

## The Blue Economy

### 蓝色经济

10 Years, 100 Innovations, 100 Million Jobs

一世纪，一百种革新，一亿个工作机会

**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**.

「蓝色经济」一开始是一个为了要找出由大自然启发，而可能影响世界经济的一百种科技，同时又能提供人类基本需求：饮用水、食物、以及健康方面的庇护。在两千两百三十一篇由同侪研读的文章中，Pauli 博士发现了三百四十种创新发明，这些发明在系统化之后有可能像生态系统一样运作。这些文章又再由一群企业策略家、金融专家，以及公共策略制定者研读。在进一步与企业家、金融分析师、企业专栏记者，还有企业策略学者会谈之后，精简剩下一百种。这些都被列在「蓝色经济」的附录当中。

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.

这些受到自然启发的创新想法本身就非常有趣，因此让读者很容易忽略这本书的关键其实是，它们与真实世界的经济整合之后，可以带给一般人在水平之上的益处。「蓝色经济」这本书总共有十四章，每一章节都深入探讨世界经济的一个层面，也提出一连串能够有助于这些经济维持下去的创新发明。下列是这些章节的「精简」叙述，其中也附上简短的例子以利说明。如果读者需要更详尽的说明，请看由上方字段的目录。

## 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.

### 一、永恒的资源挑战有限的时间

第一章说明了大自然是与物理，以及永恒的法则运作，这些法则有不需外来能源的天然优势。「蓝色经济」的中心准则是串连营养物跟能源，正如同生态系统一样。一个串连就是一个瀑布。它不需要任何能源，它随着地心引力的力量流动。它转换在各个生态王国中的营养物：被吸收的矿物质喂养微生物、微生物喂养植物、植物喂养其它物种，因为一个生物的排泄物可以是另一个生物的营养物。藉者减少或是消除像是能源的输入，而且消除废弃物以及处理废弃物的花费，串连能源和营养物带来永续性；这个方法不是只有让废弃物变成污染，而是让它成为使用上比较没有效率的物质。在生态系统中，并没有废弃物，因为一个过程所产生的副产品总是被输入到另一个过程中。

## 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.

### 二、仿造生态系统，创造蓝色经济

第二章讨论如何达到真正的经济永续性。解决之道在于把过程连结入整个系统当中。例如，在美国新墨西哥州的 Picuris Pueblo，营养物跟能源的串连创造收入，又可以同时防止经常毁灭西半部的森林大火。让森林大火恶化的「灌木丛」经常由会另外对生态造成破坏的机器来移除。相反地，森林大火的预防已经结合入可以跟原有文化并存的整个生态模式。

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.

上述提到的灌木丛并不是被烧毁，而是被做成护根层。由废弃木材所制成的护根层一部分会与当地的菇类混合一起覆盖在用来收成灌木丛的装备所留下的小径。在短短两年之内，森林地面层就会被修复。大量的木材就会干燥而且被保存。但是，这样的保存方式是完全零污染的，也没有使用任何的化学方法。反而，木炭不完全燃烧所制造出的燃料会被用来保存建筑用木材。木材收集后以及木匠工程所留下的碎木以及木炭会跟培养皿得来的当地菇类混合。在这些特殊的菇类收成之后，被用作生长基座的碎木被用来喂养新引进的野牛群。本来没有东西的地方现在有了一些东西，而且也可以制造出可持续的森林、建筑用木材、人类及动物的食物，而且没有废弃物。

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.

在 Songhai 中心的 Father Nzamujo 提供来自于屠宰场废弃物的食物保全、工作机会以及健保。这些是真实的结果，而这些结果是今天就可以看见的，不是明天，也不用等到企业在某个未知的未来花了大笔金钱绿化工厂才看得见。Las Gaviotas 的 Paolo Lugari 负责饮用水、可再生能源、工作、生化燃料以及食物的安全，而在这个地方一度是干涸而无用的土地。串连营养物以及能源来得到明显的目标，像是食物、水，以及能源，在大自然中是常见而自然的事情。然而，像 Nzamujo 还有 Lugari 成功达到目标的永续制造系统也可生产远超过他们设计目标的益处。这些额外的益处提供了额外的正面的现金流动，减少物质的需求以及能源花费。这个整合现金流动的提高正是支持（也是最有力理论）这个新方法的逻辑。

### **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.

### 三、大自然资源的效率

第三章描述我们要如何解决在自己个人住家以及大环境（我们的地球）所面临的复杂问题。成功的未来企业将会重新检视科学的基础，为置物理于化学之前的创新解决方法寻找灵感。如果我们好好考虑潜藏的力量以及预测受物理学制定结果的系统条件，我们就会了解为什么大自然中的化学作用跟支配我们生活的化学作用其实是大大不同了。在自然产品以及制造过程中所保留的极少数分子反映了最好的物理学使用方法。

A gravity driven vortex device will eliminate air from water without 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.

由地心引力启动的涡旋装置在不需额外能源输入的情况下就可将空气从水中消灭。如果你制冰，你其实让水跟空气都结冻。空气是个隔绝体，而且是个保持冰上曲棍球场冷冻的昂贵能源，所以冰上竞技场必须依赖水中空气的数量。借着消除空气，能源的节省减少了生产花费；每年用来维护冰上竞技场所需的每小时十万千瓦所产生大量的温室效应气体，消除这些气体也会减少对气候变迁所产生的影响。但是，正如同环保运动失败例子所显示的，减少对气候变迁所做的努力并不足以激发企业主投入资金。另一方面而言，额外的广告收益却激发每一个人。没有冰的水给人清楚的讯息。在专业的冰上曲棍球当中，清澈的冰可以让队伍做宣传或是做电视广告。在地区性的溜冰场也有同样的效果。省下一些，赚得一些，这就是永续的关键。

## 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.

### 四、带领市场领导者

在第四章中，我们知道标准的「企管硕士」分析如何让大企业无法创新：因为许多公司制度以及许多人要求的「盒子内」思考经常使管理阶层以及股东们的利益相冲突。本质上，许多公司因为它们决策过程的逻辑而被排除在永续的发展之外。在这些原则中，其中一个著名的就是「供应链管理」。这描述了一个公司在将货物生产上架时对控管供应、物资的花费及时机所需要的心血。

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.

第四章中讨论到的一个成功的创新告诉我们如何借着将一个永续的科技整合纳入一个现有的生产链来获得优势。天然的酵素可以阻隔二氧化碳，让二氧化碳在其它需要它的过程当中可以被使用，例如建材制造所使用的碳酸气体。企业一直因为花费过高而拒绝甚至更传统的刷洗技术。但是，当加拿大企业家策画出一个将酵素隔离直接用在煤炭发电以及水泥工厂的现有刷洗系统上，甚至最不先进的管理阶层都会被激发而投资。隔离后的二氧化碳可以产生额外收益的这个事实可能已经够激发人了。大多数的时候，创新的想法或是科技都需要淘汰现有的设备。这样的情况让即使最先进的公司也很难采用新的科技；但是，不需要额外费用或是额外费用很低，但是可以创造额外收益的新方法却让任何人都想参与。

## 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!

### 五、大自然的 MBA（神奇的适应能力）

第五章详述「蓝色经济」如何让地球永续存在。介绍这些创新想法的目标是为了要对人类基础需求做出更好的响应。当我们用一个比较没有毒性的过程取代有毒的过程，这就代表「坏处比较少」。就是这个方法让数百亿资金所投资到比较无毒的以及持续较久的电池上。它们坏处比较少，但是好处不够多。大部份的电池都没有被回收，而被倾倒入我们的环境中，毒害我们的生态系统，而且对健康造成长期的危害。但是，使用「坏处比较少」的方法真的就够了吗？当我们同意偷多偷少都是小偷的同时，却有企业因为造成比较少的污染而得奖，但是它们还是在污染环境啊！

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.

一个声称自己只偷小东西的小偷绝对不会让法官撤回告诉；反正，他就是不应该偷窃。我们必须调整我们的思考逻辑，增加自己的野心。在旧的企业模式下，要是一间公司污染变少，减少对环境、我们的房子，还有甚至是小孩卧房里有毒物质的排放，它甚至有可能得环保奖章！相反地，在「蓝色经济」当中描述的创新做法取代了「有优点的缺点」。例如，利用食物成分做成的防火物质。这些都可以在不危害食物供应的情况下达到必要的保护作用。

## 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.

### 六、串联模式，滚滚钱潮

第六章描述在混乱的时代当中，积极的人如何随时寻找解决之道。即使当大家都认为整体经济下滑的时候，还是有成长的空间。健保、营养，还有环境是专家预期在艰苦的时候消费还是持续增加的三大区块。最好的例子就是全球对热带菇类急速成长的需求。自从拥有强大购物能力的中国中产阶级出现，「Shiitake 香菇」可食部分还有类似商品的需求就一直激增。二位数的成长率在过去的二十年当中都是稀松平常的。欧洲和北美也发现日式金菇、舞菇和灵芝是很健康，而且富含蛋白质的食物。

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.

要是咖啡厅可以制度化地透过城市间生产中心将它们煮咖啡（或是茶）产生的废弃物转化为可以种植菇类的物质，那有多好！这是可能的，而且也有人成功做到过。修剪兰花剩下的部分也可以有同样的功用。这会刺激更多人成为企业主，就像旧金山的湾区一样。两个大学毕业生抓住机会，从早上六点就开始到咖啡厅收集咖啡渣，然后把种子放在这些渣里。在他们充满朝气的创举之后，随之而来的是在整个马林城市的海湾区都有类似的人做类似的事。在那里，孩子们只有在混合了大量生物体的咖啡渣中种植香菇。

## 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.

### 七、细说丝绸

第七章讨论丝如何取代钛。钛在地表最丰富元素中排名第九，在最多的金属中排名第七。钛的生产要消耗大量的镁、氯和氩，以及大量的能源。钛必须要在真空的大气中焊接，以保护它不受氧气、氮气或是氢气的污染。这需要用到大量的能源以及稀有的矿物资源。但是，即使是那些准备好付钱，而且忽略环境破坏的顾客都愿意采用一个新的产品，只要它适合使用、符合它们的生产标准，而且比较便宜。

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

由 Fritz Vollrath 教授带领的牛津大学动物学系的丝绸小组是个适用生物聚合物的创意资源。在巴拿马为 Smithsonian 热带研究机构工作时，Vollrath 教授遇见了「金丝圆蛛」。借着研究这种蜘蛛如何结网和回收牠的丝，以及牠结出立体丝网的技术，这个小组已经有能力生产设备及其过程来制造丝管和细线，用来当作神经重建的导管、医学缝合、用来再生受损软骨和骨头组织的医学仪器，也可以用来取代像飞机零件及刮胡刀这类各式各样商品当中的钛。如果我们拿钛金属的生命周期分析跟转换桑树叶成丝的简易性，以及控制旋转压力，以及周遭温度的湿度来比较，我们很快就会了解我们如何能向永续性迈进。

## 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.

### 八、从伟大到微小

第八章告诉我们 Jorge Reynolds 博士的故事，他是心跳节律器最原始发明者之一。任何一个研究心脏的人都会为鲸鱼的心脏感到惊叹不已，Jorge Reynolds 博士也不例外。透过活鲸鱼的大量研究，他发现鲸鱼有引导电流进入心脏及在心脏四周的细胞管。这些电流协调了心脏的律动。Reynolds 博士发现这些细胞可以调整它们的路径，绕过受损的组织。鲸鱼调节电流的能力来自于钾、钠、钙在分子层的混合。为了要了解这些电流如何在没有金属或是电池的情况下被制造出，Reynolds 博士用怀孕期的胚胎重建鲸鱼的心脏。他的发现让他重新思考心跳节律器的基本原则。

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.

今天，心跳节律器延长了数百万个生命，这个以电池发电，与心脏紧紧接合的仪器取代了产生电流的自然能力。数百万心跳节律器的回收使得这个仪器问题层出不穷。从鲸鱼身上得到灵感，Reynolds 博士重新创造了像细胞一样薄的管子来改善心脏里电流的分配，而发展出一种微毫刻度的心跳节律器。这个仪器并没有取代原本心脏自然的功能，反而，它将电流从健康的组织导向受损的组织。正当医疗仪器花上好几年的时间做测试，这个创新做法对于永续性及健康的重要贡献是功不可没的。一项花费十万美金的手术、昂贵的药物，以及持续的治疗可能由一项美金五百元，病人不需要留院观察的简易程序取代。的确，想象一

下，要是有一天每一种用电仪器不用那些回收困难，又因为金属太小而无法找回的电池就可以运作，那有多好。消除这些极小电源对地球健康造成的有害冲击可以减缓生态的负担，我们依赖这个生态给我们对生命不可或缺的，像是喝水或是为土壤施肥的重要服务。

## Nine - A Rainbow of Possibilities

### 九、无数可能性

#### 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.

#### 重新创造色彩和装饰

第九章重新思考。有时候创新的东西是最令人讶异的方式找到市场。蜻蜓的翅膀有一种可以集中阳光的独特功能。在日本，蜻蜓象征新的光亮以及喜悦，这种能力引起研究人员注意到蜻蜓产生的能源的能力有效率到让煤炭发电像个古董。蜻蜓的这种技术正是我们所需要的；我们需要这种能力来把重污染的硅胶发电转换为著名而易懂的蒸气涡轮发电，这种发电的工程知识和生产管道都随处可得。

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 CO<sub>2</sub>!

太阳能发电在西班牙已经是一种已经被证实的新兴工业。集中太阳能就是利用镜子把阳光集中到水上，就像蜻蜓一样。加热后的水可以为发电机发电，这是一种简易可装置的科技。到了二〇五〇年，太阳能发电年度投资资金就会超过一千亿，创造将近两千万个工作机会，也可以省下二十一亿吨的二氧化碳！

## 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 CO<sub>2</sub> 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.

### 十、展望新能源契机

第十章提出一个问题：「为什么椰子里充满了水？」椰子里面没有帮浦，也不会吸收雨水啊。树是如何克服地心引力长得高高壮壮的？植物的渗透作用是利用哪里来的力量超越重力？毛细管里的渗透作用和二氧化碳气泡把充满水的营养物往上推。表面张力是会互相作用的。当然，我们怎么能够忽略地心引力的强大力量，或是月球的引力？另一个可预测的力量，潮汐，是需要我们的重视的。很多力量被大自然这个系统大量利用，这样一来可确保每一样东西以及生物在需要的时候会得到力量。这跟现今我们已经投注心力以及金钱的工业化解决方法完全不同。

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.

热电就是利用温差的转换来发电。在未来，许多仪器都会在没有电池或是插电的情况下运作。例如，电子设备可能从人体的温度来发电。在德国，Fraunhofer 物理测量技术中心已经发展出一种可以从自然人体发电的方法。人体体温跟周围冷热环境之间的差距就足以发电。通常，要产生足够的电力需要好几十度的温差，但是人体表面跟邻近环境的温差只有几度而已。德国研究机构的计划主任就解释：「像这样的方法只能产生低瓦数的电。」既然像是手机的这些东西可以创造出数量可观的比例来取代污染环境的电池，这就足够来让地球永续生存。

## 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?

### 十一、真金：使用矿物来当作地球复原的平台

第十一章的目的是讨论人类最具侵略性的行为之一：采矿。当一小块黄金被从地底深处开采出来，爆裂物以及大量的水和能源都被消耗。这跟大自然的系统一样吗？地衣也是采矿高手，它可以把像镁一样的特定无生物分子从岩石当中撷取出来。很多人都知道细菌可以透过与螯化的过程把金属选择性地分开，但是大自然中没有任何生物曾经用这么野生的力量来取得这么微小的数量。要改变已经犯的错是不可能的，所以现在的问题是：「我们可不可以在未来做得更好？」虽然我们没有办法把采矿变成一个善意的运作，我们能不能至少设计一项策略来抚平采矿所带给环境和社会的痛？

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 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.

矿区需要大量的电力来吸取水和空气，或是制造冷却矿井用的冰。找方法在这方面节省能源是合理的。这是让 Fibonacci 法则离开理论，走进现实的最理想环境。启发 Jay Harman 的数学模型是他的 Pax 科技公司创新发明的根基。鹦鹉螺号的外壳可不可以提供把能源减少百分之二十到三十的方法？这个机会并不是 Pax 专有的。Watreco 的科技是根据瑞典涡旋专家 Curt Hallberg 的成果得来的，而 Watreco 也有同样的机会。在矿口必须的庄意来控制温度的制冰机必须要跟含有大量空气的水合作，这样一来，只用地心引力移除空气就可以降低百分师时到十五的能源花费。

## 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.

### 十二、水流设计成的高楼

第十二章深入探讨楼房。我们每个人都有机会在家、学校，或是工作地点创造自己的空间。就算外面的空气受污染、酸性高，我们没有理由在家也要受同样的苦。相反地，我们的楼房设计很复杂，所以内部自然形成一个轻微碱性的环境，就像小肠一样。就算胃部是酸性的，但是大部分免疫系统所在的生命引擎是碱性的，这是无所谓的。类似地，你家里的卧室就像小肠一样，应该是碱性的。从在家做起，我们应该善用我们对空气及其它东西流动的了解还创造一个适合居住的环境。我们需要利用同样的逻辑来设计住家、学校、办公室还有育婴室，就像我们知道，大海里的生物在碱性环境中大量繁殖，而我们的身体却在不一样的环境中生长。

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.

瑞典来的 Anders Nyquist 说服了负责在 Tinrå 的 Laggberg 学校在增加校园设施的时候改见旧校园。他设计了一种由自然气流驱动而且可以持续保持空气新鲜的控温系统。当大家都发现正面的健康数据和低的缺席率的时候，许多家庭都搬进这个小区，确保自己的孩子可以在现代社会当中在最健康的环境中受教育。当家长开心，孩子学习更有成效。当孩子学习有成效，而且健康，家长更开心。这并不难了解。在生态系统中也是相同的，一种营养物和能源流动，更多物种加入、演化，把少数族群转换成一个开心而美丽的环境。



## 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.

### 十三、串连一个蓝色经济

第十三章说明整个生态系统不停地连接、创造无数个网状系统、让所有的生物贡献所长，同时也可以清楚的限定范围之内运作，在这个范围之中无数的营养物以及能源也受到物理法则的定义，像瀑布般串连。这些制度都像沙漠一样多变，有阿尔卑斯山的范围、一块湿地或是一个热带雨林，在这些制度之内，适用同样的原则。传统的企业思维主张唯一有可能增加生产力的方法就是裁员。大自然却不这样认为。在危机的时候，数百万人失业，上亿的年轻人心中充满无用感，因此，我们能够起动这座「蓝色机器」、让「蓝色经济」成形的机会是鼓舞人心的。大自然系统可以释放许多当地的企业机会，就像演化透过多样性来迎接创新。最大的改变力量莫过于年轻人接手这项任务了。

## Epilogue - Realizing A Dream

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

### 结尾短文：实现梦想

Gunter Pauli 来自非洲津巴布韦、美国加州激发人心的成功故事，以及对未来的展望。

## **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.

### **附录一、一百项受到自然启发创新发明的列表**

这个附录显示「蓝色经济」这本书副标题的基础：「一世纪，一百种革新，一亿个工作机会」。里面列出每一种创新发明以及这种发明大约会带来工作机会。这些估计数字来自于 Pauli 博士的研究。这是一个企业家的梦想。有一些发明已经在现实生活中被应用，有一些在未来被应用的时候会设下新的准则，有一些是同侪间互相讨论科学后做出的估计。每一样都可以以它们自己的方法改变世界。

## **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

### **附录二、一百项创新发明激发出充满竞争的企业模式**

这个附录描述了这些创新发明，它们借着创造出有竞争力的新企业来创造新的工作机会。每一个都列出可能随之而来的工作机会，以及描述有可能的现金流动。

## **Bibliography and References**

The Bibliography includes Books, Journals and other works by Gunter Pauli.

### **目录及参考书目**

参考书目包含了书、日志，以及其它 Gunter Pauli 的作品。