

THE BLUE ECONOMY

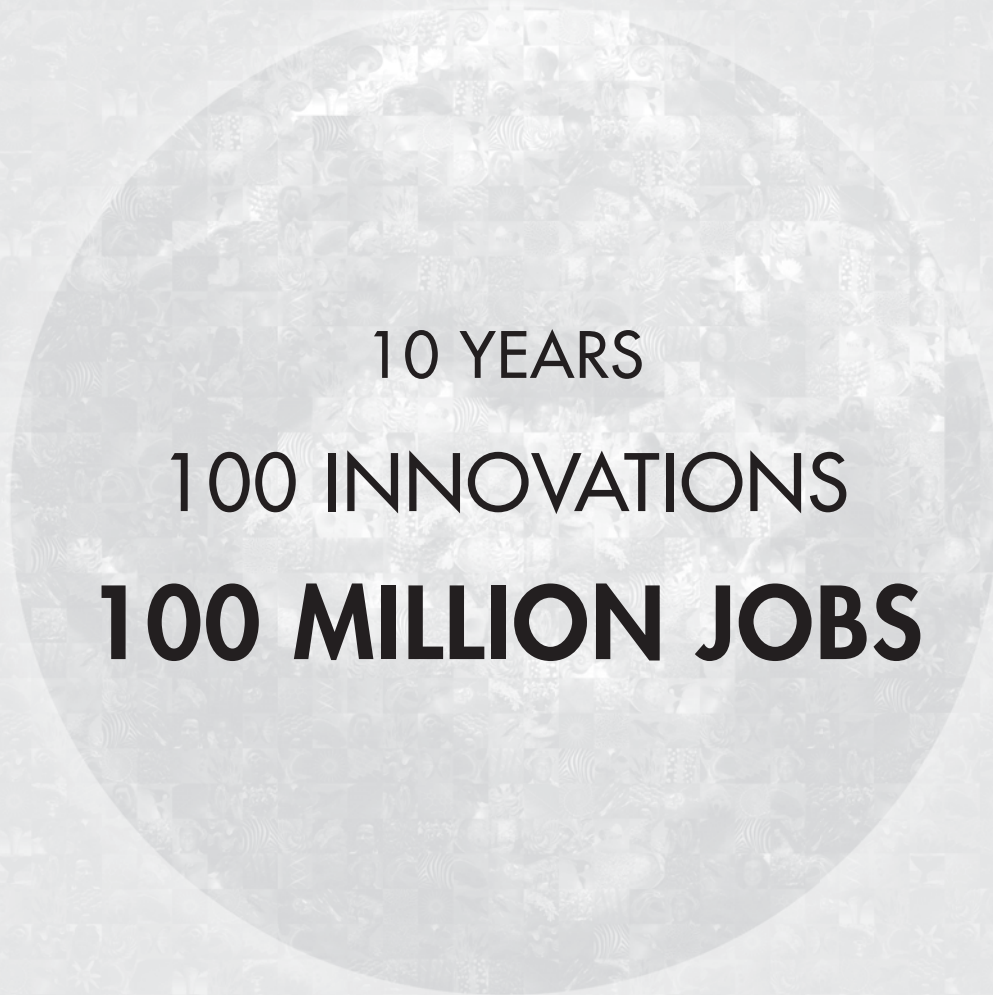


10 YEARS
100 INNOVATIONS
100 MILLION JOBS

Gunter Pauli

REPORT TO THE CLUB OF ROME

THE **BLUE** ECONOMY



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Paradigm Publications, Taos, New Mexico, 2010

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10 Years, 100 Innovations, 100 Million Jobs

Report to the Club of Rome

Gunter Pauli

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PRAISE FOR THE BLUE ECONOMY

The Blue Economy describes innovations that are certain to change our habits of production and consumption. It points us in a strategic direction for sustainable development. Dr. Pauli's new economic model gives aspiring entrepreneurs and political leaders the means to contemplate and achieve a sustainable future. They will be able to take advantage of manifold opportunities and make policy decisions that serve both economy and community.

NOEMI SANIN POSADA

Colombia Ambassador to Spain (2003-2007),
UK (1994-1996, 2007-2009), Venezuela (1990-1991) Colombia Minister of
Communications (1983-1986), Colombia Minister of Foreign Affairs (1991-1995)
Government of Colombia Peace Negotiator

The Blue Economy is exactly the kind of tool we need to help us repair our broken economy and create a more sustainable model. The new ideas and innovative thinking compiled here give us exciting new options about how to transform our economy so that it can generate new jobs and sustain healthy, happy communities far into the future.

PHAEDRA ELLIS-LAMKINS

CEO, Green For All

Over the past 30 years as I have built up the computer industry around ACER, Dr. Pauli has introduced me to many creative ideas, especially through his Zero Emissions Research and Initiatives (ZERI) organization. He has devoted himself for decades to theoretical development as well as practical application of zero emission concepts. The ideas he puts forth in *The Blue Economy* represent a sustainable and competitive business framework based on innovations that offer investors and society financial, social, and environmental benefits. Such opportunities to achieve sustainability, parity, and profitability are not only inviting but tremendously compelling.

STAN SHIH

Founder, ACER Computers
Chairman, IDSoft Capital Venture Fund

Gunter Pauli masterfully elucidates examples from nature that can help us solve our sustainability problems. There are refreshing and competitive options to artificial chemical and technological fixes and their unintended toxic consequences.

YVON CHOUINARD
Owner, Patagonia, Inc.

Nature holds all our solutions. Gunter Pauli is a visionary entrepreneur who is able to help us create a Blue Economy based on respecting the Earth's ecosystems and humankind. His book is destined to be the bible of this new economy, meant for all of us who are working to build a better world.

CHRISTIAN COURTIN-CLARINS
Chairman, Clarins (France)

Our current economic crisis is also a crisis of ethics and values which has led to the enrichment of a few and the disempowerment of many. *The Blue Economy* advocates for a new economy, one led by innovation and creativity to cultivate the next generation of social entrepreneurship. We are in need of such an economy and no one is better placed than Gunter Pauli to offer this to the world.

WENDY LUHABE
Chancellor , University of Johannesburg
Chair, Industrial Development Corporation of South Africa

Fifteen years ago Gunter Pauli came to my Tokyo office where I was serving as Rector of the United Nations University. He explained his concept of "Zero Emissions" and I immediately hired him as my Special Advisor. In a very short time, the Zero Emissions concept was thoroughly disseminated in Japan and other countries. Private Japanese companies quickly began to invest in technologies and facilities to implement, in practical terms, that original concept.

Gunter's new work, *The Blue Economy*, presents excellent innovative ideas with practical applications that will help entrepreneurs and consumers to significantly impact the economies of the world, while earning money, generating jobs, and protecting the environment. In envisioning the future, Gunter continues to be an optimist. I am one too. As you read *The Blue Economy*, you will be introduced to these ideas and their concrete applications. Don't miss it and recommend it to your friends.

PROFESSOR HEITOR GURGULINO DE SOUZA
Rector, UN University, Tokyo, Japan (1987-1997)
Secretary General, IAUP (International Association of University Presidents) Brasilia, DF Brazil

Ultimately, our civilization will survive if we are able to emulate nature. *The Blue Economy* illuminates the way.

LESTER R. BROWN

President, Earth Policy Institute

Author, *Plan B 4.0: Mobilizing to Save Civilization*

Though I know too little of ecology, the rich ideas and inspirations set forth in *The Blue Economy* are worthy of our greatest attention.

ELIE WIESEL

1986 Nobel Peace Laureate

The Blue Economy shows us that by securing materials and aligning production schemes as nature does, many problems of environmental degradation and pollution would disappear. However, economic policy and core business models largely ignore integrated solutions. Future economic models would do well to take into account the strategic advantage of a portfolio of innovations based on nature and physics. That will be a tall order, but Gunter Pauli's book, with its rich presentation of how nature and economy can and must collaborate, convincingly shows the way.

ANDERS WIJKMAN

Member, Swedish Royal Academy of Sciences

European Parliament (1999-2009)

The Blue Economy is an exceptional vision of what is truly possible in the context of a sustainable economy. Gunter Pauli has worked tirelessly for many years to put substance to the promise of a Blue Economy. His book is the fascinating result of true dedication to unlocking the potential for sustainability that is universally practiced in Nature's ecosystems. As investments managers we always seek great, unique ideas that can make money while solving the world's greatest challenges. I would urge anyone who is interested in going beyond shallow notions of sustainable business to read this book and be inspired by the real opportunity we now have to create a truly enduring and sustainable economic system based on Nature's profound wisdom.

COLIN M. LE DUC

Partner, Generation Investment Management LLP (London)

Gunter Pauli is an inspired and visionary entrepreneur. He is the kind of business leader and educator the world needs. His concepts and ideas for creating sustainable business and social enterprises are based on a deep understanding of ecosystems. This book belongs in the library of every university, business school, and entrepreneur who wants to make a difference in the world today.

HAZEL HENDERSON

Author, *Ethical Markets: Growing the Green Economy*
President, Ethical Markets Media (USA and Brazil)

The Blue Economy describes in a clear and inspiring manner a systems approach that models Nature and provides a way forward. For anyone who wants to profit from the economic opportunities concomitant with 21st century changes, Gunter Pauli explains how to restructure economies and reshape societies.

HARVEY STONE

President, Open Circle Innovations

Gunter Pauli has formulated an entrepreneurial business model that can respond to basic needs, build social capital, and achieve sustainability. His current economic development work with READ in Bhutan is focused on introducing a portfolio of the innovations described in this book as tools to improve the National Happiness Index and foster environmental and social entrepreneurship. Given the mission of the Social Venture Network, his message in *The Blue Economy* is certain to resonate with a growing community of business and social leaders.

OMER L. RAINS

Chairman, Rural Education & Development (READ)
Global Director, Marshall Plan Venture Capital Fund
Member, Social Venture Network (SVN)

Gunter Pauli has carefully gathered many concepts that can achieve harmony with nature, wealth for entrepreneurs, and opportunities for food and livelihood security for all. *The Blue Economy* is important reading for all entrepreneurs who embrace environmental awareness and celebrate human evolution.

PAUL MAHAL

Co-founder, CoroCare

Hawai'i is moving to revitalize the 'āina – (the land and the ocean) using the principles of prosperity from the *ahupua'a* model, originating from the indigenous culture, aligning with the ancient systems of the Earth and the values and spirit of Aloha and Pono. The innovations described in *The Blue Economy* honor this spirit. *Aloha ke Akua, e mālama kakou.*

MARK MCGUFFIE

Managing Director, Enterprise Honolulu.

Japan was among the first to support Gunter Pauli's early work with zero emissions. I am certain that the innovative approaches he describes in *The Blue Economy* will give the entire world a powerful engine for a new kind of economy.

PROFESSOR KIYOSHI KUROKAWA, M.D.

Special Science Advisor to the Prime Minister of Japan (2006-2008)

President, Science Council of Japan (2003-2006)

The Blue Economy fosters our transition from a product-based economy to a system-based economy. Such a cultural leap requires all of us to see – and move beyond – the connections that have gone into an oblivious core business strategy subject to market tyranny.

DR. CATIA BASTIOLI

President, Novamont SpA (Italia)

European Innovator of the Year (2007)

As a species we have evolved in interdependence, formulating the tools for brilliant co-existence. The novel ideas and breathtaking concepts presented in *The Blue Economy* resonate with our deepest knowing. We are led to recognize that Nature devises systems perfectly suited to continuance. The model of cascading energy and nutrients from one kingdom of nature to the next offers us a necessary paradigm that allows us to envision our place in nature's congruence.

AMY MCCONNELL FRANKLIN, PH.D., M.ED., M.P.H.

Emotional Intelligence Education Consultant and Lecturer

Author, *Choose to Change*

In *The Blue Economy* Gunter Pauli exposes readers to a brilliant compendium of innovations that hold the potential to intertwine profitability with sustainability. He shows us how business, science, civil society, and community can partner and profit in meeting the needs of all. This work will energize entrepreneurs to meet the challenge set by former United Nations Secretary-General Kofi Annan: “Let us choose to unite the power of the markets with the authority of universal ideals. Let us choose to reconcile the creative forces of private entrepreneurship with the needs of the disadvantaged and the requirements of future generations.”

FREDERICK C. DUBEE

Professor, World Peace Academy, University of Basel
Senior Advisor, United Nations Global Compact, China Network
Executive Director, International Global Management Education Institute

The Blue Economy holds a special place on my desk – front and center. In my 30 years of working for a sustainable future, it is rare to come across a book with such a high level of both intellectual rigor AND joyful wonder. I consider both essential. Gunter Pauli’s insights and extraordinary breadth of solution-oriented scenarios can make your head spin and your heart beat fast. As a student of systems thinking and design, the 100 innovations described fill me with a sense of hope and thrill me with the possibilities for a future I’ll be happy to leave to upcoming generations.

KRIS HOLSTROM, REGIONAL SUSTAINABILITY COORDINATOR
The New Community Coalition
Colorado organic farmer

The Blue Economy reveals, through the eyes of an economist, a panoply of technological innovations based in nature. It shows us that environmental sustainability and company profitability are far from mutually exclusive.

ANDREW PARKER, PHD
Research Leader, London Natural History Museum & Green Templeton College,
Oxford University; Blue Economy Innovator

From the GREEN (initiative)
Jump into THE BLUE (economy)
Your RED (balance sheet) becomes BLACK (wealth)!
With the true dynamic of GAIA (naturally . . .)

TOMOYO NONAKA
Chairwoman, Gaia Initiative
CEO, Sanyo Electric Group (Japan) (2005-2008)

CONTENTS

Foreword	xvii
Dedication	xxi
Preface	xxv
ONE — TIMELESS RESOURCES FOR THE CHALLENGES OF OUR TIMES	1
Physics and Practicality	2
Wasting Away	4
How to Welcome Waste	7
Achieving Abundance	11
TWO — EMULATING ECOSYSTEMS FOR A BLUE ECONOMY	13
Plenitude from Paucity	15
Food Security in Africa	19
An Island Afloat a Dream	21
Progressive Pueblo Solutions	24
Bagasse, a Sweet Solution	26
Urban Whole Systems	27
THREE — NATURE’S RESOURCE EFFICIENCY	29
Structure and Flow	30
Termites, the Masters of Flow	31
A Stripe of a Different Color	34
A Desert of Plenty	35
Collecting Water by Attraction and Repulsion	36
Sophisticated Sticking	37
Vortexes as Viable Bactericides	38
Natural Ways to Avoid Fire and Flame	41
Unlocking Solutions to the Challenges of Sustainability	44
FOUR — LEADING THE WAY FOR MARKET LEADERS	47
Oak from Seed	48
New Possibilities, New Perspectives	49
Getting Out of the Box	52
Management Principle 1: Core Business Defined by Core Competence	53
Management Principle 2: Supply Chain Management	56
Management Principle 3: Outsourcing	58

Management Principle 4: Cash Flow as King	59
Management Principle 5: Crowding Out	60
The Downside of the Upside	62
So Many Solutions, So Little Time	62
Greenwashing	63
From 20 Thousand to 100 Million	65
FIVE — NATURE’S MBA (MASTERY OF BRILLIANT ADAPTATIONS)	68
Empowering Entrepreneurs	70
Three Levels of Sustainability	74
One Innovation, Multiple Revenues	75
Cascading Resources in a Community	77
Real Opportunities, Real Solutions	78
SIX — CASCADING MODELS, MULTIPLE CASH FLOWS	81
The Buzz about Coffee	85
Pulp to Livelihood	90
From Waste to Superfood	94
SEVEN — SPINNING A SILKEN TALE	97
Topsoil on the Cutting Edge	98
Silk for Carbon Capture	101
The Geometry of Silk	102
A Close Shave	105
Smooth as Silk	107
Biocompatible Medical Uses	108
EIGHT — FROM THE MIGHTY TO THE MINISCULE	111
Only a Heartbeat Away	112
Energy from Whales	113
Healthy, Battery-Free Electrical Current	116
Health Data Online	118
A Cooler Way to Cool	121
(Did You Hear?) The Furor over Furanones	123
Miraculous Maggots	128
Painless Injections	134
Gasless Propulsion	135
Bundling Innovations	137
Biodiversity and Health	139

NINE — A RAINBOW OF POSSIBILITIES: REMAKING COLORATION AND COSMETICS	141
Light Perception	143
Ultraviolet: Light Humans Do Not See	144
The Evolution of Color and Perception	146
Color Pigmentation as Commodity	148
Waste for One, Resource for Another	151
The Biorefinery of the Future	154
TEN — ENVISIONING NEW ENERGY OPTIONS	157
Rethinking Demand-Side Energy Policies	160
Unlocking New Energy Options	163
Electricity from pH	165
Electricity from Temperature Differential	165
Electricity from Gravity and Pressure	167
Energy from Movement (Kinetic Energy)	170
CO ₂ as a Source of Energy	171
ELEVEN — TRUE GOLD: MINES AS PLATFORMS OF HEALING	179
How to Restore Errors of the Past	180
Binding the Wound to Heal	183
A Method for Methane Capture	184
Converting water from cost to revenue	186
Electrifying Savings	188
Power from Airflows	189
Energy Generation from Temperature and Pressure	189
Environmental remediation	190
Contributions from Complex Ores	192
Mines as Biorefineries	194
Financial Engineering	196
TWELVE — BUILDINGS DESIGNED BY FLOWS	197
Creating an Ecosystem of the Domicile	198
The Seven Flows of Building Design and Living Space	200
The Thoroughly Modern Nursery	203
The Flow of Air and Light	205
Insect Insights Relative to Humidity	207
A Living Filter	208
Fungi in the Basement	209

The Challenge of Triple Glazing	211
The Flow of Water	211
The Heat Island Effect	217
The Flow of Sound	218
The Flow of Energy	219
The Flows of People and Matter	222
Schools as Sustainability Classrooms	223
Housing for All	225
All Flows Considered	228
50 Technologies Inspired by Nature Integrated into Building Design	230
 THIRTEEN — CASCADING A BLUE ECONOMY	 231
Opting Out of a Dead End	232
A Curiously Winding Path	233
Nature’s MBA, Core Business MBA – A Qualitative Comparison	238
 EPILOGUE — REALIZING A DREAM	 239
Success in California	242
Coffee, Invasive Species, and Local Biodiversity	244
Overcoming an Unjust Boycott	245
From ZERI to 100	247
 APPENDIX 1 — A TABLE OF 100 INNOVATIONS INSPIRED BY NATURE	 251
 APPENDIX 2 — 100 INNOVATIONS INSPIRING COMPETITIVE BUSINESS MODELS	 259
Cascading Materials, Nutrients, and Energy like Ecosystems	260
Substituting Something with Nothing	271
Platform Technologies Accelerating Sustainability	285
Extraordinary Food for Thought	293
 BIBLIOGRAPHY AND REFERENCES	 297
Books and Journals	297
Other Works by Gunter Pauli	301
Additional Information	302
 INDEX	 303

FOREWORD

The ideas you are about to encounter are among the most tantalizing prospects for realizing a low carbon, resource-efficient, and competitive economy in the 21st century. It is remarkable that some of the greatest opportunities for jobs will come from replicating the waste-free efficiency of ecosystems. The natural world, in all its splendor and diversity, has already solved many of the sustainability challenges humanity faces in ingenious, unexpected, and even counterintuitive ways. If humans could only unravel the fascinating chemistry, processes, structures, and designs that organisms – from bacteria and mollusks to reptiles and mammals – have evolved and tested over millennia, perhaps then we would have new and transformational solutions to the many challenges faced by a planet of six billion people, rising to over nine billion by 2050.

Gunter Pauli's book, *The Blue Economy*, opens the door to this fresh, forward-looking field. The pioneering advances it profiles will quickly persuade business and government leaders to explore and develop the cutting-edge sciences at the foundation of these new developments. It highlights the innovative work of many, including Emile Ishida (Japan), Wilhelm Barthlott (Germany), Andrew Parker (UK), Joanna Aizenberg (Russia/USA), Jorge Alberto Vieira Costa (Brazil), and other front-line scientists who refuse to accept either the conventional wisdom or the status quo. In featuring their work, *The Blue Economy* demonstrates that we can find ways of utilizing physics, chemistry, and biology with renewable materials

and sustainable practices just as ecosystems do. This is no longer the realm of science-fiction; it is actually happening here and now. With appropriate policies to support research and development, with promotional strategies delivered through market mechanisms, these materials and methods offer abundant opportunities for accelerating adaptation to pressing global issues.

In turn, widespread adoption of the framework proposed in *The Blue Economy* can provide a solid rationale for implementing the agenda of the Convention on Biological Diversity and the missions of organizations like UNEP and IUCN. Currently, species are being lost at an unprecedented rate. Many scientists believe that the world is now undergoing the sixth wave of extinctions, primarily caused by economic models and human behavior that undervalue the contributions of species, habitats, and ecosystems to our lives and the planet's life support systems.

These species within ecosystems underpin our mega-trillion dollar economy by providing essential services at the local, regional, and global level. Many ecosystem species and processes hold clues for potentially significant achievements in the production of medicine, food crops, biofuels, and low-energy materials. These could prove to be essential for societal measures to mitigate or adapt to climate change. Such achievements will certainly be needed to catalyze new sustainable businesses and industries to provide decent, sustainable jobs. For the 100 innovations it describes, *The Blue Economy* estimates an employment potential of 100 million jobs. The plausibility of this estimate is enhanced by the fact that there are today more people employed in renewable energies than in the oil and gas industries combined, and that investment in wind, solar, and geothermal power generation exceeds investment in new fossil fuel power plants.

The United Nations forecasts that by 2025, 1.8 billion people will be living in countries or regions suffering from water scarcity. Two thirds of the world's population could be living with conditions of water stress. Meanwhile, climate change is expected to aggravate water problems via more extreme weather events. Consider a water-collecting system modeled after that of

the Namib desert beetle. This resourceful creature lives in a location that receives a mere half-inch of rain a year, yet it can harvest water from the fogs that blow in gales across the desert several mornings each month.

Researchers have recently designed a surface that is inspired by the water-attracting bumps and water-shedding valleys of scales on this beetle's wings. These scales allow the insect to collect and funnel water droplets that are thinner than a human hair. Trials have been conducted to capture water vapor from cooling towers by using a technique modeled after the beetle's skill. Initial tests have shown that this film invention can recover 10% of the water lost. This lowers energy bills for nearby buildings by reducing the heat island effect. An estimated 50,000 new water-cooling towers are erected annually and each large system loses over 500 million liters of water per day. Thus a savings of even 10% is significant. Other researchers are adapting the beetle's water collection system to develop tents that collect their own water, as well as surfaces that will mix reagents for "lab-on-a-chip" applications. Twenty people are employed on this fledgling development but the true world-wide potential might be as many as 100 thousand new jobs.

The Blue Economy cites a project in Benin where a novel farming and food-processing system emulates the way an ecosystem "cascades" nutrients. Animal wastes from the slaughterhouse are processed in a maggot farm to feed fish and quail; biogas provides electricity and plants purify water. The project is a microcosm of the Blue Economy. For the same Dollar, Euro, Rupee, or Yuan it generates, it produces income, livelihoods, and food security while recycling and re-using wastes. To date 250 people are employed. There is a potential of 500 thousand jobs if this cascading model were used in every African abattoir, and five million jobs worldwide.

It has been nearly 70 years since Swiss engineer George de Mestral, having examined the natural hooks of the burdock seeds that stubbornly attached to his clothes while on a countryside stroll, came up with an invention we know as "Velcro™." More recently, buildings such as a shopping centre in Zimbabwe, a hospital in Colombia, a school in Sweden, and the Zoological

Society of London are cooled by structures inspired by termite mounds. Meanwhile, engineering schools around the world are racing to develop far more efficient solar power based on the molecules and processes of photosynthesis. What *The Blue Economy* emphasizes is the vast potential of such innovations. It spotlights the tipping point inherent in the immense number of such breakthroughs currently in the laboratory, under development, or being commercialized.

The world has been racked by food, fuel, environmental, financial, and economic crises. Ecosystem and biodiversity loss has led to an emerging climate crisis and a looming natural-resource calamity. A Blue Economy, able to deal systematically with these many challenges, and ready to seize the manifest multiple opportunities, is now essential. Our Earth has always been our greatest resource, and this book cites 100 new reasons why investing in both local and global ecosystem sustainability is even more valid and central today. If we follow the logic of nature we can create a foundation for societal sea-change and economic transformation that manifests from the ground up.

Leonardo da Vinci neatly summed up the power of ecosystems and nature's material efficiency in his *Codex Atlanticus*: *“Everything comes from everything; everything is made of everything; everything turns into everything, for all that exists in the elements is made of these elements.”*

ACHIM STEINER
Under-Secretary of the United Nations
Executive Director, UN Environmental Programs (UNEP)

ASHOK KHOSLA
President, International Union for Conservation of Nature

DEDICATION

Let us not demand more of the Earth.
Let us do more with what the Earth provides.

— GUNTER PAULI

The endeavor to grasp new insights based on the elegance of nature’s ecosystems is anything but a solitary exercise. While this book was written by one person, the impulses, energy, and support emerged from a diverse network, ranging from old friends, close family, and surprising new arrivals. Since 1982, Yusuke Saraya, my long-time friend from Japan, often conspired with me to explore the possibilities offered by ecosystems. The strongest encouragement for this project came at the start from my friend Yasuhiro Sakakibara. After a memorable visit to Reims, France, in 2006, the moment I first discussed the idea with him, he offered his full encouragement. His unconditional support, combined with his admonition that it had to make business sense, typifies the personal generosity that accompanied his promise of funding.

The intellectual supports from Ashok Khosla, Anders Wijkman, and Heitor Gurgulino de Souza, who have been fellow co-inspirators and members of the Club of Rome, have offered structures for debate. From the beginning they provided generous support for this endeavor to identify real breakthroughs beyond “green” batteries and corn-based plastics. Jorge Reynolds, whom I have had the privilege to follow and work with over a quarter of a century, provided first-hand and deeper insight as to how single discoveries into the functioning of the whale heart could impact society beyond the health of heart patients. His inventions provide a fresh look at how innovative advances in health care could provide breakthroughs for

planetary health and simultaneously build a competitive industry, in effect achieving a powerful and deliberate synchronicity. Jorge is also part of a small nucleus of individuals who witnessed Paolo Lugari's emerging dream at Las Gaviotas that used the powers of symbiosis in natural ecosystems to heal centuries of thoughtless human abuse of the land.

The technical and innumerable pages of listings of what nature and ecosystems accomplish, gathered with painstaking effort, came to life only when scientists like Joanna Aizenberg, Andrew Parker, Peter Steinberg, Christer Swedin, Jorge Alberto Vieira Costa, Peter Steinberg, and Fritz Vollrath plumbed the depths of their insights and described opportunities with passion and clarity. These efforts, complemented with the entrepreneurial pragmatism of Curt Hallberg, Emile Ishida, Mats Nilsson, and Norman Voyer, provided a wealth of content that helped establish the vision and the foundation for the ideas that stand at the core of this book. When I subsequently contemplated the work of systems integrators like Paolo Lugari (Gaviotas), Father Godfrey Nzamujo, John Todd, and Anders Nyquist, I realized the tremendous power of bundling these technologies into systems to achieve something that is economically viable, eminently natural, quite complex, yet very simple. I knew that their energy had set me on track toward something truly worthwhile. Without the generosity of time offered by over a hundred scientists and entrepreneurs, I would never have had their perspective for my goals to describe how adapting the logic of ecosystems to economic models can generate sustainable livelihood and provide the basic needs of all.

Then, there is the energy to pursue this endeavor against all odds. When my partners of the moment abandoned larger goals and chose to control intellectual property for personal benefit, it was the ethical leadership of my mentor, Elie Wiesel, that helped direct my focus to the greater good. It permitted me to drop the excessively romantic view of each species that had diverted my attention from the real power of ecosystems and the vast portfolio of entrepreneurial opportunities. Within that changing world my wife, Katherina, provided the greatest support. Her unconditional backing

helped me realize the importance of discarding the superficial calculations of idealized businesses in favor of a vision of systemic job generation that could redefine competitiveness and offer a new economic framework to a global population.

Several organizations around the world invited me to share emerging insights, engage dialogues, focus proposals, and prioritize the cases. Addressing Bioneers at the Bay (Massachusetts, USA – organized by the Marion Institute); the governing council of UNEP in Nairobi, Kenya; the COP on Biodiversity in Bonn, Germany; the Industry Leaders’ Summit in New Delhi, India; bankers and farmers at ABSA in Stellenbosch, South Africa; Al Gore’s Expert Panel on Solutions for Climate Change in New York, USA; the GLOBE Meeting at the G8 in Tokyo, Japan, the LIFT Conference in Marseilles, France; the Annual Congress of Engineers (ANPEI) in Brazil; the APEC CEO Summit in Singapore; the General Assembly of UNIDO in Vienna, Austria; and the 2009 Annual Meeting of the Club of Rome in Amsterdam, Netherlands, are some of the valuable exchanges that enriched my insights.

Perhaps the greatest gift over the past decade was the spider bite (from the brown recluse) that put me on crutches for nine weeks and in a wheelchair for four. While this did not stop me from scouting the world for solutions, it did offer me time in Marion, Massachusetts to reflect upon pathways towards the future. Michael Baldwin, founder of the Marion Institute, and Peter Dean, his fellow board member, offered me a rare chance to think and rethink, while a new world emerged on my horizon.

It was at this nexus in time that Peter Dean and Erin Sanborn’s crystallizing energy provided the platform this project has deserved ever since Achim Steiner, the Executive Director of the United Nations Environment Programme, opted to support this initiative. I am very grateful that Achim has continued to support this effort to look at the emerging Blue Economy. Then the editors appeared who could convert the spirit of this epochal insight into language that reaches everyone. Martha Fielding and Bob Felt

translated my insights into this emerging world into a fluid chain of words and concepts that reaches a larger readership, beyond the experts and the converted.

In 1979 Aurelio Peccei, founder of the Club of Rome and a personal mentor, invited me to attend the annual meeting of the Club in Salzburg, Austria. Three decades later, the members of the Club have considered this book worthy of being named a Report to the Club of Rome, in the rich tradition of milestone publications like *Limits to Growth* and *Factor Four*. It is a humbling honor. Thus it is with deep gratitude that I undertake to merit these expectations. My deepest wish is to fully contribute to the vision and the shaping of the sustainable society articulated by the founding fathers of the Club of Rome.

There are many people who have been key to making certain that this book came to be; but perhaps the most momentous inspiration has been my son, Philipp-Emmanuel, who just arrived to this world, opening wide my eyes and making me look positively into the future, reawakening that fundamental feeling that parents have a responsibility to create an environment that is conducive to a better future. My older sons, Carl-Olaf and Laurenz-Frederik, were the first readers of this book. My adopted daughter Chido deserves full credit for demonstrating that all in this book is not fantasy. It is reality in the making as described throughout the chapters of *The Blue Economy*. This is what offers hope.

PREFACE

If we teach our children only what we know,
they can never do better than we do.

— GUNTER PAULI

In the 1980s when I read the books of Lester Brown and his team at the Worldwatch Institute, I had the urge to make available to everyone this wealth of data concerning global environmental issues. The onslaught of negative statistics and trend analyses, based on data assembled in Washington DC, showed only a few positive lights on the horizon. Consequently I created a dedicated publishing company to bring the *State of the World* and *Vital Signs* to a recalcitrant listener: the business community in Europe. As an entrepreneur who had established a half-dozen companies by then, I was also a concerned citizen. In the early 1990s with the arrival of my two sons, Carl-Olaf and Laurenz-Frederik, a reflection crossed my mind as happens with so many young fathers and mothers: we want to leave the world to our children in a better condition than we received it from our parents. As my first sons graduate from high school nearly two decades later, I must confess it seems a Herculean task.

However, as life matures and wrinkles unveil deep concerns, we cannot simply remain concerned citizens, worried about the future, sorry about every error. Rather we must regroup and find ways to create the foundation on which we can allow the next generation to surpass our achievements. Perhaps the greatest freedom we can offer our children is to allow them to think differently and, more importantly, to act differently. It is therefore helpful to reflect on what we can bequeath future generations as a structure for positive thinking and a platform for concrete action. This is perhaps the

greatest challenge. The bad news is not only about the health of our planet. For the first time in decades we are realizing that the economic system is also crumbling.

As an early member of the Club of Rome, the informal gathering of concerned policy makers, scholars, business leaders, and international civil servants, I know all too well the importance of sounding a wake-up call. The *Limits to Growth* report put forth by the Club of Rome clearly delineated the vicious cycle of population explosion, environmental degradation, unbridled industrial growth, and collapse of ethical standards. As a publisher of the Worldwatch *State of the World* in selected European languages, and as an avid participant in the Club of Rome for three decades, I could never separate the negative conclusions from the need for positive action.

I began working with Ecover, a Europe-based producer of biodegradable cleaning products. When even the largest manufacturers adopted our biodegradable ingredient – the fatty acids of palm oil – as an industry standard replacement for petrochemical surfactants, it dramatically increased demand for this alternative. This spurred many harvesters, especially in Indonesia, to replace vast swathes of rainforest with palm tree farms. In destroying the rainforest, much of the habitat for the orangutan was also lost. Thus I learned to my chagrin that biodegradability and renewability do not equate with sustainability.

In my first article on the subject, published in Seoul, Korea in 1991, I exhorted the industry to emulate the efficiency of ecosystems. The wisdom of an ecosystem is not just that it provides services like fresh water and clean air, replenishment of topsoil, balanced control of bacteria, and a never-ending evolutionary pathway, always searching for better solutions and higher efficiencies. Ecosystems are also an inspiration for changing our highly wasteful production and consumption model. The article suggested that sustainability is only foreseeable when our system eliminates the concept of waste, and starts cascading nutrients and energy as nature does.

After the disenchanting experience with Ecover, I was challenged by Prof. Dr. Heitor Gurgulino de Souza, the Rector of the United Nations University hosted by the Japanese government, to model an economic system that generated no waste and no emissions, yet created jobs, contributed social capital, and did not entail a higher cost. I accepted this challenge three years before the Kyoto Protocol was approved. Thus I had the opportunity to imagine, from an academic ivory tower, how we could emulate the productive and evolutionary interactions of natural ecosystems where waste for one is food for another. Following three years of research, and in cooperation with the United Nations Development Programme, the ZERI Foundation was established in Switzerland with its sole objective to implement pioneering cases that could demonstrate a scientifically feasible and economically viable model of production and consumption.

Celebrating the first decade of pioneering around the world, the Board of ZERI commissioned an inventory of innovations inspired by natural systems. Although the starting point was nothing more than assembling peer-reviewed, publicly accessible scientific literature, it quickly evolved from a romantic and fascinating search for the brilliance in each species that dramatically enriches biodiversity, to a quest for an economic model that could inspire entrepreneurs to put humanity in general and its production and consumption in particular on a viable and sustainable path. At the outset of this search I had the opportunity to work with Fritjof Capra to edit the book, *Steering Businesses towards Sustainability*. This project triggered a deluge of ideas. I realized that my search for a next generation of business opportunities was based on the conviction that if I could portray the models I envisioned, it might inspire others to become entrepreneurs. The review team ploughed through and annotated thousands of pertinent articles in English-language scientific publications. These were complemented with similar Spanish, German, and Japanese publications. My task was to sift through one after the other and imagine which one of over 3,000 cases would present an opportunity to move industry and commerce toward sustainability independent of subsidies or tax breaks. I pondered which innovations could be bundled into a system that could

work the way ecosystems do, clustering innovations developed by diverse players, making a more efficient use of all the existing, unfailing forces described by the laws of physics for which there are no exceptions.

As an entrepreneur who embraces innovation, I submitted a shortlist of 340 technologies to a team of corporate strategists, expert financiers, investigative journalists, and public policymakers. This exercise happened prior to the current recession, while the world was still building castles in the sky with money that did not exist. Over a period of two years I met with inventors and entrepreneurs in all four corners of the world. I held dozens of meetings with financial analysts, business reporters, and corporate strategy academics. This helped sharpen the logic behind the ultimate selection of the 100 most remarkable innovations cataloged in Appendix One. Then, the recession hit. At the end of 2008 when the United Nations announced that the collapse of the financial markets had cost developing countries over 50 million jobs, a sense of realism emerged. I could find no satisfaction in matching a captivating photograph to a scientific explanation. I needed to communicate something more than the inspirational brilliance of every species we had examined.

A new team undertook a complete reassessment of all the information before us and examined the dynamics of the current economic model's demise in the light of the innovations we had cataloged. We spotted the phoenix of new growth that seemed to shift the logic of short-term results and bonuses to one that gives a world constrained by limited resources the ability to respond to people's basic needs with what we have. I saw a clear model emerging that could offer entrepreneurs around the world a unique window of opportunity to change the dominant business paradigm. It was not about cloning and genetic manipulation, protected by patents that appear closer to bio-piracy than actual innovation. It was about the pervasive logic and sensibility of ecosystems. This short list of 100 innovations drew inspiration from the ability of ecosystems to always evolve to higher levels of efficiency, to cascade nutrients and energy, to leave nothing to waste, to utilize the abilities of all contributors, and to respond to the basic needs of all.

Such insights into ecosystems logic have crystallized into the underpinnings of this book, allowing me to establish the framework for a Blue Economy and to realize that the current economic upheaval is a blessing in disguise. It may be that we are finally calling a halt to the unrealistic consumerism that has propelled the economy into insurmountable debt. Exhorting consumers to spend more is a stereotype of the blind logic that cajoles citizens to buy their way out of crisis by indebting all of us as well as subsequent generations, beyond our capacity to ever repay. This unconscionable approach siphons the entire world's liquidity into an elite "bankonomy," denying credit for everyone else. Such actions are at the base of a bankrupt economic model, a Red Economy model that borrows – from nature, from humanity, from the commons of all – with no thought of repayment beyond postponement to the future. Insatiable economies of scale callously search for ever lower marginal costs for each additional unit manufactured, making dismissive abstraction of all unintended consequences. The financial crisis of 2008 stemmed from bankers and corporate decision-makers embarking on a merger and acquisition frenzy, leveraging assets and amassing such enormous debt that the growth became self-defeating. Such is the tale of an "In-the-Red" (debt) Economy that failed.

In comparison, a Green Economy model has required companies to invest more and consumers to pay more, to achieve the same, or even less, while preserving the environment. While this was already a challenge during the heyday of economic growth, it is a solution that has little chance in a time of economic downturn. The Green Economy, in spite of much goodwill and effort, has not achieved the viability so greatly desired. If we shift the spectrum, we see that a Blue Economy addresses the issues of sustainability that go beyond mere preservation. A Blue Economy engages regeneration. We might say that the Blue Economy is about ensuring that ecosystems can maintain their evolutionary path so that all can benefit from nature's endless flow of creativity, adaptation, and abundance.

It is the young at heart who will seize upon the entrepreneurial opportunities that emulate ecosystems and cascade energy and resources to add value

and generate multiple exchange benefits, translating them into income and employment. When we implement the concepts of a Blue Economy, the decisions of millions of actors can supercede the *dirigisme* of a few market makers, monopolistic companies, or state controls, and a powerful new social and economic structure manifests. The engagement and commitment of citizens is what will change the rules of the game and what will effect a real shift. At a moment in history where peak oil and peak food are clearly hovering, we can draw practical ideas and inspiration from ecosystems as we witness their ability to apply creativity and evolution in overcoming challenges to survival. This book aims to contribute to the design of a new economic model that is not only capable of responding to the needs of all but converts the artificial construct called “scarcity” into a sense of sufficiency and even of abundance.

While the waste of material resources exemplified by modern landfills and incinerators is to be deplored, the waste of human resources is absolutely unacceptable. When the numbers of unemployed youth oscillate between 25% in industrialized countries and over 50% in the developing world, it is easy to imagine what it means to our global society if its leaders consider the next generation useless – or even worse, if the young and disadvantaged consider themselves useless. It is indicative of a system in severe decline, a society in extreme crisis, underscored by mounting statistics of violence, criminality, terrorism, drug abuse, illegal immigration, relinquished education, and the deplorable treatment of populations or communities already at-risk or underserved.

Abdul Samer Majali, who served as President of Jordan University as well as Prime Minister, once said, “*Expose – do not impose.*” If our aim is to create a better world for all, not just a fuller bank account for a few, if we are prepared to counter risk with gain, then thoughtful considerations, based on solid science and documented illustrative cases, can help us envision and achieve it. A strong platform for entrepreneurship could emulate the success of ecosystems in eliminating waste and achieving full employment and productive capacity. Multiple small initiatives around the world could

provide the basis for new entrepreneurial opportunities that would permit the shift to a macro-economic system. Instead of deferment as policy-makers reach agreement, the direction we take is to expose individuals everywhere to the open-source opportunities provided by nature.

It is amazing how little natural logic there is in modern society. To cool a building, air-conditioning experts pump cold air “up”? To clean water we dump chemicals in it to kill all life? Greenhouses heat the air, not the roots? We pay upwards of \$100 per kilowatt hour for electricity provided by a battery that toxifies our environment? When we drink a cup of coffee we give value to only 0.2% of the biomass while the rest is left to rot, generating methane gas, or stressing earthworms, who suffer as much from the neurotoxin called “caffeine” as we do. A hundred thousand tons of titanium, mined and processed at high temperature, are flung into landfills when we “discard” our “disposable” razors. Humanity makes excessive use of energy, emits greenhouse gases beyond reason, and causes havoc in the environment. We can hardly be surprised that we face climate change. Indeed, the only excuse for what we do and the way we do it is that we are ignorant about unintended consequences. Once we know, we not only have the clarity needed to change, we are also empowered to consciously make it happen.

Chido Govero, an orphan who lost her mother at the age of seven and never knew her father, turned immediately from a young girl to the head of her family with the responsibility to provide food for her grandmother and little brother. Although such tragedy is real, it is far too common. There are millions of people, many of them women and children, who must tolerate abuse to guarantee a semblance of food, water, and shelter. As someone who quickly learned how to survive for years on nothing more than a bowl of peanuts a day, Chido also quickly learned to appreciate the generative capacity of ecosystems. In Africa, these natural systems have been pillaged by the irresponsible farming of settlers who brought their traditions from temperate climates with four seasons, whose techniques not only denuded the land of its natural vegetation but drastically eroded the rich topsoil.

Yet Chido does not judge the errors of the past. She has grasped the opportunity to redefine the potential of coffee-crop agro-waste to achieve food and livelihood security for herself and her fellow orphans in Zimbabwe. Given food and livelihood security, abuse – both of young girls and of natural systems – can be eliminated. Chido’s vision is to accomplish this in her lifetime.

What more do you expect to achieve in your lifetime? Do you mind waiting to answer until you have read this book?

Gunter Pauli
10th of January 2010
La Miñoca, Columbia

CHAPTER FIVE



NATURE'S MBA
(Mastery of Brilliant Adaptations)

How strange that Nature does not knock,
and yet does not intrude!

— EMILY DICKINSON

An MBA (Master of Business Administration) degree confers a status to the holder that makes them desirable as business managers and leaders. They have learned to analyze transactions and interactions that help pinpoint cost reduction for labor and raw materials, maximize cash flow, increase market share, and fine-tune supply chain management. Unfortunately these experts, who are today's dominant business leaders, seem on the verge of disconnection from the habitats and inhabitants of our planet. Worse, their narrow focus on one core business blinds them from recognizing viable opportunities outside their sphere of interest or knowledge. Our production and consumption schemes are outdated, incapable of responding to the basic needs of all. They must either evolve or be replaced by ones that thrive by functioning harmoniously with all life, promoting diversity, and fairly ensuring food, shelter, health, and livelihood for everyone. It is with this conclusion that we turn our admiration and attention to nature's MBA – Mastery of Brilliant Adaptations.

Ecosystems offer tremendous inspiration for devising economic models capable of responding to the needs of all. Natural systems always change, always evolve. That is their power and their beauty. When we attend to nature's MBA, we can begin to understand how to integrate innovations into multifaceted models cascading nutrients and energy, supplying energy from integrated and renewable sources, designing structures that capture and utilize what is minute and transform it into what is grand, into networks that become so efficient that nothing is wasted and we have a net energy gain.

Industry is resistant to continuous change. Predictability is the name of the game. The model of core business and core competence pursues productivity in a manner that actually inhibits the natural path of evolution and change. This is in fact the logic by which industry arrives at solutions based on genetic manipulation. Once you know how to alter genes, you believe you know how to predict their outcomes. Where industry leaders prefer a predictable production system that uses harsh chemistry to stabilize molecules forever, and genetic modifications that stifle natural evolutionary tendencies, natural systems offer a different solution. Water is the solvent; molecular bonds are temporary to permit high biodegradability, so that molecules can be combined over and over again. Genetic modifications naturally occur in the realm of bacteria as this is part of their evolutionary pathway.

These differing frameworks explain why natural systems are always changing while industrial systems are inherently resistant to change. To avoid change and to provide more of the same, industrial systems create global standards that apply everywhere, under the pretext that this reduces costs. In contrast, ecosystems source everything locally. They satisfy their needs with what is readily available. Since ecosystems thrive on local biodiversity, standardization is of little use. After all, biodiversity is based on – as the word implies – diversity. This helps elucidate why new business models based on bundled portfolios of innovations will be implemented through thousands of entrepreneurs, each of whom will find their niche and their chance. Industry's desire is to control and standardize, to merge and expand on the imaginary curve of economies of scale, externalizing all costs outside their narrow focus. The fact that only a few varieties of tomatoes and potatoes are commercialized, while there are hundreds of varieties, and that our main crops are primarily wheat, corn, and soy monocultures, makes it evident why soils are depleted and disease infestations meet little resistance.

If we observe nature we see that ecosystems evolve towards ever-higher levels of efficiency and diversity thanks to contributions from all players. A 500-year-old cedar tree and a majestically erect bear may be the most

remarkable inhabitants we notice when hiking the Rocky Mountains, but a closer look shows that millions of other species, mostly invisible to the eye, are not only contributing but are critical to the whole system. Evolution implies a constant trend towards greater efficiency and greater diversity. So may it be with economies, shaped by entrepreneurs at all levels in business, science, culture, and education.

As Fritjof Capra has pointed out, ecosystems are networks of networks. The same management principles can be observed layered within each network. Indeed, ecosystems are all about connecting, about allowing everyone to contribute to the best of their abilities, while operating within clearly defined boundaries where nutrients and energy are endlessly cascaded and the laws of physics are followed without exception. Following a cascading model and capitalizing on the principles of physics makes it possible to respond to basic needs, in every location, with whatever is locally available. Instead of contrived scarcity and shortages, what we see in a Blue Economy model is abundance – of food, energy, jobs, and revenue. How many communities would oppose? Given the potential outcome, how many entrepreneurs would refuse the risk of bringing such innovations to the market?

Everyone can also imagine what it means to have the benefit of a platform technology that replaces chemicals with purely physical effects, as the vortex has been documented to do. Everyone can understand what it means for food security when coffee waste, or other agro-waste, turns into protein-rich mushrooms, contributes income from both the waste and the mushrooms, and provides high-quality animal feed from the spent mushroom substrate. We are building up social capital and eliminating abuse. We are turning a globally traded commodity like coffee into a resource for food security. Surely everyone can understand such value.

EMPOWERING ENTREPRENEURS

The model for a Blue Economy is based on what is real. While job losses and youth unemployment are dramatic in the industrialized world, the

reality we must confront is that the present economic disarray leaves no place for the one billion new arrivals entering the labor market, especially those from developing nations. The incapacity to imagine meaningful jobs and to provide worthy challenges to a whole generation equates to telling the young that there is no future for them, that their generation is lost. Every night over a billion people go to sleep hungry. Nearly two billion have no access to safe drinking water. Worse, the current economic system is based on the bankrupt notion of scarcity where growth is funded with debt perpetually carried over to future generations. Shortages and deficiencies are considered the logical base and a necessary evil from which a more efficient allocation of resources will evolve. This same scarcity mentality also foments debate and social resistance to innovation, because it portrays such change agents as threats to job security, by proposing to replace labor with no labor.

Thus it will require creativity and inclusiveness of the entrepreneurs in science, social affairs, business, ecology, and media to move us toward a Blue Economy. Natural systems can build local entrepreneurship much as evolution embraced innovations through diversity. There may be no greater power for change than the young at heart, ready and willing to assume the risk. It requires as much clarity of purpose as it requires perseverance. Fortunately, it does not require experience in a given sector, nor a lot of money. It does require maintaining a solid ethical underpinning, and knowing how to generate cash flow against all odds.

As we have noted, innovations outlined in this book may prove hard for mainstream businesses to adopt. Big companies content with producing more of what has proven successful may lack cutting-edge competencies, or may be unwilling to commit the initial capital necessary for a new approach. This is a major advantage for committed entrepreneurs. Basing their actions on solid science and their vision on social and emotional consciousness, they can implement and develop these innovations to create waves of change that infuse every business sector, shifting entire markets towards sustainability.

They will succeed by developing successful partnerships, taking advantage of institutional aggregation, and achieving market viability by garnering consumer support across a wide socioeconomic stratum. Market success will stem from the availability of better products that cost less than their competition.

A time of crisis, when market leaders are stressed, and some are even on the edge of survival, is perhaps the best moment for the young and the young at heart to set their minds on a new business model. Practically speaking, there are not too many careers available when millions of jobs have been lost and well-paid jobs for graduates are the exception rather than the rule. As well, and contrary to expectation, the barriers to market entry are actually lower in a downturn. In a relatively stable economy, innovations do not easily find their way to market. However, when the entire economic framework evidences turmoil, decision makers latch onto any object that seems stable or that stands out. A major firm may be disposed to accept products and methods with a fundamentally new or different approach.

The task of an entrepreneur is literally to coalesce something new into being, to be the carrying force that brings an idea into substance, the agent between thought and realization. Yet alone, even if well funded and passionate, you are just alone. Market success often depends on partnerships. One of the ways to succeed with the introduction of these innovations is to build partnerships with change agents who have the power to influence the market and tip the balance. Innovations do not necessarily flow into the market, nor are company executives and investment bankers the only players who shape the market. Often market breakthroughs are brought about by change agents. Though numerous innovative consortia exist (consider the role of media, grassroots activists, and NGOs), there are established ways to create pressure effectively.

For example, insurance companies have the pulse of today's market, tabulating trends in the world economy through the monies they must pay out. Insurance companies are an obvious pressure point for change in the market, especially when savings are substantial. They closely follow a

wealth of statistics, which is one of their core competences. No one knows how to crunch numbers better. In fact, a decision on their part to object to business as usual is based entirely on the simple science of statistics. Insurance companies, along with consumers, institutional investors, local communities, and local governments, are the stakeholders who drive decisions that stimulate innovation beyond the steady pace and comfort zone of industry.

To illustrate this, let us consider how insurance companies earn money offering fire insurance policies. When infant death by fire became a concern based on statistical data, insurance companies and industry manufacturers lobbied for the adoption of requirements specifying the use of fire and flame retardants. The risk of fire damage statistically decreases when any fire and flame retardant is used. A lower incidence of fire means an increase in industry's profit. A few decades later, if their statistics indicate an increase in male infertility, allergies, or even cancer at young age, and these statistics can be scientifically linked to the fire and flame retardants in use, then the insurance industry could once again stimulate change by urging lawmakers to accept a new standard or a new solution, while restricting (even against the will of the industry) the agents suspected of causing such conditions.

Insurance companies and their expert statisticians know all too well that correlation does not prove cause and effect. Rather, it is the reversal of the burden of proof that changes the business model. To achieve a secure angle, the company must demonstrate that it has considered all options and has concluded that negative effects could never occur. For change agents, it offers another lever for securing faster acceptance of breakthrough innovations. In our case in point, consider that insurers could earn multiple revenues by selling product liability policies to the makers of toxic fire retardants. If emerging evidence were to link a particular chemical to a specific illness, the liability insurance premium would increase, perhaps to a point where cost pressures would spur management to change even faster than legal guidelines dictate. The cost of insurance and the reluctance of re-insurance companies to cover the risks would force the company into action.

Insurance companies could further augment their revenue potential by integrating data from each of their separate risk businesses. This would provide a formidable base of information with obvious pathways for shifts in industry, encouraging innovations on the recommendation of insurance companies. Health insurers could link toxicity beyond the Ames Test, which assesses the mutagenic potential of chemical compounds. They could rank the chemicals suspected to cause health problems, suggesting substitutes.

THREE LEVELS OF SUSTAINABILITY

All too often industry finds natural substitutes for effective but toxic products, then manufactures the natural replacements in the traditional “heat and beat” mode that is responsible for our excessive carbon footprint. When industry finds solutions in biology, it reverts to cloning and genetic manipulation to secure “predictable” results. Thus, the inspiration from nature to find substitute molecules for the market’s standard bearers requires more than the simple shift from one molecule to another. The molecule and the manufacturing system must be inspired by natural processes to create the desired convergence toward sustainability. A Blue Economy offers a blueprint that follows physics and nature in materials selection and production methods. From this basis it initiates a generative and regenerative cascade of implementable innovations. We thus have sustainable product, sustainable manufacture, and sustainable whole systems. In terms of business and economic benefit, this creates competitive products, competitive processes, and competitive business models that go far beyond core business practice.

Nature works at ambient temperature and pressure. Even abalone shells, which are stronger than the bullet-proof ceramic Kevlar™, are methodically assembled layer by layer. The shells are made from calcium carbonate and proteins, materials that are completely locally sourced. The process is sustainable. The ceramics manufacturer could argue that nature produces too little, too slowly, and that industry standards require efficient, timely, and predictable results. It is true that the time needed to manufacture

ceramics in an oven at a temperature over 1000° is considerably less than the time needed by the abalone. However, a ceramics company purchases mined materials. These mines had to be discovered. A permit was needed to exploit the resources. These materials must be shipped around the world, processed (at high pressure and high temperature to speed and standardize operations and product output), and delivered in the appropriate format. When we take these factors into account, beginning with the search for the mine to the arrival of the calcium carbonate at the ceramic production facilities, the time and efficiency advantage is less obvious. It is worth noting that whenever mining is part of the production process, natural systems will perform faster and at a fraction of the energy cost.

ONE INNOVATION, MULTIPLE REVENUES

The innovations described herein clearly have the potential to generate multiple revenue streams. The market turns around money; money is thus a medium of exchange. Innovations that generate more market applications have greater appeal, and are thus most likely to be embraced by established businesses and entrepreneurs. The opportunity to generate multiple revenues is a very attractive phenomenon since it mobilizes parallel investments for several niche markets. This reduces the risk of innovation. Nonetheless, these are still high risk investments. The terms may not be appealing for the inventors but the need for cash may be so urgent that they accept an investment agreement.

In a downturn, cash is king. Those who have billions to invest can easily set the terms of the deal. The model of a core business with a single revenue stream is often preferred by investors who want management to focus on the single most promising application. Any investor will assess a new technology's chances for success. Entrepreneurial companies wishing to raise venture capital must reveal a very long list of "things that can go wrong." At the same time, hardened Silicon Valley venture capital companies will listen to a presentation of one innovation with dozens of possible applications. Without exception they will ask for the one application that guarantees to gross \$100 million dollars within three years.

While risks are inherent to business, those associated with the majority of the innovations considered and reviewed this book have been calculated, mitigated, and are much lower than usual for the market. In fact, these innovations can reduce risk because they alter the business model at its core. The achievements of a platform technology where basic parameters have been successfully applied clearly reduces risk and offers potentially better returns than funding a narrowly defined niche. Such a vast potential for sales implies that investors reassess the risk in light of these multiple revenues. This is the key advantage to nearly all the top innovations we describe.

We need not look far to demonstrate this fact. For example, there are 37 known commercial applications for the vortex. There are over 20 for seaweed furanones that control the proliferation of biofilm by jamming bacterial communication (see Chapter 8). Savings are hard to miss in replacing a \$50,000 surgery with a \$500 non-surgical intervention that provides permanent heart monitoring without batteries and at a lower cost. Instead of selling a pacemaker one million times per year, the medical industry can sell monitoring patches a billion times a year.

The silk polymers developed by Oxford Biomaterials (see Chapter 7) are already under development in five different companies, each with separate financing. Pax Scientific has opted for the same approach, raising financing in five separate fields of application for its insights on how nature moves water and air with less friction. Biosignal, the Australian startup developing antibacterial applications for furanones (see Chapter 8), had a comparable strategy of spinning off potential applications for agriculture, consumer, industrial, medical equipment, and therapeutic markets before its technology portfolio was merged with another company. Each of these in turn might raise diverse funds for mobilizing niche solutions such as anti-corrosion in oil and gas, antiperspirants, or a potential cure for cystic fibrosis. All derive from the same platform technology. Watreco, the start-up company built around Curt Hallberg's mathematical interpretations of a vortex, brings solutions to the market as varied as saving energy in ice

making, speeding percolation on golf greens, de-scaling pipes, and pumping air into fish farm tanks. These venture companies exemplify entrepreneurs who are ready to move businesses forward.

The power of these technologies to provide multiple cash flows through multiple applications reduces risk and dramatically increases the value of the intellectual property, potentially allowing inventors to sub-license technological applications and focus on what drives their interest and stimulates their curiosity. The power to overcome obstacles requires partnerships. Although inventors and marketers have different goals, a winning coalition can begin with solid leading-edge science and build on the sharp competitive analysis of entrepreneurs. The world of risk capital is ready to finance people with good ideas. What is needed now is the capacity and willingness to bring innovations to the market.

Innovations with the potential to generate multiple revenues in diverse markets are attractive. If these cash flow generators change the business model, then businesses that develop these innovations not only meet an important need, they will be pursued as investment and entrepreneurial opportunities.

CASCADING RESOURCES IN A COMMUNITY

Such innovations can also empower communities to respond to their own needs, especially in societies under major stress. They offer the foundation and the means to grow initiatives into movements, achieving market share despite adverse conditions. Communities that have neither money to trade nor capital to invest are often regarded as less responsive to the introduction of new ideas. Yet the achievements of Father Godfrey Nzamujo in Benin, Chido Govero in Zimbabwe, and Paolo Lugari in Colombia demonstrate that this is not true. The design and implementation of these integrated biosystems have converted nonviable communities into economic successes where money flows and capital grows. Half of the world's human population lives in rural or agricultural settings. Developing nations with rural and

agricultural populations can greatly benefit from integrated biosystems complemented with bio-refineries, such as the method of conversion used in Las Gaviotas for collecting resin from harvested trees, locally processed with renewable energies from the region into nine different products, with all waste from the process used in the production of construction materials. Integrated biosystems will also permit industrialized nations to dramatically reduce their ecological footprint and increase their material efficiency.

REAL OPPORTUNITIES, REAL SOLUTIONS

This shift in business model that is becoming more evident and necessary develops from our growing understanding of nature's MBA – how natural systems rely on the forces of physics, rather than consuming the resources of the planet and the very things needed to maintain survival. The impact is surprising. The results are compelling. There are vaccines that need no refrigeration, heart rhythm devices that need no surgery, vortex technologies that de-scale water pipes without chemicals, algae that defeat bacteria by deafness, or silk that cuts with razor-sharpness – the list is long! The replacement of something that is chemically toxic and clearly unsustainable with what is nothing more than a natural process may well help solve the biggest challenges of our time, while opening a window of opportunity for a portfolio of completely new products and services.

This opportunity to replace “something” with “nothing” – to replace a toxic or non-renewable material or process with one that relies merely on physics and natural processes – is particularly exciting. The capacity to reduce risk by generating more cash flow makes products and services competitive. This is where it will foster a new wave of entrepreneurship. This is how millions of sustainable jobs will be created, fundamentally shifting old model products and by-gone production methods to innovations and processes based on the scientific understanding of already benchmarked solutions that encourage the next generation to become innovators. The billions of years of experience accumulated in the evolution of ecosystems and species do count when it comes to perfecting solutions and providing

alternatives for different environments. These are proven solutions that evidence resilience and flexibility.

In past decades the goal of sustainability required everyone to pay more and invest more to save the environment or reduce pollution. Few were prepared or willing to adopt this means to effect that goal. Even government tax levies and fines for polluting practices did not noticeably promote stewardship. Now we can achieve better results and create multiple revenue sources while building social capital and community resilience. Those who profited in the past from poor choices can now rationalize investing in new solutions that will strengthen economies and communities from the roots upward. The driving force of success could well be thousands of entrepreneurs whose boundless enthusiasm and commitment more than compensate for any lack of capital or experience. Moreover, innovations with the greatest market success will be those that address basic needs. This is what management wizard Peter Drucker claimed in the 1980s: *“The needs of the poor are opportunities waiting for entrepreneurs.”*

When manufacturers choose to replace a toxic process with a less toxic alternative, they are simply “doing less bad.” That is the option taken when billions of dollars are poured into less toxic though longer lasting batteries. These batteries still rely on mining, smelting, and harsh chemistry with an overwhelming majority ending up in landfills that pollute the environment, poisoning ecosystems while posing a long-term health hazard to us all. Many will argue that a halfway measure is at least on the right track. Yet this is nothing short of a duplicitous moral standard. We all have the urge to do more good. Let us not accept that doing less bad is good enough.

Current scientific literature offers insights into thousands of possible breakthroughs inspired by ways that natural species have solved challenges to procurement and survival. Though fewer have revealed the entirety of their process, the possibilities remain and the mysteries can be solved. Time will permit us to understand and implement innovations that will dramatically shift our methods of production and consumption toward sustainability.

In the next chapters we will further explore the framework of the Blue Economy from the basis of existing contributions and solutions that are at work right now. A Blue Economy is what will apply the achievements of ecosystems to economic systems. Indeed, implementing a Blue Economy will ensure that human systems, in fact all living systems, can attain the stability and security that will safeguard and maintain their evolutionary and regenerative path.

THE BLUE ECONOMY

10 YEARS

100 INNOVATIONS

100 MILLION JOBS

GUNTER PAULI

The Blue Economy began as a project to find one hundred of the best nature-inspired technologies that could effect the economies of the world, while sustainably providing basic human needs - potable water, food, jobs and healthful shelter. Starting with 2,231 peer review articles Dr. Pauli found 340 innovations that could be bundled into systems that function the way ecosystems do. These were then additionally reviewed by a team of corporate strategists, expert financiers, and public policy makers. Further meetings with entrepreneurs, financial analysts, business reporters and corporate strategy academics reduced the list to one hundred. These are listed in an appendix of **The Blue Economy**.

Many of the innovations inspired by nature are so interesting by themselves it is easy to forget that the key to the book is their integration with real world economies as ways to provide sustainable benefits to the commons. **The Blue Economy** is presented in fourteen chapters, each of which investigates an aspect of the world's economies and offers a series of innovations capable of making aspects of those economies sustainable. Following are "in-a-nutshell" descriptions of the chapters with very brief examples. Please see the Table of Contents (upper right column) for further details.

CHAPTER ONE - TIMELESS RESOURCES FOR THE CHALLENGES OF OUR TIMES

Chapter 1 makes the point that nature works with physics, with immutable laws that have the inherent advantage of requiring no externally-provided energy. The central principle of **The Blue Economy** is the idea of cascading nutrients and energy the way ecosystems do. A cascade is a waterfall. It requires no power, it flows with the force of gravity. It transports nutrients between biological kingdoms - absorbed minerals feed microorganisms, microorganisms feed plants, plants feed other species, with the waste of one being nourishment for another. Cascading energy and nutrients leads to sustainability by reducing or eliminating inputs such as energy and eliminating waste and its cost, not just as pollution but also as an inefficient use of materials. In ecosystems there is no waste because the by products of one process are inputs to another process.

CHAPTER TWO - EMULATING ECOSYSTEMS FOR A BLUE ECONOMY

Chapter 2 discusses how to achieve true economic sustainability. The solution rests with linking processes into whole systems. For example, at Picuris Pueblo in New Mexico cascading nutrients and energy produces income while preventing the forest fires that so often devastate the western landscape. "Slash" (the small diameter wood that intensifies fires) is usually removed with machines that do their own ecological damage. Instead, fire prevention is integrated into a whole systems model that is compatible with Native culture.

Slash is not burned but chipped into mulch. Some of the mulch made from the removed wood is inoculated with local, native mushrooms and spread on the tracks left by the equipment used to harvest the slash. In as little as two years, the forest floor is restored. The bulk of the wood is dried and preserved. However, it is preserved without using a polluting, chemical approach. Instead, the fumes created by the incomplete combustion of charcoal production are used to preserve the construction grade lumber. The chips that remain after the process of collection, carpentry and charcoal, are inoculated with native mushrooms obtained from a tissue culture. After harvesting the very marketable mushrooms, the spent chips used as the growth substrate are fed to the newly introduced bison herd. Something is replaced with nothing and produces sustainable forests, wood for construction, food for people and animals. There is no waste.

Father Nzamujo at the Songhai Center provides food security, jobs and health care from slaughterhouse waste. These are real results, the results of today not tomorrow or in some unspecified future when enough corporations have spent enough on greening their factories. Paolo Lugari at Las Gaviotas secures drinking water and renewable energy, jobs, biofuels and food where there was once only dry, useless land. Cascading nutrients and energy to attain clear objectives like food, water and energy is the norm in nature. However, sustainable production systems such as those where Nzamujo and Lugari have succeeded, also generate multiple benefits beyond the principle aim of their design. These additional benefits provide additional positive cash flows, reduce material intensity and energy costs. This rise in integrated cash flow is the logic that supports, and the strongest argument in favor of, this new approach to business.

CHAPTER THREE - NATURE'S RESOURCE EFFICIENCY

Chapter 3 describes how to resolve the complex problems we are confronting, both in our individual domiciles and our greater domicile, our Earth. Successful future industries will reexamine the basics of science and seek inspiration for innovative solutions that apply physics first and chemistry second. If we consider the underlying forces and the systemic conditions that predict the results prescribed by physics, then we will understand why chemistry in nature differs markedly from the chemistry that dominates our

lives today. The few molecules retained in natural products and production processes reflect the best possible use of physics.

A gravity driven vortex device will eliminate air from water with out any additional energy input. If you make ice, you are freezing both water and air. Air is an insulator and the expensive energy needed to freeze and maintain the ice in hockey rinks and ice arenas is thus dependent on the amount of air in the water. By eliminating the air, the energy savings reduce production cost, decreasing the effect on climate change by eliminating the greenhouse gases produced by the 100,000 kW hours per year of electrical generation required to maintain ice arenas. Yet, as is shown by the green movement's largely unsuccessful efforts, reducing the inputs to climate change does not inspire businesses to risk their capital. Additional advertising revenue, on the other hand, inspires everyone. Ice without water is clear. At the level of professional hockey, clear ice permits using the rink for team branding and television advertising. At the local skating arena, it does the same for local businesses. Save some, earn more, the key to sustainability.

CHAPTER FOUR - LEADING THE WAY FOR MARKET LEADERS

Chapter 4 we learn how standard "MBA" analysis makes it impossible for large companies to innovate because of the "inside the box" thinking demanded by corporate systems and the many, sometime conflicting interests of management and shareholders. In essence, corporations are locked out of sustainable advances by the logic of their decision making process. One of these principles is known as "supply chain management." This describes a company's efforts to control the supply, cost and timing of the materials it needs for the items it produces for sale.

One successful innovation discussed in Chapter 4 shows how to use this to advantage by integrating a sustainable technology into an existing supply chain. Natural enzymes can sequester carbon dioxide, making it available for other processes that require it such as the carbonic gases used in the production of construction materials. Industry has resisted even more conventional scrubbing technologies because of their cost. However, when Canadian entrepreneurs devised a means of using enzyme sequestration directly in the existing scrubbing systems of coal fired power plants and cement factories, even the least progressive management can be inspired to invest. The fact that the sequestered carbon dioxide can create additional revenue may be inspiration enough. All too often breakthrough innovations require scrapping existing facilities. That makes it hard for even the most progressive companies to adopt innovations; however, no or low additional cost to provide an additional income stream can motivate everyone.

CHAPTER FIVE - NATURE'S MBA (MASTERY OF BRILLIANT ADAPTATIONS)

Chapter 5 expands upon *The Blue Economy* approach to planetary sustainability. The objective of introducing innovations is to better respond to basic needs. Replacing a toxic process with a less toxic alternative is "doing less bad." That is exactly the approach that sees billions of dollars invested in less

toxic and longer lasting batteries. Yet, even less toxic batteries will still rely on mining, smelting and toxic chemistry. They will do less bad but not enough good. The vast majority of batteries are not recycled but are dumped into the environment, toxifying our ecosystem and posing long term health hazards. Is it enough "to do less bad?" While we agree that a thief is a thief when stealing less; companies get environmental awards for polluting less -- even though they are still polluting!

A thief claiming to steal less will never earn a reprieve from the judge; he simply cannot steal. We must adjust our thinking and increase our ambitions. Under the old business model a company polluting less, reducing its release of toxins into the environment, our homes, and especially into childrens' bedrooms, might even get an environmental award! In contrast the innovation described in **The Blue Economy** replaces "bad with good." For example, fire and flame retardants produced from food grade ingredients. These can accomplish the necessary protections without endangering peoples' food supply and health.

CHAPTER SIX - CASCADING MODELS, MULTIPLE CASH FLOWS

Chapter 6 describes how at a time of upheaval positive minds look for solutions, wherever they can. There are always pockets of growth even when the overall economy is considered to be in decline. Health care, nutrition, and the environment are the three areas where experts anticipate increased expenditures even in rough times. Few markets better exemplify growth potential than the burgeoning worldwide demand for tropical mushrooms. Ever since a middle class with purchasing power emerged in China, demand for the fruiting bodies of *shiitake* and the like has been explosive. Double digit growth rates have been the norm for over two decades. Europe and North America are also discovering the *enoki*, *maitake* and *reishi* as healthful, protein-rich foods.

What if coffee shop chains systematically converted all their waste from brewing coffee (and tea) into growing mushrooms through inner-city production centers? It can and has been done. The same can be even done with abundant orchard prunings. This would stimulate further entrepreneurship like that in the San Francisco Bay Area. Two college graduates grasped the opportunity and started collecting coffee grounds from shops at 6:00AM. They then seed them in a warehouse. Their dynamic start was quickly followed by a similar initiative across the bay in Marin City. There, children grow mushrooms on nothing less than the biomass of removed invasive species blended with coffee grounds.

CHAPTER SEVEN - SPINNING A SILKEN TALE

Chapter 7 discusses silk as a replacement for Titanium. Titanium is the ninth most abundant element in the Earth's crust and the seventh most abundant metal. The production of titanium consumes large quantities of magnesium, chlorine and argon gas as well as vast amounts of energy. Titanium must be welded in an inert atmosphere to protect it from contamination with oxygen, nitrogen or hydrogen. Both the energy inputs and the use of scarce and mined resources are extremely high. Yet, even those

customers who are prepared to pay the price and ignore the environmental damage will adopt a new product if it is compatible to their use, meets their production criteria, and cost less.

The University of Oxford, Department of Zoology, Silk Group directed by Prof. Fritz Vollrath is a creative resource for biocompatible polymers. While working in Panama for the Smithsonian Tropical Research Institution, Prof. Vollrath encountered the "golden silk orb weaver" spider. By studying how this spider composed and recycled its silk, and its three dimensional spinning techniques, this group is able to produce equipment and processes to manufacture silk tubes and filaments as a conduit for nerve regeneration, medical sutures, medical devices to regenerate damaged cartilage and bone tissues, as well as substituting for titanium in products as various as airplane parts and razors. If we compare a life cycle analysis of titanium with the simplicity of converting mulberry leaves to silk and controlling spinning pressure and moisture at more-or-less ambient temperature, we quickly understand how we can move towards sustainability

CHAPTER EIGHT - FROM THE MIGHTY TO THE MINUSCULE

Chapter 8 tells the story of Dr. Jorge Reynolds, one of the original inventors of the pacemaker. Anyone studying the heart must be fascinated by the whale's heart, and Dr. Reynolds is no exception. Through extensive studies of living whales he learned that whales have channels of cells dedicated to guiding electric currents in and around their hearts. These currents coordinate the cardiac rhythms. Dr. Reynolds realized that these cells can adjust their pathways to bypass damaged tissue. The whales' regulating currents are produced by the blending of potassium, sodium and calcium at the molecular level. To understand how these electric currents were produced without either metals or batteries, Dr. Reynolds reconstructed the whale heart beginning with the embryo at the time of conception. What he learned made him rethink pacemaker fundamentals.

Today pacemakers prolong millions of lives by replacing the natural capacity to generate electric currents with a battery-powered device that connects deep into the heart. Recalls in the hundreds of thousands have lately plagued these devices. Inspired by the whale, Dr. Reynolds recreated the cell-thin tubes to improve the distribution of current throughout the heart and developed a nano-scale pacemaker. Instead of replacing the natural function of the heart, it channels current from healthy to damaged tissue. While medical devices take years of pre-approval testing, the potential contribution of this innovation to sustainability and health is immense. A \$100,000 surgery, expensive drugs and continuing care could be replaced with a \$500 outpatient procedure. Indeed, imagine that one day every electrical device operates without small batteries that are difficult to recycle and often so small that their metals are never recovered. Eliminating the adverse environmental impact these tiny power sources have on the health of the planet will relieve the ecosystem on which we depend for life-important services like drinking water and fertile soil.

CHAPTER NINE - A RAINBOW OF POSSIBILITIES: REMAKING COLORATION AND COSMETICS

Chapter 9 rethinks coloration. Sometimes new applications find their way to the market in a most surprising manner. The wings of a dragonfly have a unique ability to concentrate sunlight. In Japan where dragonflies symbolize new light and joy, this ability caught the attention of those studying how to generate renewable energy so efficiently that it makes the coal fired power station look like a dinosaur. This dragonfly technique for concentrating light is what we need to shift from generating electricity with silicon, a highly polluting process, to generating electricity with a steam-powered turbine, a well-known, well-understood, technology for which engineering knowledge and manufacturing access are readily available.

Solar power concentration is already an emerging and proven industry in Spain. Concentrating solar power (CSP) uses mirrors to focus sunlight onto water, very much as does the dragonfly. Heated water can power a generator, a technology that is easily implemented. By 2050 annual Concentrated Solar Power investments could exceed \$100 billion, creating almost two million jobs and saving 2.1 billion tons of CO₂!

CHAPTER TEN - ENVISIONING NEW ENERGY OPTIONS

Chapter 10 asks "How does the coconut fill with water?" There is no pump. Neither does it absorb rainwater. How do trees build giant structures overcoming gravity? Where does osmosis in plants derive its power to override gravitational forces? Osmosis and CO₂ bubbles in capillary veins push juicy nutrients upward. There is interplay with surface tension. Indeed, how can we neglect the power of that grand force of gravity, the attraction of the moon? It is responsible for tidal ebb and flow, another very predictable force to be reckoned with. There are many forces that are exploited in great detail by natural systems and at minute levels to insure that everything has power whenever it is needed. This stands in stark contrast with the industrial solutions we have invented and financed.

Thermoelectricity is the conversion of temperature differentials to electricity. In the future, many instruments will work without a battery or power from a wall socket. For example, electronic equipment might draw power from the warmth of the human body. In Germany, the Fraunhofer Institute for Physical Measurement Techniques has developed a way of harnessing natural body heat to generate electricity. The difference between the temperature of the human body and the surrounding hot or cold environment is enough to generate electricity. Normally, a difference of several tens of degrees is required to generate enough power but the differences between the body's surface temperature and its immediate environment is only a few degrees. "*Only low voltages can be produced from differences like these,*" explains Peter Spies, the project manager at the German research institute. Since these, like cell

phones, create a significant portion of the demand for polluting batteries, that will be enough to help sustain the planet.

CHAPTER ELEVEN - TRUE GOLD: MINES AS PLATFORMS OF HEALING

The purpose of **Chapter 11** is to discuss one of humanity's most aggressive interventions: mining. Armed with dynamite, consuming massive amounts of water and energy, minute concentrations of gold are extracted from the depths of the earth. Could this ever emulate natural systems? Lichens are great miners, capable of extracting specific inorganic molecules like magnesium from rocks. Bacteria are known to selectively separate metals through chelation but none in nature ever uses such brute force to acquire such minute amounts. It is impossible to undo the errors of the past, thus the question is: "can we do better in the future?" Although we may not be capable of converting mining into a benign operation, can we at least design a strategy that can undo the environmental and social pain that mining has inflicted?

Mines need massive amounts of electricity to pump water and air, to produce ice to cool the shafts, and to transport ore. It makes a lot of sense to explore opportunities to save energy. This is the ideal environment for the Fibonacci code to leave theory and enter reality. The mathematical model inspired Jay Harman is a the root of the innovations by his Pax Scientific companies. Could the Nautilus shell provide insights how to cut energy costs by twenty to thirty percent? This opportunity is not limited to Pax. It is also an opportunity for Watreco's technology based on the pioneering work of Curt Hallberg, the vortex expert from Sweden. The ice making machines in the deep shafts necessary to control temperature must cope with water containing so much air that removing the air would reduce the energy cost by ten to fifteen percent using only the force of gravity.

CHAPTER TWELVE - BUILDINGS DESIGNED BY FLOWS

Chapter 12 investigates buildings. Each of us has an opportunity to create our own little cosmos at home, at school or at work. Even though the air outside is polluted and acidic, there is no reason to suffer the same assault inside. On the contrary, the design of our buildings could be so sophisticated that the interior naturally evolves to a slightly alkaline habitat comparable to the small intestine. It is fine that the stomach is acid but the engine of life where a major portion of the immune system resides is alkaline. By analogy, the bedroom of your house compares to the small intestine and should also be alkaline. Starting at home, we should use our understanding of the flows of air and matter to create an environment conducive to life. We need to design homes and schools, offices and care centers, with the same logic as our bodies have evolved while remembering that life in the ocean thrives on alkalinity.

Anders Nyquist from Sweden convinced the local authorities responsible for the Laggberg School in Tinrå by Sundsvall to convert an old school building while adding a new wing to the school facilities. He designed a temperature control system driven by natural airflows that continuously refresh the air. Guess what happened when the positive health statistics and the low rate of absenteeism became known?

Families started moving to the neighborhood to insure that their kids would be educated in the healthiest environment of modern times. When parents are happy, children study better. When children study well and are healthy, their parents are happy. This is not difficult to understand. The same happens in ecosystems, once nutrients and energy flow, more species join and evolve, converting a perceived scarcity to a happy and beautiful environment.

CHAPTER THIRTEEN - CASCADING A BLUE ECONOMY

Chapter 13 notes that ecosystems are all about connecting, creating networks of networks, allowing everyone to contribute to the best of their abilities, while operating within clearly defined boundaries where nutrients and energy are endlessly cascaded as defined by the laws of physics. Within each of these systems, which can be as diverse as a desert, an alpine mountain range, a wetlands or a tropical rainforest, the same *management principles* apply. Traditional business thinking asserts that an increase in productivity is only possible by shedding jobs. Nature knows better. At a time of crisis, with millions out of work, and hundreds of millions of young people suffering from a sense of uselessness, our opportunity to put "the blue job machine" in motion and to shape the blue economy is very encouraging. Natural systems can unleash local entrepreneurship much like evolution embraced innovations through diversity. There seems to be no greater power for change than youth prepared to take the risk.

EPILOGUE - REALIZING A DREAM

Inspiring success stories from Zimbabwe, California, and a look to the future by Gunter Pauli.

APPENDIX 1 - A TABLE OF 100 INNOVATIONS INSPIRED BY NATURE

This appendix demonstrates the foundation of **The Blue Economy's** subtitle - "100 innovations, 10 years, 100 million jobs." It presents a synopsis of each innovation and an estimate of the jobs it could create. These estimates are based on Dr. Pauli's study of the industry effected. This is an entrepreneur's dream. Some of the innovations are proven in the real world, some are bench marked in pilot implementations, some are estimations drawn from peer reviewed science. All can change the world in their own way.

APPENDIX 2 - 100 INNOVATIONS INSPIRING COMPETITIVE BUSINESS MODELS

This appendix provides descriptions of the innovations that have a bench-marked ability to create jobs by producing competitive businesses. Each is accompanied by an estimate of the jobs created, and a description of the cash flow potentials

BIBLIOGRAPHY AND REFERENCES

INDEX

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Our current economic crisis is also a crisis of ethics and values which has led to the enrichment of a few and the disempowerment of many. *The Blue Economy* advocates for a new economy, one led by innovation and creativity to cultivate the next generation of social entrepreneurship. We are in need of such an economy and no one is better placed than Gunter Pauli to offer this to the world.

WENDY LUHABE

Chancellor, University of Johannesburg
Chair, Industrial Development Corporation of South Africa

The Blue Economy shows us that by securing materials and aligning production schemes as nature does, many problems of environmental degradation and pollution would disappear. However, economic policy and core business models largely ignore integrated solutions. Future economic models would do well to take into account the strategic advantage of a portfolio of innovations based on nature and physics. That will be a tall order, but Gunter Pauli's book, with its rich presentation of how nature and economy can and must collaborate, convincingly shows the way.

ANDERS WIJKMAN

Member, Swedish Royal Academy of Sciences
European Parliament (1999-2009)

The Blue Economy takes readers beyond the obvious and aims to wake up the entrepreneur in all of us. The innovations it explores are founded in solid science and demonstrated by multiple platforms. Committed grass roots entrepreneurs worldwide can realize triple cash flow using open-source innovations that create competitive business models. This book will encourage thousands and perhaps millions of us to apply a Blue Economy business model that will shift us from scarcity to abundance.



GUNTER PAULI

