life. That world imagined by human beings is held together by love, given form by spirit. What about us, here in the world we've built for ourselves? We're part of the same reality whether we like it or not. That's what science is telling us. How you imagine the world determines how you live in it.

After five days of work, the monks have finally completed the sand mandala. Every detail is perfect, according to the protocol.

Buddha has entered his palace, and the entire mall is now a sacred place. Buddhists believe that form comes out of nothing and returns there -- like the elements that move through the living world, making and unmaking life. Like everything else, we're the raw material of reality -- matter transformed to life.

Next time on The Sacred Balance, we'll explore the elements from which all life emerges. We'll journey through a world created by water, transfigured by air -- the matrix we all are part of.