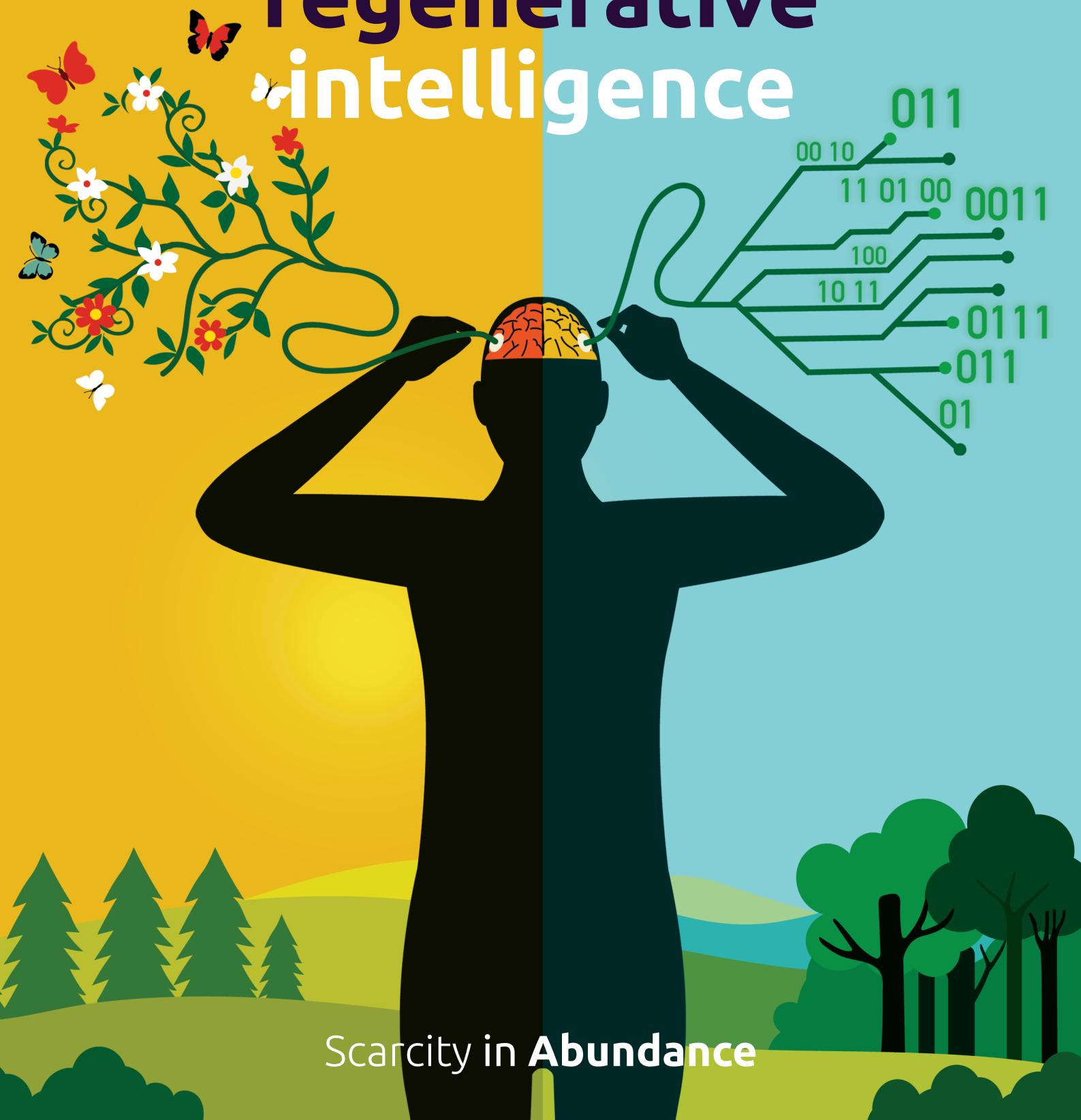


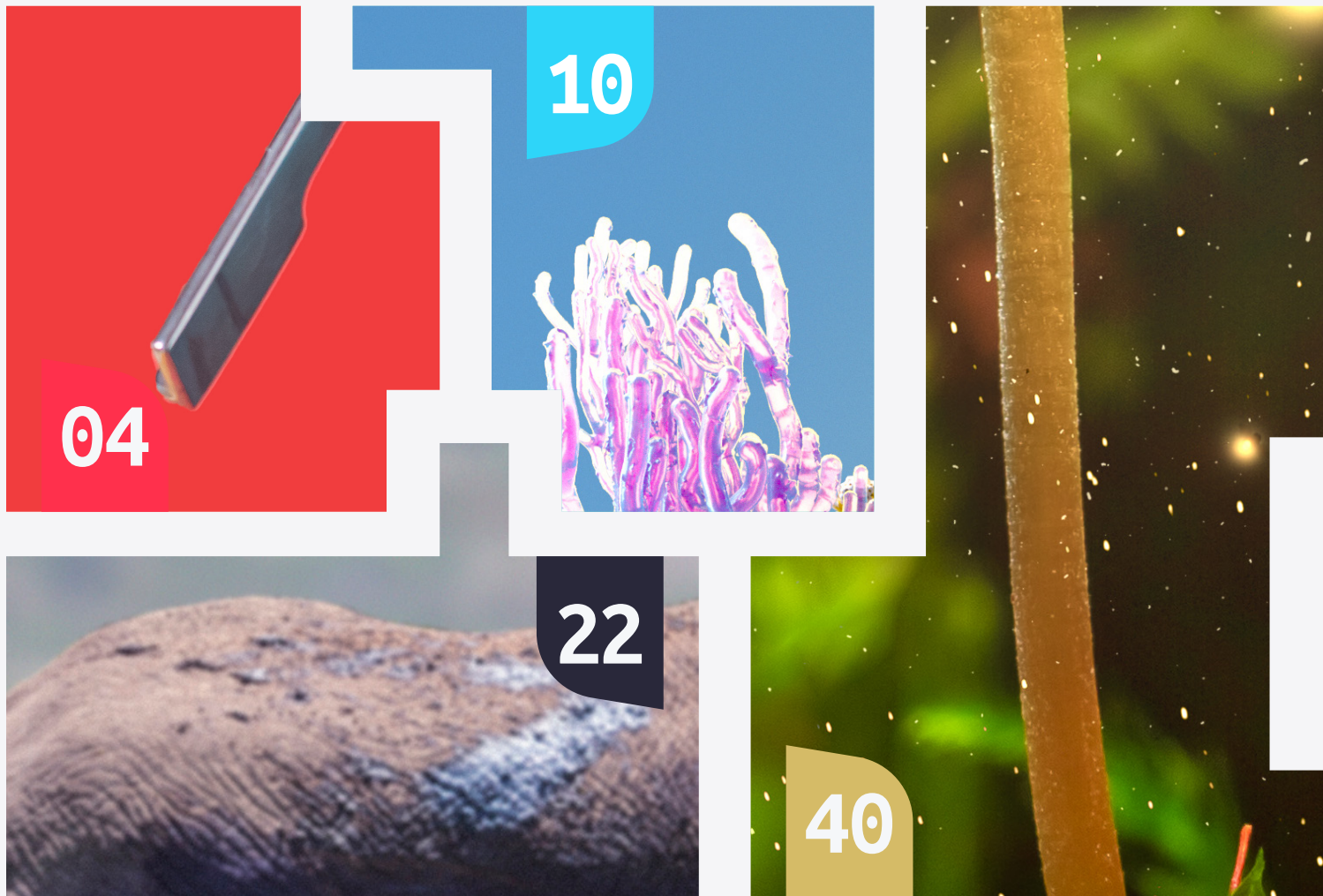
A discovery journey into

regenerative intelligence



Scarcity in **Abundance**

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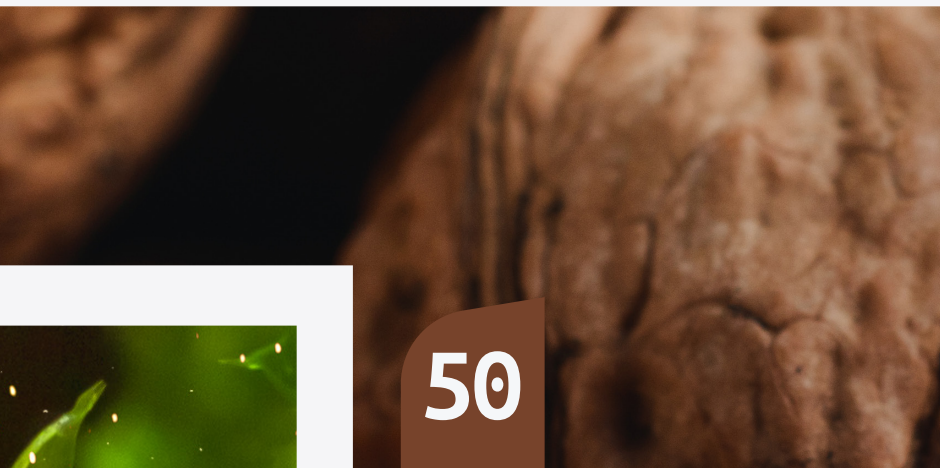
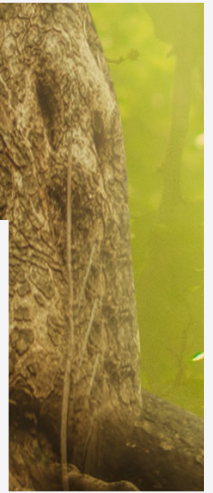
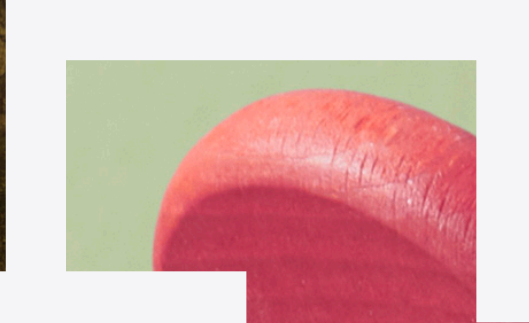


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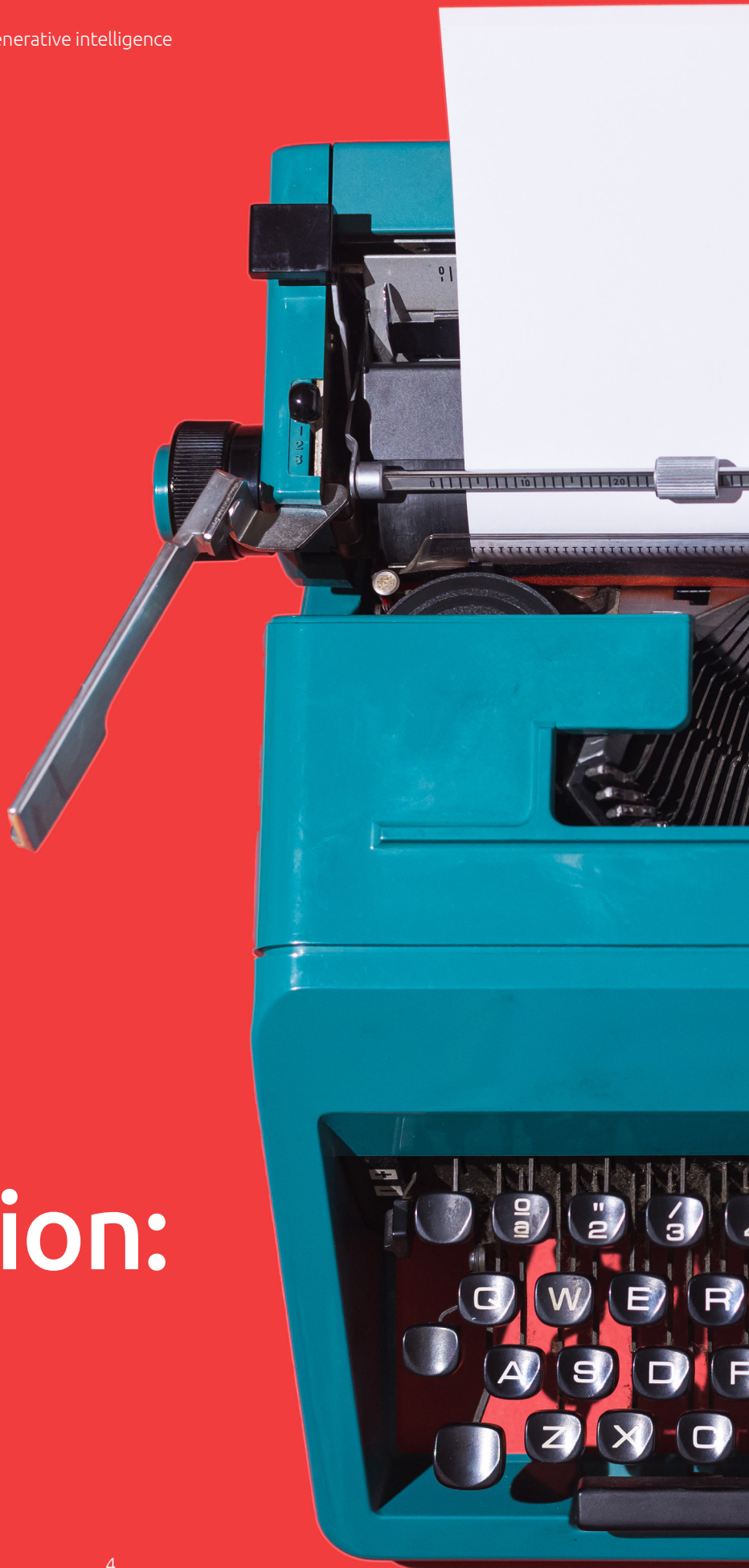
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Introduction: 2125



If you are looking for longer-term footing, this report puts you comfortably in your seat. Feel free to think of a timeframe of 50, 60, possibly even 100 years or more. Let's take 2125 as a starting point.

The hype cycle of AI

Anyone looking back from the future will marvel at Gartner's 2024 hype cycle. In 2024, Large Language Models, a cornerstone of artificial intelligence, have just passed their peak. At this stage, anticipation is high for the 'plateau of productivity,' as Gartner terms it. In other words, people are eager to see how AI will genuinely enhance organisational productivity once the initial hype has subsided.

Changing perspectives

The words 'productivity' and 'artificial intelligence' will only be vaguely familiar to us in 2125. Living a hundred years from now has taught us to look at these concepts differently. Lifestyles have changed, our way of 'being' has changed. Looking back at the present day, we note that we owed a lot to technological breakthroughs, but we were not really smart.

Understanding life in 2024 is becoming increasingly challenging. During that time, there was growing discussion about computers potentially matching or surpassing human intelligence. The long-term forecast was a transformative event known as the 'technological singularity,' when AI would advance so rapidly that it would surpass human control and comprehension. This notion harks back to an era when nature was seen merely as a backdrop to technology—a dangerous blind spot of techno-determinism.

The limited view of intelligence

In 2024, our understanding of the often-misused concept of intelligence was limited. At that time, the idea of regenerative intelligence—the ability to repair and renew in harmony with natural systems—was largely unknown. Reflecting on this era feels like flipping through an old family album from the 1920s, seeing great-grandmother as a 12-year-old servant in a wealthy household. While you've heard of it, the specifics are hazy. Women's suffrage, just introduced then, faced significant opposition, a concept hard to imagine now. Over time, concepts evolve and fade, and when you're immersed in history, there are always gaps in understanding.

The Ego Era

A significant blind spot of our current era is our excessive focus on ourselves. We are in the midst of what could be called the Human Era or the Ego Era, centered around our intelligence, economy, inventions, and resources. We've distanced ourselves from the notion that we're part of a much larger system. In fact, our self-absorption has led earth scientists to seriously consider naming this period the Anthropocene. It's increasingly likely that during our lifetimes, the Holocene, the era we currently inhabit, will be renamed the Anthropocene. This designation is far from a compliment.

The shift to a holistic worldview

The realisation that we are part of something far greater will have arrived in 2125. We discovered cycles that have persisted for hundreds of millions of years, making Gartner's trends seem insignificant by comparison. These include the food and carbon cycles—nature's operating systems that sustain life on Earth. For too long, we were unaware that every second breath of oxygen we take is owed to plankton in the oceans. This ignorance was a hallmark of the ego-centric era, which we left behind in 2125. Since then, we have not only transcended the eco-centric era but also embraced a new paradigm: 'selfless service,' rooted in the Sanskrit concept of 'seva.'

The cycles we now recognise are not so much a hype but have sustained life for millennia. This is the Circle of Life, of which we had been a forgotten part—until now. The picture is changing as we continue to uncover profound connections between ourselves and the natural world. We are beginning to understand how our brains function in comparison to other intelligent species and, more importantly, how intelligent nature itself is. Its resilience is evident in the symbiotic relationships it forms with other life, revealing an inherent wisdom in the natural world.





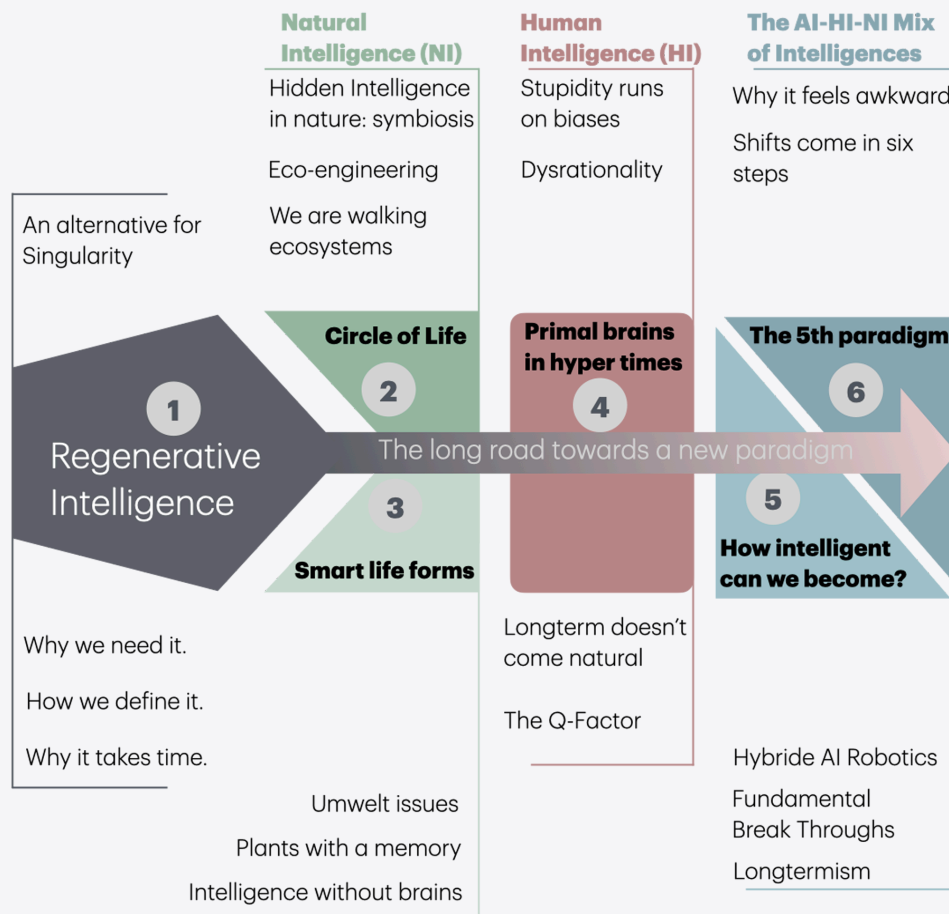
A new take on intelligence

This hidden and explicit intelligence found in nature redefines our understanding of human intelligence. Primitive life forms have thrived on Earth for billions of years, with plants emerging around 500 million years ago, coexisting with dinosaurs around 250 million years ago. Their remarkable ability to adapt, evolve, and develop their own form of intelligence commands deep respect. In contrast, modern humans are relative newcomers, having appeared only about 300,000 years ago. When we discuss intelligence, it's crucial to recognise that nature has had a significant head start.

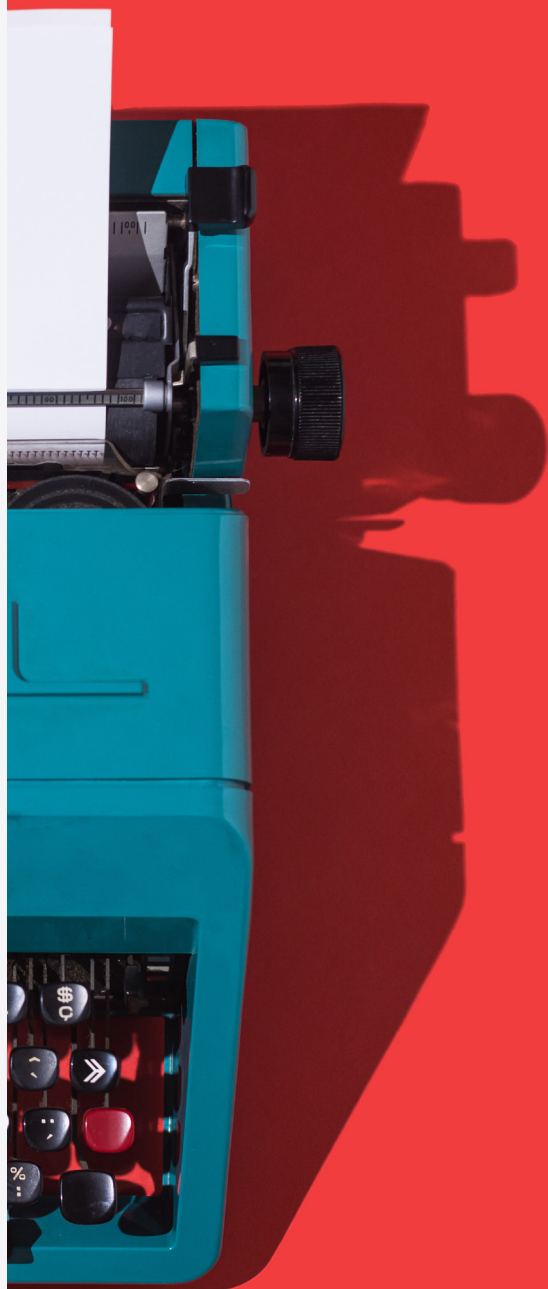
We are discovering that the true strength of AI lies not in mimicking human intelligence but in addressing its limitations. The key realisation is that to move beyond this era, we need to integrate all forms of intelligence—natural, human, and artificial. This leads to a paradigm shift from degenerative to regenerative intelligence.

In this report

The term regenerative intelligence in this report represents a turnaround in our thinking about intelligence, creating an opportunity to start acting 'really smart'. We blend it all together: cutting-edge artificial intelligence, the ancient intelligence of nature, and human intelligence. The outcome is best captured by a familiar metaphor: someone points toward the starry sky, but we focus only on their finger. In this analogy, the arrow in the reading guide on the next page represents the finger pointing us toward the long road to a new paradigm.



However, embracing a new worldview is far easier to write about than to widely accept, as Galileo Galilei, the father of modern science, learned firsthand. Resistance is inevitable—not just from shareholders, but also from readers who view a ‘different way of being’ as incompatible with their current lifestyles. Despite this, we hope that reading this report creates the intellectual space for you to reconsider what an intelligent future could look like. In the following chapters, let ancient nature and cutting-edge machine intelligence inspire your imagination.



Chapter 1: We begin by exploring why regenerative intelligence is necessary, what it entails, and how we define it. In this report, we emphasize a form of intelligence that aligns with nature, moving the focus from being merely ‘techy smart’ to being ‘truly intelligent’ or ‘genuinely smart.’ This means no AI as a mere imitation of humans or a ‘stochastic parrot’ regurgitating information—it’s about intelligence that works in harmony with the world around us.

Chapters 2 & 3: The next two chapters explore the intelligence found in nature—one focused on ecosystems, the other on the intelligent life forms around us. Our brain-centric view of intelligence seems outdated, as we discover that intelligent solutions to complex problems can emerge from unexpected sources, even from the most primitive organisms. Life forms like slime mold and plants, despite lacking brains, demonstrate cognitive abilities. Ecosystems, too, display intelligent behaviours, even though neither the systems nor their individual components possess brains. We hope these insights contribute to your own bio-intellectuality, fostering a deeper understanding of how nature functions and encouraging a more biophilic way of thinking.

Chapter 4: In ‘Human intelligence: primal brains in hyper times’, we outline the limitation of human intelligence by ‘ratio dyslexia’. We learn about the brain as a survival machine, full of so-called ‘biases’. Longer-term thinking, a necessary quality of regenerative intelligence, turns out to be very difficult for humans.

Chapters 5 & 6: How intelligent can we become? What steps are needed to bring about a paradigm shift? These are the guiding questions for the final two chapters. We explore how ‘hybrid AI robotics’ can drive fundamental breakthroughs and introduce the concept of ‘longtermism’. Long-term thinking, supported by AI and informed by the wisdom of nature, is a critical component of regenerative intelligence.



Chapter 1: Introduction – Regenerative intelligence

‘We have named our species *Homo sapiens*—the wise human. But it is debatable how well we have lived up to the name.’

Yuval Noah Harari, Historian

Sandra Phlippen, Chief Economist at the Dutch bank ABN Amro, finds it perplexing. The global economy faces a potential shrinkage of at least 20% due to climate change. For Phlippen, the business case is straightforward: every euro invested in preventing this outcome will yield a double return. It seems like a no-brainer. Yet, instead of taking decisive action, we remain stagnant—even engaging in fierce battles over proposed sustainability measures. Her message is clear: it’s time to leave the fossil fuel era behind once and for all. This is important not only to avert impending natural disasters, but also because the economy will go downhill fast.¹ In a candid interview with *de Volkskrant*, she boldly addresses the issue head-on.² She says we are collectively victims of short-termism. Phlippen: ‘Man is inclined to emit CO₂, despite widespread awareness of its role in causing catastrophic global warming.’

¹ World Economic Forum assumes 11% drop in global GDP if climate warms by two degrees. Source: Marchant, N. (2021, 28 June). This is how climate change could impact the global economy. <https://www.weforum.org/agenda/2021/06/impact-climate-change-global-gdp/>

² Sitalsing, S. (2024, 4 July). Sandra Phlippen: ‘Mijn grote zorg is dat de maatschappij uit elkaar zal vallen’. *de Volkskrant*. https://www.volkskrant.nl/volkskrant-magazine/sandra-phlippen-mijn-grote-zorg-is-dat-de-maatschappij-uit-elkaar-zal-vallen~bc591a1f?utm_campaign=shared_earned&utm_medium=social&utm_source=copylink

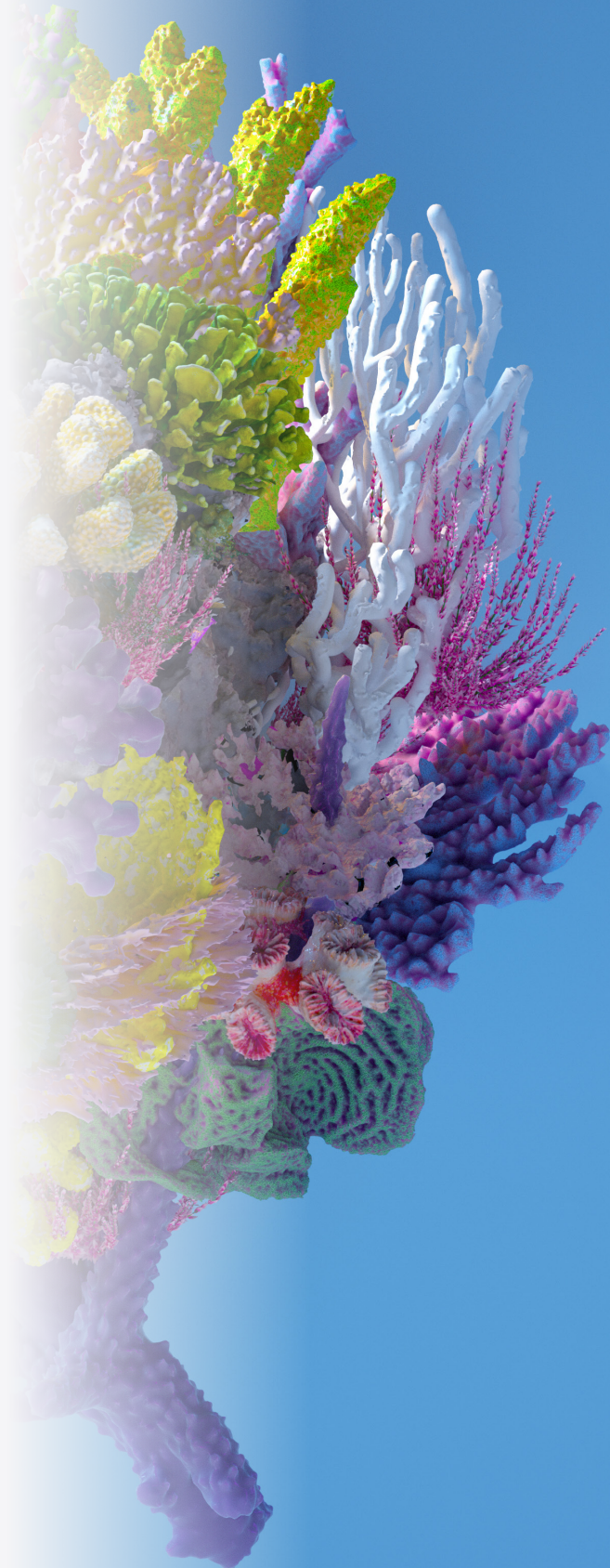


FIGURE C

Global risks ranked by severity over the short and long term

"Please estimate the likely impact (severity) of the following risks over a 2-year and 10-year period."



The World Economic Forum (WEF) asked 1490 experts (in for example, academia, business and government) about the most important global risks. In the coming years, technology risks slide down and climate risks climb to the top.

Inimitable

Estimates of how disastrous this is going to be are accelerating. Following the publication of our report on the ecological state of the planet, 'The Rise of Experience Ecology', global heat records are being broken month after month. NASA figures show that climate change is accelerating. Climate scientist Frank Selten, much like Phlippen, finds it incomprehensible. 'The latest climate graphs deserve to be front-page news' he says.³ Climate institutes such as NASA, Berkeley Earth and the Global Climate Change Initiative (GCCl) are tumbling

over each other to deliver the alarming message. According to the Intergovernmental Panel on Climate Change (IPCC), the 1.5-degree warming limit could be reached in as little as 15 years, followed by the 2-degree warming limit, which the international community describes as 'dangerous'.⁴ It is suggested that cleaner air is one of the causes of the acceleration.⁵ China has reduced sulphur emissions and international shipping has also become cleaner. As unstoppable as the acceleration of global warming may seem, some of its causes are equally unique: for example, polluted air can actually dampen solar warming.

³ Keulemans, M. (2024, 23 July). De klimaatverandering versnelt: 'Hiervan zou iedereen rechtep in zijn stoel moeten zitten'. *de Volkskrant*. <https://www.volkskrant.nl/wetenschap/de-klimaatverandering-is-in-een-stroomversnelling-gekomen~bc4551ce/>

⁴ Hausfather, Z. (2024, 4 April). Factcheck: Why the recent 'acceleration' in global warming is what scientists expect. *Carbon Brief*. <https://www.carbonbrief.org/factcheck-why-the-recent-acceleration-in-global-warming-is-what-scientists-expect/>

⁵ Hansen, J., Kharecha, P. & Sato, M. (2024, 16 May). Comments on Global Warming Acceleration, Sulfur Emissions, Observations. <https://www.columbia.edu/~jeh1/mailings/2024/MayEmail.2024.05.16.pdf>



We need to become ‘eco-wise’. The agenda is vast, the action list long. But there are also many omens that ecosystem change will gain importance on organisations’ agendas in the coming years. This is reflected in, for example, the World Economic Forum’s (WEF) risk reports. Every year, they ask experts about the global risks they foresee in the coming years. The most recent report from January 2024 shows a striking shift. Over the next two years, the top concerns include cyber insecurity, societal polarisation, disinformation, and misinformation. However, when looking a decade ahead, these risks are overshadowed by more severe threats like extreme weather, biodiversity loss, ecosystem collapse, and shortages of natural resources. The risk table turns green, but in this context, it’s anything but positive.

Are we intelligent enough?

Are we as smart as we think? With all our knowledge, shouldn’t we be able to change course easily? Yet somewhere, our reasoning falters. Do we still truly understand nature? And do we fully grasp the nature of our own intelligence?

It’s no coincidence that existential questions about humanity and its nature are emerging now. Nature is confronting us with undeniable realities, while science is also challenging our understanding. The traditional concept of intelligence is being stretched by breakthroughs in fields like computer science, cognitive science, microbiology, and

quantum physics. Human intelligence is beginning to reveal itself as just a subset of something far greater—a spectrum of diverse forms of intelligence.

We’ve said it before: nature’s intelligence is the result of 4 billion years of evolution. Its mysterious mechanisms are becoming increasingly understood by science. Now, with the advent of artificial intelligence, we’re introducing a new form of intelligence. But this expansion calls for an update to the concept itself. You could call it Intelligence 2.0, or as we refer to it in this report, ‘regenerative intelligence’.

Ratio dyslexia

There is a growing consensus in cognitive science that our brain is ‘predictably irrational’, or ‘dysrational’ (a form of ratio dyslexia).⁶ One such dysrationalia is the short-termism Philippen gets so worked up about. We increasingly understand our own intelligence and its shortcomings. Computer science further reinforces this view. The images we generate with AI aren’t neutral or entirely rational—they carry a ‘bias.’ And that bias is a

⁶ *Predictably irrational* is a term and book by Dan Ariely. He is a professor of psychology and behavioural economics at Duke University and was Chief Behavioral Officer of AI-driven insurance company Lemonade from 2015 to 2020. *Dysrational, of dysrationalia*, is a term coined by John Vervaeke, professor of psychology and cognitive science at the University of Toronto.

reflection of ourselves. Through AI, we peer into the soul of human intelligence.

Indeed, strange things are happening. What was once considered self-evident in nature is now being rendered mystical again through science. Researchers are using AI to decode animal communication, and vast terrestrial ecosystems are being mirrored as digital AI twins. A closer look at photosynthesis reveals quantum effects in plant cells, explaining their super-efficient energy conversion. While science once stripped phenomena of their magic and wonder, it now seems to be restoring them. Thanks to this wave of insights and breakthroughs, it is becoming increasingly clear how humans are connected to the natural world. Call it the great unravelling of the *Circle of Life*. Once sung by Elton John in the Disney film *The Lion King*, now a rewarding research object for AI scientists and biologists. On this frontier, questions like ‘Should we model AI more closely on a dragonfly’s brain?’ have become commonplace.⁷ Neuroscientist Frances Chance explores this approach by developing biologically inspired algorithms. Numerous experiments have revealed that plants can ‘see,’ possess memory, and that trees can ‘listen’ (we’ll explain this later). Moreover, chimpanzees have been shown to outperform humans in certain

cognitive tasks.⁸ But the true intelligence found in nature lies primarily in the interrelationships—among animal, fungal, and plant species—and in the collective intelligence of entire ecosystems.

There have also been remarkable developments in computer science, but these are more widely known. Generative AI seems to blur the line between technology and magic, from delivering a brilliant wedding speech to making breakthroughs in fundamental science. We’re no longer astonished to learn that what we thought was a human creation was generated by a computer. AI pushes the boundaries of human understanding, enabling us to think twenty steps ahead and uncover previously hidden connections. In a sense, AI makes the invisible visible.

Regenerative intelligence

Human intelligence is now, rather clinically, positioned alongside artificial and natural intelligence. When these different forms of intelligence work together optimally towards a regenerative future, we call this new concept regenerative intelligence.



⁷ Chance, F. S. (2022, April). *Are insect brains the secret to AI?* [Video]. TED. <https://www.npr.org/2024/03/08/1236671158/can-the-insect-brain-help-us-develop-smarter-faster-ai>

⁸ Pomeroy, R. (2023, 3 March). Chimps beat humans in these cognitive tests. *Big Think*. <https://bigthink.com/life/chimpanzees-beat-humans/>

Regenerative intelligence is the synergistic integration of natural, human and artificial intelligence aimed at creating sustainable, self-healing systems that contribute to the well-being of all life forms and ecosystems.

If we express the concept in a formula, it could look like this:

$$RI = (NI + HI + AI) \times S \times R$$

RI = regenerative intelligence

NI = natural intelligence

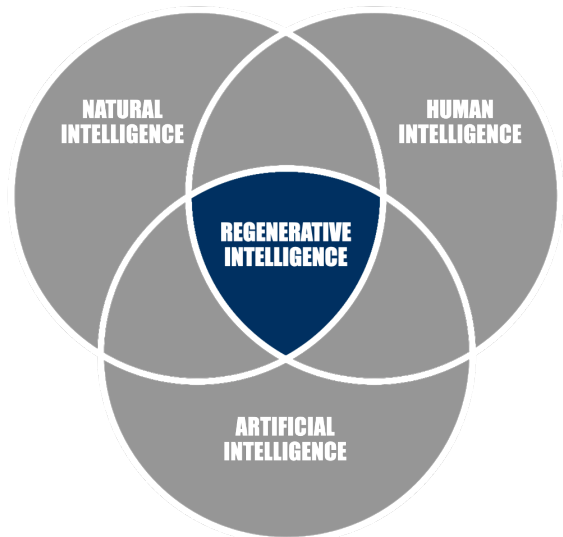
HI = human intelligence

AI = artificial intelligence

S = synergy factor

R = regenerative impact

It could also be called the 'really smart formula'. Harnessing various forms of intelligence to disrupt the current degenerative ecological spiral is arguably the most intelligent course of action humanity can take at this moment.



This report focuses on three forms of intelligence: natural, human and artificial intelligence. All three are unique and have their strengths and weaknesses. An ultimate symbiosis between these three forms of intelligence is called regenerative intelligence.

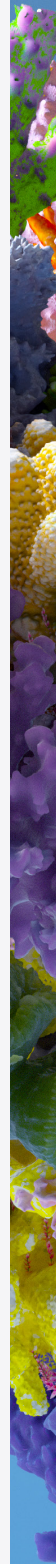
A new paradigm

Terms like ‘groundbreaking’ and ‘breakthrough’ are increasingly frequent in many scientific fields, often accompanied by even more ambitious claims. Last year, for example, *The Economist* argued that a new era of ‘enlightenment’ is among the possibilities. The argument was that AI is uncovering new knowledge hitherto hidden from humans.⁹ They write about the promising ‘literature-based discovery’ (LBD) approach, which, as the name suggests, aims to make new discoveries by analysing scientific literature. Artificial intelligence is used to make connections between different scientific research papers, facilitating the emergence of new knowledge. Yann LeCun, a pioneer of modern artificial intelligence, agrees. He suggests that enhancing human intelligence with AI could usher in a new renaissance—or even a new phase of enlightenment. He shared this view in a tweet on April 1, 2023, quickly clarifying that it was not an April Fools’ joke.

Similar sentiments are echoed by biologists, who describe a paradigm shift towards a fundamentally new perspective on nature, with ‘regenerative’ at its core. Leen Gorissen, author of ‘Natural Intelligence: Building the Future of Innovation on Millions of Years of Natural Intelligence’, is a prominent advocate of this view. Her book reveals the ancient logic of nature, showcasing how ‘billions of years of research and design’ have resulted in a system that innovates without depleting, polluting, or degenerating. She distils this paradigm into ten principles, which can be seen as nature’s guiding precepts or the operating system of natural intelligence.

1. There is no taking without giving
2. It takes an ecosystem to sustain an ecosystem.
3. Interdependence prevails; nothing happens in isolation.
4. The by-products generated are as fundamental to evolution as the innovations themselves.
5. Diversity, decentralisation and redundancy build resilience; monocultures and monopolies build fragility.
6. Key species create favourable conditions, conditions that allow regeneration from below.
7. It is the avoidance of competition that drives evolution.
8. Invest in the health of others to ensure your own health.
9. Leave it better than you found it.
10. Never take everything.

⁹ *The Economist* (2023, 13 September). Could AI transform science itself? <https://www.economist.com/science-and-technology/2023/09/13/could-ai-transform-science-itself>





Paradigm shifts come in many shapes and sizes, with some beginning with a capital ‘R’ for Revolution. Some of those kinds of revolutions are behind us¹⁰ and we are preparing for the next one. The essence of such a ‘Revolution,’ or new paradigm, is that it shifts humans away from the centre of the worldview. For example, we once believed that everything, both literally and figuratively, revolved around our Earth. Copernicus revealed that we are merely a small part of a much larger cosmos and that we are not at the centre at all.

While the idea of transitioning to a new paradigm is compelling, it is a challenging concept during a time when deep wounds may be inflicted on individual egos and collective identities. The world suddenly reveals itself to be different from what we once believed, and the old narrative about our place in it no longer holds. Paradigm shifts are inherently difficult because they threaten careers, power positions, rituals and customs, and personal identities. This makes them complex processes fraught with resistance. However, paradigm shifts also possess a stoic quality. The discovery that Earth is not the centre of the universe—an early scientific revolution—was initially met with ridicule and hostility. Yet, in the end, the truth prevailed.

¹⁰ Floridi, L. (2016). Hyperhistory, the emergence of the MASSs, and the design of infraethics. In M. Hildebrandt & B. van den Berg (eds.), *Information, Freedom and Property: The Philosophy of Law Meets the Philosophy of Technology*. Routledge. <https://philarchive.org/rec/FLOHTE-2>



From devolution to evolution

In the new paradigm, the worldview evolves from devolution to evolution and from degeneratively intelligent to regeneratively intelligent. This transition marks a shift from the Ego era, through the Eco era, and towards the Seva era.

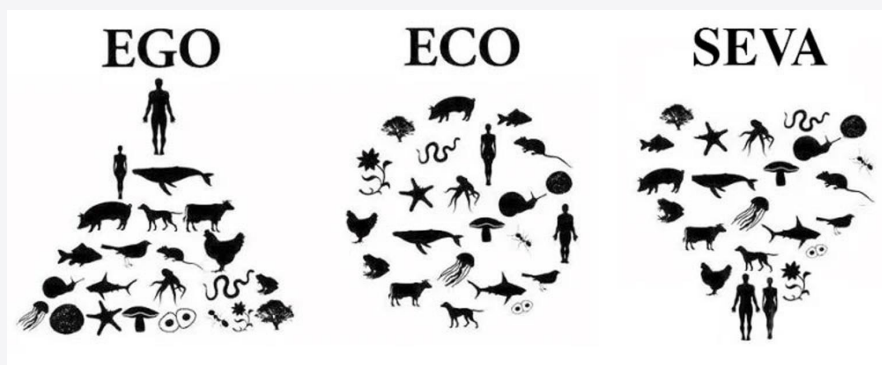
1. Ego: a worldview according to which we see nature as something to be controlled and exploited for the benefit of our own ends.

2. Eco: we recognise that we are an integral part of the ecosystem and not superior to nature. We strive for harmony and sustainability.

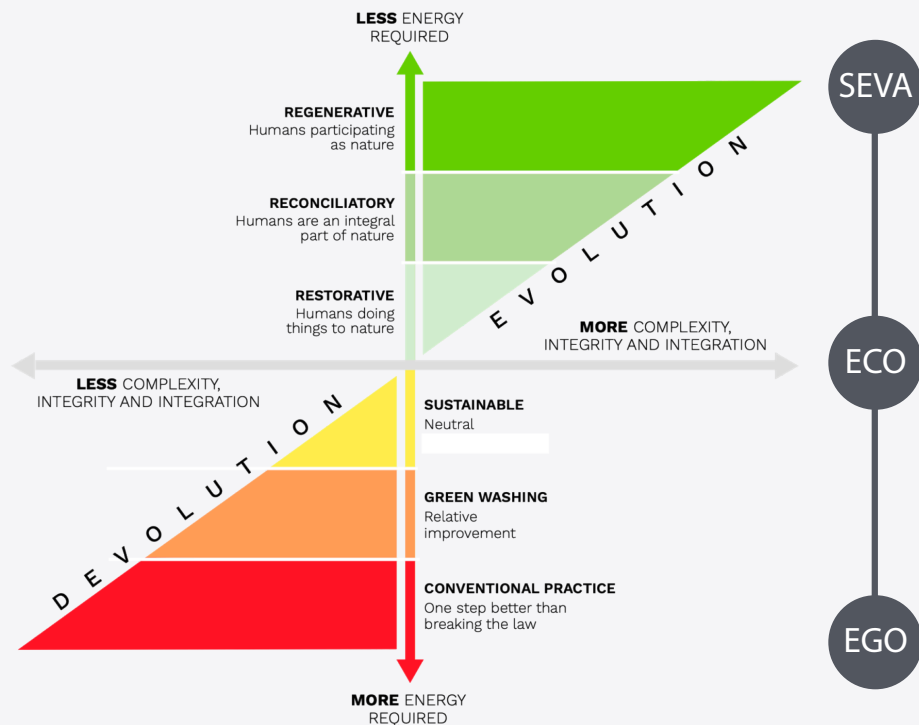
3. Seva: this is the highest level, where we see ourselves as serving the greater good. We act from a profound connection with and respect for all forms of life.

‘The major problems of the world are the result of the difference between the way nature works and the way people think.’

Gregory Bateson, Systems theorist and author of *Mind and Nature: A Necessary Unity*



The ancient Sanskrit word ‘seva’ is usually translated as ‘service’ in the sense of ‘being in the service of a greater whole’ and ‘giving more than once’. It resonates strongly with the goal of nurturing ‘co-evolving reciprocity’, something that regenerative work aims to promote.

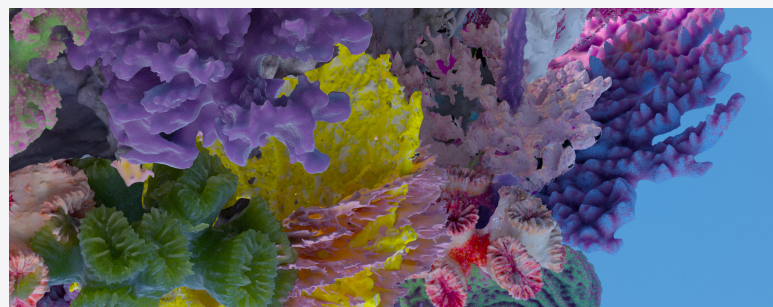


Commissioned by the European Union, a vision for this transition was developed, outlining six approaches for how individuals and organisations can interact with nature.¹¹ The vision outlines a spectrum of approaches, from conventional—where efforts might merely exceed legal requirements by a step—to regenerative, which embraces serving a greater whole. This vision is crafted with an evolutionary perspective. It identifies three ‘devolutionary’ levels, where practices such as greenwashing and traditional

notions of sustainability are criticized for lacking true evolutionary insight. Each of the three evolutionary levels begins with a distinct starting point. The ‘restorative’ level focuses on returning nature to its original state and doing beneficial things for the environment. Recognising that humans are an integral part of nature is referred to as ‘reconciliatory.’ In contrast, ‘regenerative’ behaviour involves aligning with nature and serving its needs, embodying a deeper commitment to its principles.¹²

¹¹ Belgian presidency Council of the European Union (2024, 17 June). Regenerative Development: improving governance and planetary health. <https://belgian-presidency.consilium.europa.eu/en/news/regenerative-development-improving-governance-and-planetary-health/>

¹² Federal Public Service (FPS) Health, Food Chain Safety and Environment (2024, 13 juni). Regenerative development and design. <https://www.health.belgium.be/en/news/regenerative-development-and-design>



Bring nature into your boardroom

You might recall that around 2017, it was all the rage to assert that AI had a seat at the boardroom table. Now, a new form of intelligence is being invited: that of nature. This concept, known as becoming a 'zoöp', is both simple and powerful: it means giving nature an actual voice in the decision-making process.¹³ This is achieved through a nature representative, known as a nature proxy, who sits in the boardroom to advocate for the interests of ecosystems and biodiversity.

BUSINESS

Artificial intelligence gets a seat in the boardroom

Hong Kong venture capitalist sees AI running Asian companies within 5 years



BUSINESS

Natural intelligence gets a seat in the boardroom

Hong Kong venture capitalist sees AI running Asian companies within 5 years



¹³ Nieuwe Instituut (2024). Zoöp Model. <https://nieuweinstituut.nl/en/projects/zoop/zoop-model>



Conclusion

1. Short-term thinking as an obstacle to sustainable progress.

Human beings have a tendency towards short-term thinking, or 'dysrationalia', which is a major cause of the current ecological and economic crises. Despite the clear benefits of proactive action against climate change, many decisions remain based on immediate benefits rather than long-term sustainability.

2. The rise of regenerative intelligence. Regenerative intelligence is a new way of thinking beyond traditional, human intelligence. It focuses on integrating natural, human and artificial intelligence to create sustainable and self-healing systems that promote the well-being of all life forms.

3. Synergy between different forms of intelligence. Regenerative intelligence is a synergy between natural intelligence (NI), human intelligence (HI) and artificial intelligence (AI). This combination aims to generate innovative solutions to the complex challenges of our time, emphasizing collaboration and mutual reinforcement.

4. Challenges in embracing a new paradigm. The transition to regenerative intelligence is not easy. This paradigm shift will be accompanied by resistance, both at an individual and collective level. This is because existing power structures, identities and lifestyles will be challenged and have to be reinvented.

5. The importance of bio-intellectuality. People need to learn to think and act in harmony with nature. This involves understanding and appreciating the deeper intelligence of natural systems and applying these insights to human technology and policy.

Case Study

Lush: Pioneering a Regenerative Approach to Business

In the complex landscape of global commerce, few companies dare to intertwine profitability with environmental stewardship as deeply as Lush: a \$1 billion revenue company with around 900 stores. Renowned for its handmade cosmetics and ethical business practices, Lush serves as a model for how businesses can transition from sustainability to regeneration. While many organizations prioritize minimizing harm, Lush goes further—actively repairing and renewing ecosystems while maintaining a thriving business.

Beyond Sustainability: Embracing Regeneration

The term ‘regenerative organization’ signifies an approach that not only respects but actively enhances the ecosystems it engages with. Lush embodies this ethos by embedding ecological health into its core operations. For instance, the company sources raw materials like cocoa butter and essential oils from regenerative agricultural systems. These systems not only produce high-quality ingredients but also enrich soil health, enhance biodiversity, and empower local farming communities. Lush collaborates with grassroots organizations, ensuring that its supply chain nurtures both people and the planet. One standout example is the company’s commitment to zero-waste packaging. By introducing innovations such as ‘naked products’—shampoos, conditioners,

and soaps without plastic packaging—Lush has prevented millions of tons of waste from entering landfills. This bold move demonstrates a radical shift from the linear ‘take-make-waste’ model to a circular economy where materials are continuously repurposed.

Digital Regeneration

With the Lush ‘Lens’ app all the product information appears on your phone, so you don’t need the packaging for the information anymore. Besides that, Lush has decided to not be present on social media because of the toxic nature of it and the unethical behavior of the Big Tech industry. Read the ‘Lush Social Manifesto, an oasis of kindness’ to learn more about their principles for digital spaces, platforms and engagement, designed to enable a techno-optimist future to flourish¹⁴.



¹⁴<https://weare.lush.com/lush-life/our-staff-room/a-social-manifesto/>

Ethical Supply Chains: A Commitment to Fairness

Lush's regenerative mission extends to its partnerships with local communities. It champions fair trade and direct trade practices, ensuring that its suppliers are compensated equitably and operate within environmentally restorative systems. A prime example is its collaboration with the Permaculture Research Institute in Ghana to create sustainable farming practices for shea butter production. These initiatives not only support ecological regeneration but also provide stable incomes and education for local communities. By placing fairness at the heart of its supply chain, Lush addresses social and ecological challenges simultaneously. This approach reflects the broader principle that regeneration must encompass both environmental and human dimensions.

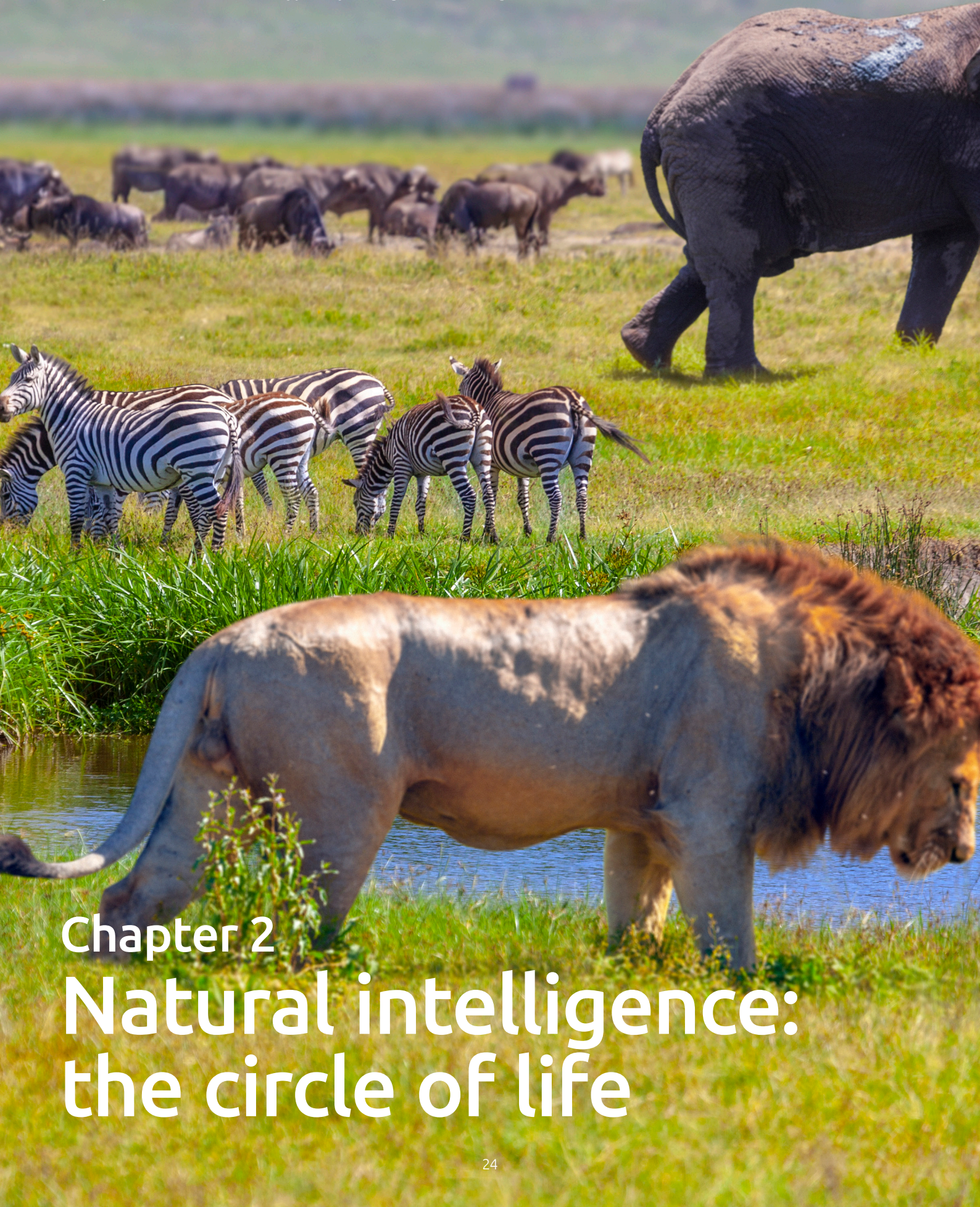
Innovating with Impact: A Regenerative Mindset

Lush's innovation-driven culture amplifies its impact on ecological restoration. The company invests in research and development to create products and systems aligned with regenerative principles. For instance, its Charity Pot program funds projects worldwide that aim to restore degraded landscapes, combat deforestation, and rewild habitats. Every purchase of Charity Pot hand and body lotion directly supports these initiatives, making customers active participants in global ecological repair. In addition to its product offerings, Lush has transformed its retail operations to align with its environmental values. Many stores operate as hubs for advocacy and education, raising awareness about the interconnectedness of consumer choices, biodiversity, and climate health. This commitment to transparency builds trust with customers and inspires collective action.

Leading by Example

Lush's journey illustrates that profitability and regeneration are not mutually exclusive. Its success challenges the traditional narrative that ecological responsibility comes at the expense of economic growth. Instead, the company demonstrates that businesses can thrive by aligning their operations with nature's cycles, fostering a resilient and interconnected approach to commerce.





Chapter 2

Natural intelligence: the circle of life

In her third healthy living principle from the earlier list of ten, Leen Gorissen emphasises that interdependence is the standard in nature— nothing happens in isolation. This lesson from nature is becoming increasingly clear: everything is interconnected, and cooperation is a fundamental force in evolution. Phytoplankton in the sea, which extract CO₂ from the air, thrive thanks to whales. Ants flourish through their communication with fungi, and humans depend on the vast numbers of microorganisms living in and on our bodies. We are all integral parts of the Circle of Life, interconnected through mutual dependencies and food and carbon chains. Science continues to deepen our understanding of these natural processes, with no end in sight. Communicating with other species could soon be a reality, and tracing diseases back to the start of the food chain is already possible. Artificial intelligence is increasingly recognising these complex patterns, offering a holistic view that can be challenging for humans to grasp. With so many factors at play, it's easy to become overwhelmed. Ecological AI could be part of the solution. The Artificial Intelligence Agency is now providing insights into the state of nature. We must take to heart the principle that everything is interconnected and part of the same life cycle. The risks highlighted by the World Economic Forum show that essential ecosystems are under tremendous pressure. This is why protecting these ecosystems with the help of AI and eco-engineering is becoming more critical and gaining greater attention.



Everything is interconnected

In Aristotle's time, this holistic way of viewing the world was the norm. In his 'philosophy of holism,' he emphasised the importance of always considering the bigger picture. He argued that systems should be studied as wholes, focusing on the connections between the parts rather than on the individual components themselves. We've all experienced the significance of holism. For example, when you visit a specialist at the hospital, you present the full picture of your symptoms. A specialist often focuses only on the area within their expertise, neglecting other complaints that might be related. Yet, the body is a system of interconnected parts, and a holistic approach can lead to a more accurate diagnosis. This principle of interconnectedness also applies to nature, such as the relationship between a flower and a bee.

According to evolutionary biologist Professor Lynn Margulis, cooperation is the essence. Organisms are linked together in what is called 'symbiosis',¹⁵ a close and long-term interaction between different species. Symbiosis can take several forms: mutualism, where both species benefit; commensalism, where one species benefits without affecting the other; and parasitism, where one species benefits at the expense of the other. Within our own bodies, mutualistic symbiosis is evident in the cooperation between bacteria, fungi in our intestinal system, and human cells. This specific type of cooperation is also referred to as the holobiont (from "holos," meaning whole, and "biont," meaning smallest part).

Margulis has shown that the strength of ecosystems lies in cooperation rather than competition. She has been dubbed the mother of symbiosis, much like Darwin is known as the father of evolution. Her argument that evolution and life on Earth are driven not only by competition but also by cooperation was initially met with scepticism. Yet, nearly 13 years after her death, her ideas are more popular than ever.

¹⁵She described this in her book *Symbiosis as a Source of Evolutionary Innovation*. The term symbiosis is much older, originating from Albert Bernhard Frank (1839-1900).

2.1 The life cycle of the *Leucoagaricus*



We travel to the tropical rainforest, where we learn more about how different life forms work together in an ecosystem. We watch and listen to Sir David Attenborough, a biologist and documentary maker for the BBC, who tirelessly drags us outside to show us the wonders of nature. Sunlight filters through the green leaves, casting a glow on his shoes. He stamps the ground a few times, drawing our attention to something hidden five meters below the surface—something he's eager to explain. And so begins the tale of an ecosystem where the star is neither plant nor animal, but a fungus called *Leucoagaricus*. Far removed from the leaves it relies on for survival, this fungus enlists a mercenary army of leaf-cutter ants equipped with an ingenious cutting ability to bridge the gap and secure its sustenance. With their jaws, they can cut the leaves of a tree or bush to pieces. Millions of these ants provide the *Leucoagaricus* with its leaves. In return, the fungus grows small packages that serve as food for the hungry ants. The fungus has its preferences and gives off chemical signals that reveal which kind of leaves it needs. Ant scouts venture out to explore, while worker ants follow, traveling hundreds of meters to locate the desired leaves. In this case, they target a young *bixa orellana*, known for its flowers that produce the red dye used in lipstick. The ants effortlessly employ their cutting tools to slice through the leaves. One by one, the leaves fall to the ground. The sound of cutting the leaves attracts even more ants and so the army expands. A column of ants forms, each carrying leaves ten times their own body weight at a speed of two meters per minute, creating a green river that winds through the jungle. Hour by hour,

thousands of leaf fragments are transported five meters underground, where the fungus eagerly consumes its spoils. But the *bixa orellana* doesn't surrender without a fight. As the ants sever the first leaves, the tree retaliates by infusing them with toxic substances. The fungus, sensing the danger, quickly issues new marching orders to the ants through chemical signals: find new leaves! This ongoing battle forces the ants to constantly change their target plants, ensuring that no single tree is overharvested. As a result, enough leaves are left for each plant to survive, and the ecosystem remains balanced and intact.

There are countless examples of such cooperation in nature—unsurprising, as it's the essence of life. Sometimes, these lines of communication are explicit, like the *Leucoagaricus* fungus guiding the ant's marching route. Other times, the cooperation is more subtle, as demonstrated when wolves were reintroduced to Yellowstone National Park in 1995. Their presence forced elk and deer to change grazing sites more frequently, allowing vegetation to recover. As more thickets appeared, other species, like otters, began to flourish. The revitalized riparian vegetation led to rivers meandering, creating deeper channels and pools that attracted even more wildlife. In this way, nature heals itself through these often hidden, intricate forms of cooperation within an ecosystem.





2.2 The Ecological Intelligence Agency

Aristotle might have wished it were different, but in our daily lives, we often fail to see the bigger picture. Instead, we become increasingly specialised, retreating into our own bubbles, leaving little room in our minds for contemplating nature's Circle of Life. Design firm Superflux has explored how AI could help restore our focus on nature. They've developed a prototype they call 'ecological AI.' What does this entail? Imagine receiving a message from the river near your house: 'The local kingfishers have just built their nest. In a few weeks, you'll see their young!' Or, 'The water is becoming polluted—action is needed!' Or perhaps, 'A green corridor should be established between the pond and the nearby river for wildlife.' In this speculative concept, AI serves as an advocate for the ecological health of the river. Superflux has aptly renamed this form of AI as the *Ecological Intelligence Agency*.

'To create a foundation for Ecological AI, we considered an alternate intelligence that does not claim unlimited access to knowledge systems, does not assume only one way to understand the world and does not perpetuate dominant extractive paradigms.'

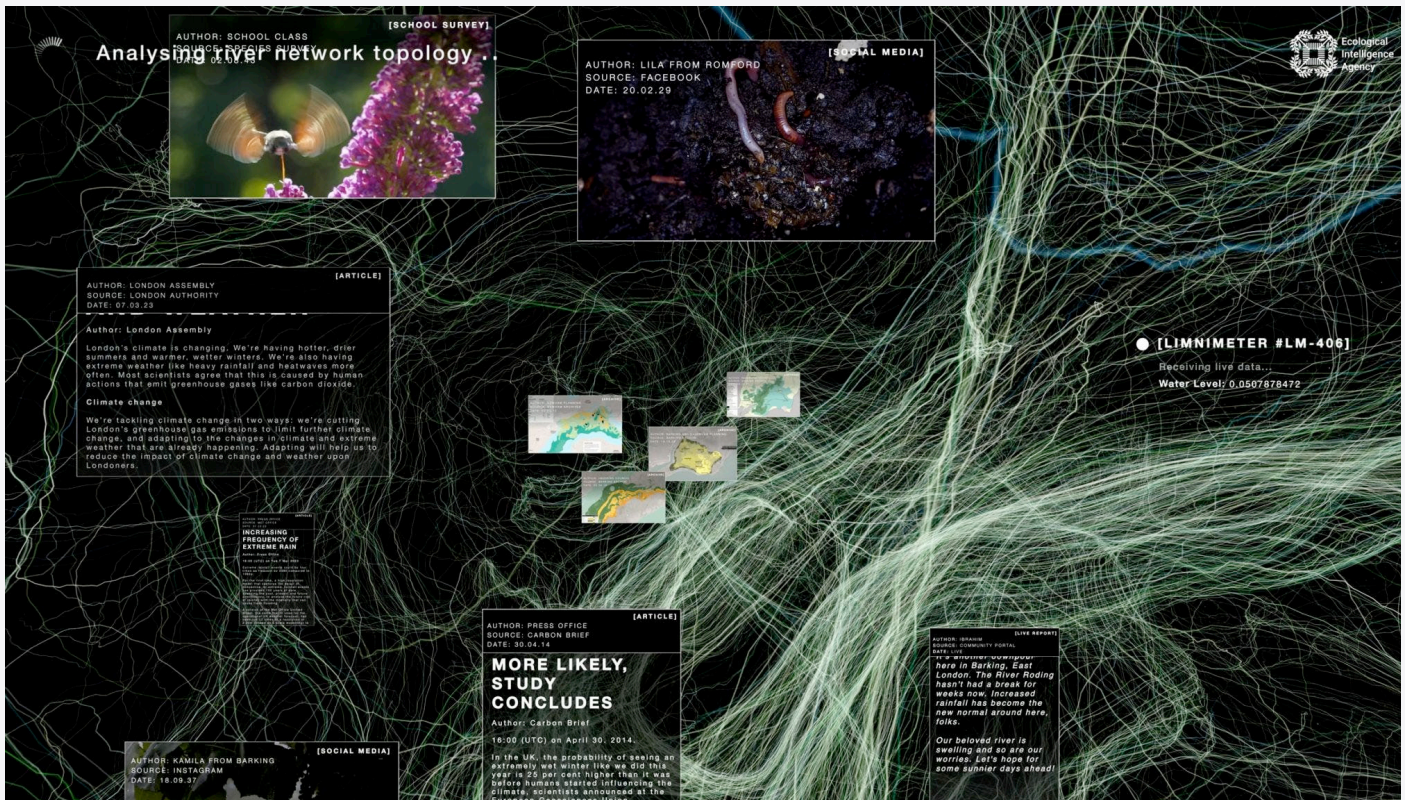
Superflux

Superflux conducted research into the pollution of the Roding River in London. The design firm focused on the impact of PFAS, called 'forever chemicals' because of their long-term effects. The team used artificial intelligence to give the Roding a 'real' voice. This AI voice was used to turn the ecological data sources into posts on social media. Their visualisations are created with generative AI.

This approach allows us to gain a deeper understanding of nature and its underlying ecosystems, with AI visualising their status on our screens, whether in our pockets or living rooms.



For instance, better information can significantly impact our conclusions. A case in point is the misinterpretation of whale behaviour: without accurate insights into their hidden cooperative dynamics, we might draw incorrect conclusions about their ecological roles.



Design firm Superflux developed the Ecological Intelligence Agency: an alternative intelligence that doesn't demand unrestricted access to expert systems and doesn't operate under the assumption that there is only one way of understanding the world.

2.3 The life cycle of whales

We once perceived whales as marauders—massive, lumbering creatures of the oceans, consuming vast quantities of fish and plankton with their enormous mouths, taking without giving. However, whales play a central role in their ecosystems, contributing to their health in ways that enable their own survival and benefit humans as well. Our earlier view projected our own destructive tendencies onto whales, masking their true impact. Although it's true that whales consume significant amounts of fish and plankton, with some species reaching lengths of 33 meters and weights of up to 190,000 kilos, their contribution to the ecosystem is far more complex. Whales enhance marine life more than they consume—a fact that was not apparent with the knowledge of the time.

We're referring to the 1970s, a period when it was believed that a decline in whale populations would result in an increase in fish and plankton.¹⁶ The idea was simple: without the warm-blooded giants, the fish and plankton would no longer be eaten, so numbers would rise. For humans, commercial whaling seemed like a win-win: it provided whale meat and other by-products, while also promising an increase in fish stocks for future catches. The hunt was highly successful but ultimately pushed whale populations to the brink of extinction.

Interestingly, the anticipated increases in fish and plankton populations did not materialise, leading to the realisation that we had fundamentally misunderstood the relationship between whales

and their food sources. It turns out that the opposite is true: in oceans where whales are protected and their populations recover, both plankton and fish numbers also increase. The plant component of plankton relies on nutrients like nitrogen and iron, which are plentiful in whale faeces. Without whale faeces, plant plankton cannot thrive; without plant plankton, animal plankton cannot survive. Therefore, the presence of whales influences the entire food chain.

Equally remarkable is the whale's impact on the carbon cycle. Phytoplankton, which flourishes due to the nutrients provided by whale faeces, contains chlorophyll and uses sunlight to convert carbon dioxide and water into glucose and oxygen. This process is crucial for generating a significant portion of the Earth's atmospheric oxygen—approximately 50 percent globally. Additionally, whales sequester up to 33 tonnes of CO₂ in their bodies over their lifetimes. Upon their death, this carbon sinks to the seabed, where it remains sequestered for centuries, keeping it out of the atmosphere.¹⁷ Little by little, we better understand these regenerative relationships in nature, but we are only at the beginning of understanding this Circle of Life.

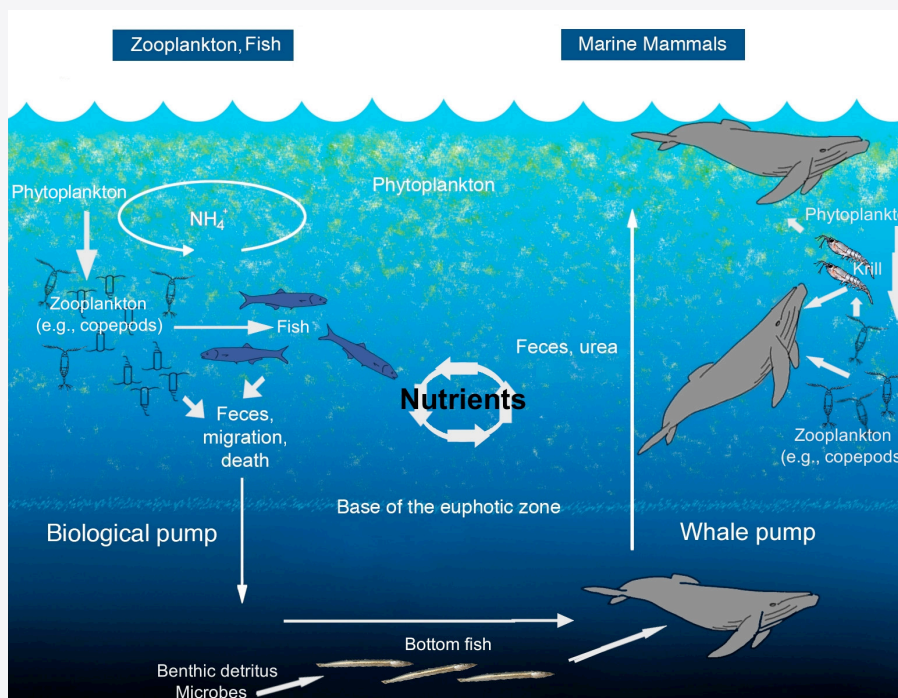
Let's revisit the surprising developments in science and explore a few examples. For years, scientists have been working to understand whales more deeply, and they are now entertaining the possibility that we could engage in fluid conversations with them within a few years. More precisely, artificial intelligence might be able to facilitate such interactions. This so-called Whale.AI could

¹⁶Lavery, T. J. et al. (2014, 6 May). Whales sustain fisheries: Blue whales stimulate primary production in the Southern Ocean. *Marine Mammal Science*, 30 (3), 888-904. <https://onlinelibrary.wiley.com/doi/abs/10.1111/mms.12108>

¹⁷Chami, R. et al. (2019, December). Nature's solution to climate change. IMF. <https://www.imf.org/en/Publications/fandd/issues/2019/12/natures-solution-to-climate-change-chami>

potentially offer even greater insights into the workings of the whales' ecosystem—provided it genuinely listens and understands.

Scientists totally misunderstood whales.
New insights forced them to adjust their worldview.



Meanwhile, initial tests have begun. Just as we've used Large Language Models (LLMs) like ChatGPT and Claude to decode human language, similar technology is now being applied to decipher animal communication. This effort falls under the scope of the start-up Earth Species Project (ESP). Expectations are high that, within three to five years, we may be able to engage in fluid conversations with animals.¹⁸ The ESP has several databases, including one with over a million sound recordings from 28,000 different animal species. They have developed a foundational model—a GPT (Generative Pre-trained Transformer) tailored for the animal domain—that has shown promising results and is being tested across a variety of species. In May 2024, it was revealed that whale communication is even more complex than previously believed. Researchers at Carleton University in Ottawa have created a kind of phonetic alphabet used by whales. Over a 15-year period, they analysed thousands of hours of vocalisations from 60 different sperm whales. These vocalisations, known as codas, have been catalogued with the aid of artificial intelligence. The study revealed that these codas consist of building blocks that can be combined in numerous ways, leading to a broader range of communication types than previously thought.¹⁹

¹⁸Rutz, C. et al. (2023, 14 July). Using machine learning to decode animal communication. *Science*, 381(6654). https://pure.mpg.de/rest/items/item_3517984_6/component/file_3519870/content

¹⁹Moran, P. (2024, 16 May). What are whales saying to each other? Scientists are a step closer to finding out. *CBC*. <https://www.cbc.ca/radio/thecurrent/sperm-whale-communication-1.7205012>



Animals-AI-ethics?

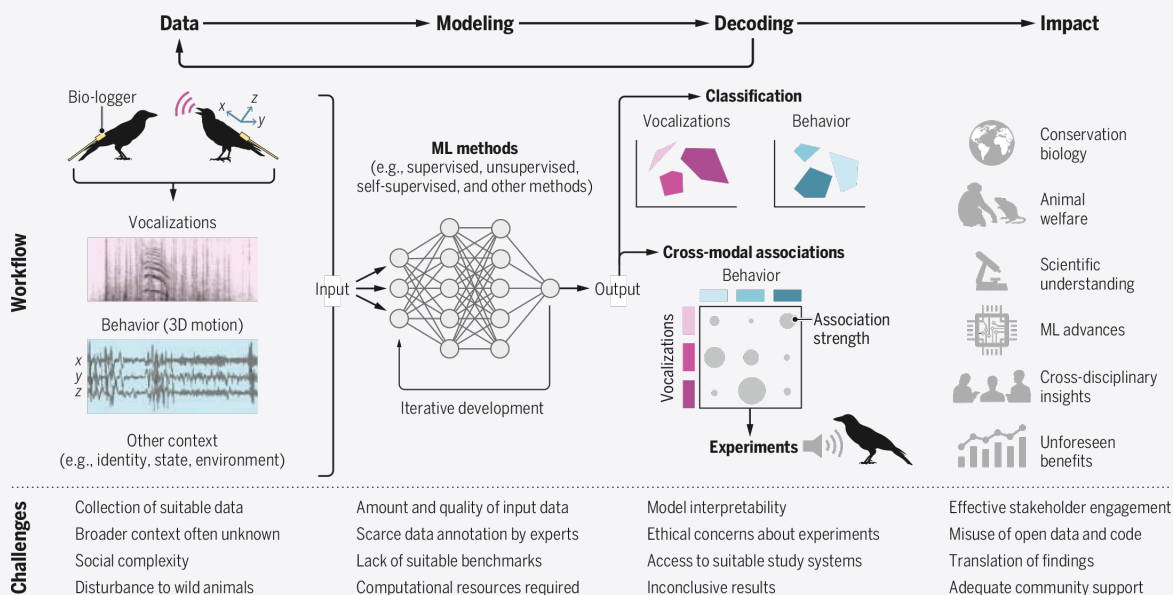
The ESP was also criticised when researchers played back sounds of whales underwater to see how the animals would react. When one of the whales showed restless and atypical behaviour during the playback, they looked closely at the data again. It turned out that they were playing back the name of this particular whale. The animal was repeatedly called, which caused it distress.

SPECIAL SECTION

A MACHINE-INTELLIGENT WORLD

Using multimodal data and experiments to understand animal signals

Machine-learning (ML) methods can be used to integrate information on sender, receiver, and communication context, revealing patterns that may inform hypotheses about signal function and, in turn, the design of controlled experiments. ML-assisted research on animal communication will likely generate important benefits, such as improving animal conservation and welfare, but is not without its challenges; addressing ethical concerns is a top priority.



This roadmap, detailed in the journal Science, outlines the ESP's approach. The initial phase, which involves gathering data, is crucial to the process. Using various machine learning techniques, basic models are developed to enhance our understanding of animal communication. The roadmap aims to achieve five key goals: advance scientific knowledge, foster interdisciplinary collaboration, improve machine learning methods, contribute to conservation efforts, and enhance animal welfare.



More data, more insights

ESP examines not only animal sounds but also behaviour. By integrating both sound and behaviour, they can extract more meaning from animal communication. This multimodal approach is outlined in the roadmap published by ESP in *Science*.

Protect ecosystems with geo-AI

While an AI conversation with animals seems promising, AI is already being used in other ways for ecosystem conservation. In Northern Alberta, Canada, a group of indigenous elders, knowledge keepers and fur hunters have formed a non-profit organisation (ShagowAskee) that collects traditional knowledge and uses it to protect their habitat, their forests and the animals that live there (such as this endangered Wabasca wood buffalo²⁰).

Or, in their own words:

‘We want to protect the Land, the Trees, the Forest for another 100 years so our next generations, them too, will benefit from what we had benefited before. We were given the Land to use. Whatever Life that is within, should be protected. By protecting the animals, we protect the forest. By protecting the forest, we protect the water and the air we all use. The only way it will work is if we work all together’.

²⁰This is a rare subspecies of bison. The original habitat of this subspecies, the *Bison bison athabasca*, was further north, in the Canadian forests. The species lives in smaller groups and the animals are heavier than normal bison.

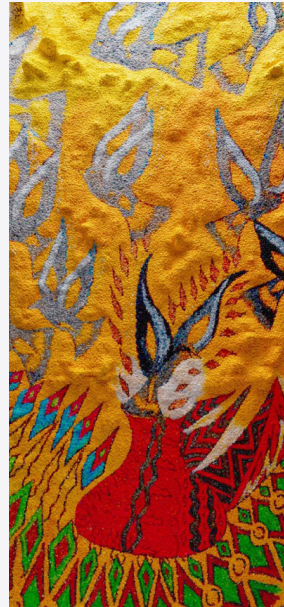
'It is one thing to talk about how much logging and other business practices affect the land and the forest bison herd living there,' says Sugu Thuraisamy, managing director at ShagowAskee.

'Being able to visualise and quantify the effects on a specific habitat is an entirely different thing.

Without this approach, the case for meaningful policy and practical change becomes far less compelling. Our goal is to provide policymakers, operators, and communities with clear evidence of how these habitats have evolved over time and how they continue to change today.'

By using Geo Satellite Intelligence and AI, they are now visualising and analysing the degenerative impact of logging and forest fires since the 1980s. Armed with this evidence, ShagowAskee is advocating for more responsible forestry practices that respect the ecosystem, ensuring that future generations can also benefit from these natural resources. The technology isn't an end in itself, but rather a tool that supports their mission to promote ecologically responsible policies by providing clear, actionable evidence of changes in the landscape.²¹

The project is part of a growing movement within AI ethics known as Indigenous AI. This movement explores how Indigenous knowledge systems and worldviews can enrich global conversations about society and AI. It seeks to expand the discourse around the role of technology, moving beyond the culturally narrow perspectives often found in Silicon Valley's research labs and start-up ecosystems. Central to Indigenous AI is imagining a future where AI contributes to the well-being of both humans and non-humans²², aligning closely with the principles of regenerative intelligence and sustainable co-existence.



Indigenous AI art

Shown here is a still from a moving AI artwork by Refik Anadol and the Yawanawá community. The artwork combines weather data from the indigenous Yawanawá community's Brazilian village with the art of a young group of Yawanawá illustrators who work in their traditional indigenous art style.²³

Eco-engineering with NI and AI

Eco-engineering focuses on designing, developing and managing systems that use and support natural ecosystems to solve environmental problems. It combines principles from ecology, environmental science and engineering to create sustainable solutions that promote the health of both the natural environment and human society. The goal of eco-engineering is to work with nature rather than against it, creating more sustainable and resilient solutions.

²¹Sogeti (2024). ShagowAskee protects the wood buffalo with an eye in the sky. <https://www.sogeti.com/why-us/proven-expertise/shagowaskee/>

²²Suhairk (2024, 8 July). Indigenous frameworks for AI. <https://suhairk.substack.com/p/indigenous-frameworks-for-ai>

²³Sharma, M. (2023, August 7). Refik Anadol collaborates with Yawanawá community to create 'Winds of Yawanawa'. Stir World. <https://www.stirworld.com/see-features-refik-anadol-collaborates-with-yawanawa-community-to-create-winds-of-yawanawa>



For instance, the Pacific oyster is helping us out in two ways. We once introduced this exotic species to the Netherlands after the flat oyster became virtually extinct due to intensive fishing. The Pacific oyster turns out to be much more resistant to the warming water.

The introduction of this exotic species also seems to lead to greater biodiversity, though this outcome is more a matter of luck than intentional planning²⁴. Now these oysters are also being used to combat rising sea levels. A 'sea wall' built of Pacific oysters is more resistant to storms. A storm surge might damage a traditional sea wall, but the natural sea wall grows back²⁵. We don't have to do anything about that, after all, nature works regeneratively.

Traditional techniques can be expensive, often temporary (such as beach sand replenishment), and frequently have negative impacts on ecosystems and biodiversity. In contrast, the Pacific oyster avoids these drawbacks. Eco-engineering becomes even more compelling when combined with AI. Design firms like Maket from Canada are using generative AI to create nature-based solutions. For example, they aim to design green roofs with the optimal mix of vegetation and soil that can adapt to varying weather conditions, optimise resource use like water and energy, and reduce the carbon footprint of buildings.

²⁴Ysebaert, T., Walles, B., Haner, J., & Hancock, B. (2019). Habitat modification and coastal protection by ecosystem-engineering reefbuilding bivalves. In: A. C. Smaal, J. G. Ferreira, J. Grant, J. K. Petersen & Ø. Strand (Eds.), Goods and services of marine bivalves (pp. 253-273). Springer.

²⁵Morris, R. L., et al. (2018). From grey to green: Efficacy of ecoengineering solutions for nature-based coastal defence. *Global Change Biology*, 24(5), 1827-1842.

2.4 The life cycle of humans

Our own life cycle is actually not that different from that of the *Leucoagaricus* fungus we talked about earlier. Like the *Leucoagaricus*, we function thanks to living material that is not our own.

The human body is a walking ecosystem, hosting an array of single-celled organisms, fungi, and bacteria that live on our skin, in our mouths, and throughout our digestive systems. Remarkably, these microbial cells outnumber our own. On average, the human body comprises around 69 trillion cells, with a roughly equal split between human and non-human cells. However, when it comes to DNA, the ratio shifts dramatically—human DNA accounts for only one five-hundredth of all the genetic material within us. This DNA is the hereditary material that stores our collective knowledge and experience, acting as the database for the human operating system. This database doesn't just include human knowledge, but also

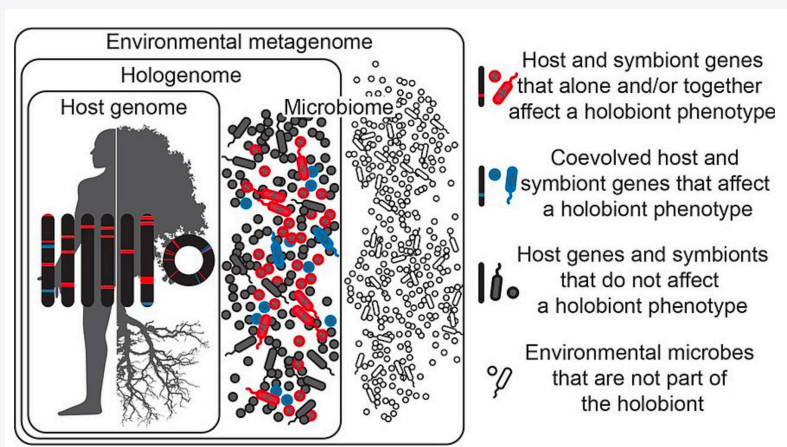
the genetic information of countless other life forms. Researchers studying this often refer to 'the host'—that's us, the body that accommodates a vast array of other life forms known as the 'microbiome.' The human microbiome is best understood as an additional organ. While earlier research focused on its role in immunity, disease, and nutrition, recent studies have expanded to explore its connection to mental disorders like ADHD and Alzheimer's, as well as cognitive function. Some even refer to the microbiome as our 'second brain.' This 'second brain' is composed of cells similar to the neurons in our brains. Through the vagus nerve, a major cranial nerve, the gut's nervous system is directly connected to the central nervous system in our brain, enabling a continuous exchange of information between our intestines and our brain.





AI accelerates our knowledge

Research into all these cross-links and causal relationships is extremely complex and cannot really be done without artificial intelligence. From DNA sequencing that decodes the blueprint of life to ‘shotgun metagenomic sequencing’ that can instantly identify the components of your microbiome, AI has become indispensable. What once was a laborious and time-consuming process—cultivating bacteria in petri dishes for analysis—now happens at lightning speed thanks to AI. In the academic paper ‘Metagenomics and artificial intelligence in the context of human health’²⁶, we read about the importance of AI in discovering relationships between health and ‘nature’. For instance, the use of AI within the fledgling field of ‘metagenomics’ has accelerated research into chemicals in relation to our food chain. We now know that preparing food in a pan with a non-stick coating of PFAS is unhealthy. However, we consume the largest amounts - which can be really harmful - through drinking water. Several studies show that the microbiome changes its composition due to overexposure to PFAS.²⁷ A possible consequence of that exposure is an excessive concentration of the *Methanobrevibacter* bacterium, which has been linked to diseases such as MS and obesity.



The sum of the DNA material of the host (in this case, humans) and the microbiome is called ‘hologenome’. Completing the picture is the metagenome, which exists beyond our body.

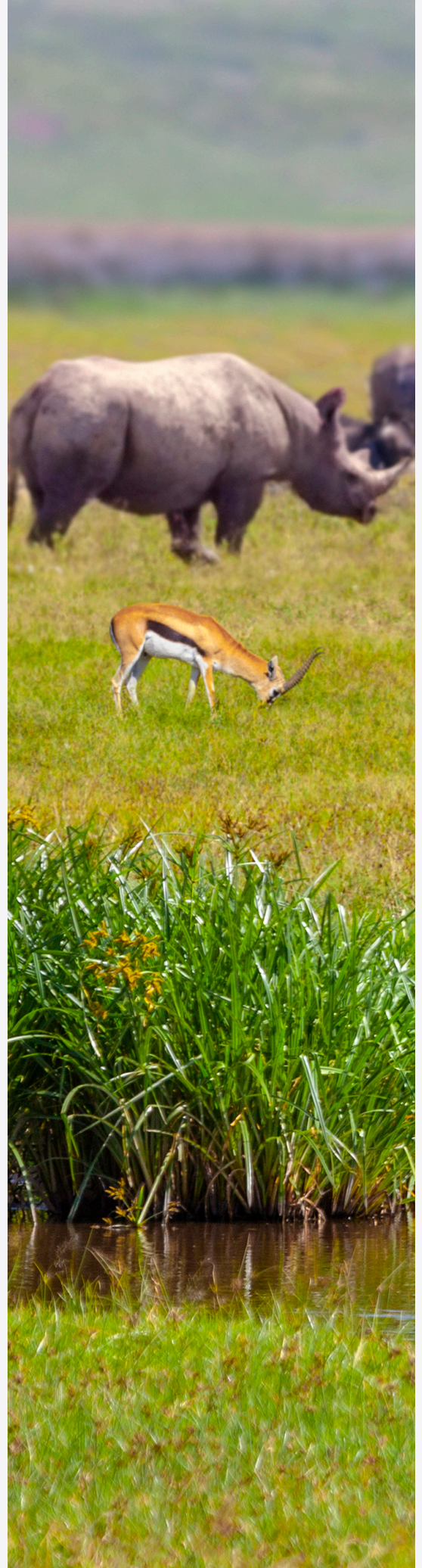
²⁶Wani, A. K., Roy, P., Kumar, V., & ul Gani Mir, T. (2022, 12 March). Metagenomics and artificial intelligence in the context of human health. *Infection, Genetics and Evolution*, 100(June 2022), 105267. <https://www.sciencedirect.com/science/article/pii/S1567134822000648>

²⁷Lamichhane, S., Härkönen, T., Vatanen, T., Hyötyläinen, T., Knip, M., & Orešič, M. (2023, 19 May, Impact of exposure to per- and polyfluoroalkyl substances on fecal microbiota composition in mother-infant dyads. *Environment International*, 176(June 2023), 107965. <https://www.sciencedirect.com/science/article/pii/S0160412023002386>

Although this kind of research is still in its infancy, scientists are sounding the alarm. A similar situation arises in the case of glyphosate, a well-known herbicide. But it is also found in cotton clothes, tampons and baby nappies, for example.²⁸ Canadian scientists link the significant increase in depression to the explosion in glyphosate use. They are advocating for a long-term study to specifically examine the effects of glyphosate on the microbiome. Glyphosate is already known to induce parkinsonism in mice, and research shows that the microbiome of Parkinson's patients differs from that of non-Parkinson's individuals. Additionally, glyphosate impacts the microbiome of plants. In summary, while a great deal is known about glyphosate's effects, further research is needed to fully understand its impact on microbiomes. This led to 156 scientists, including neurologists, evolutionary biologists and toxicologists, sending an urgent letter to the Dutch government.²⁹ The letter called for serious consideration of the scientific evidence and urged a vote against extending the approval of glyphosate in Europe for another 10 years on November 16, 2023. Despite this appeal, the decision was made to continue the use of glyphosate.

²⁸See: Medisch Dossier (2021, 23 November). Pathogenic weedkiller. <https://medischdossier.org/archief/ziekmakende-onkruidverdelger/> Also see: Shearston, J. A., Upson, K., Gordon, M., Do, V., Balac, O., Nguyen, K., Yan, B., Kioumourtzoglou, M.-A., Schilling, K. (2024, 3 juli). Tampons as a source of exposure to metal(loid)s. *Environment International*, 190(August 2024). 108849. <https://www.sciencedirect.com/science/article/pii/S0160412024004355>

²⁹Rozemuller, A. et al. (2023, 13 November). Neem de onafhankelijke wetenschap serieus bij het besluit over glyfosaat. [Letter]. <https://www.pan-netherlands.org/wp-content/uploads/2023/11/brandbrief.pdf>



Below, we quote from the letter in question:

‘Residues of glyphosate may also affect bacteria in people’s lungs and intestinal flora. This can reduce immunity, increasing susceptibility to disease. It is also possible that such impairment of gut flora could lead to a cascade of neurodegenerative processes. These negative effects on the gut microbiome and overall health have also been shown in independent studies of honeybees and birds.’

What it could also potentially lead to is us becoming collectively dumber. Researchers at the universities of Mannheim and Baltimore have shown a relationship between the composition of intestinal flora and children’s IQ.²⁹ A strong correlation was found between intestinal flora and IQ scores, specifically linked to a particular bacterium from the Enterobacteriaceae family.

Research from Xi’an Jiaotong University in China explored the relationship between the microbiome and intelligence in adults.³⁰ Over 18,000 people participated in the study, which yielded interesting results. For instance, it showed that an excess of a particular bacterium, in this case the Oxalobacter, was found to have a lower IQ. An excess of the Fusicatenibacter correlated with a higher IQ and a larger brain.

³⁰Streit, F. et al. (2021, 20 August). Microbiome profiles are associated with cognitive functioning in 45-month-old children. *Brain, Behavior and Immunity*, 98(November 2012), 151-160. <https://www.sciencedirect.com/science/article/pii/S0889159121002919>

³¹Yao, S. et al. (2023, 15 May). Mendelian Randomization analyses identify causal associations of human gut microbiome composition on intelligence. *MedRxiv*. <https://www.medrxiv.org/content/10.1101/2023.05.11.23289760v1.full.pdf>

Are we becoming infertile?

While the reports can be alarming, there's often a moment of grim amusement when it becomes clear how little we truly understand nature. Take microplastics, for example. It has recently been revealed that these tiny particles are present in human testes and have been linked to a 50 percent reduction in male fertility in the United States.³² It may come as a surprise that plastic has such an impact on our Circle of Life, but it's not unexpected. What results in diseases, lower IQ, or infertility begins with the contamination of our food and water sources. Humans are integral parts of the food chain and ultimately reflect the consequences of pollutants traveling from soil to plate.

Nature also reveals its ingenuity in the context of microplastics. Japanese researchers discovered a bacterium on a landfill that can consume plastic bottles.³³ The bacteria's plastic hunger may well be the solution to one of the biggest problems we face today. Kohei Oda is the microbiologist who led the Japanese research into the bacteria. He argues that whatever scientific problem you want to tackle, you need to look at microbes first. After all, they possess billions of years of experience and have most likely already come up with a solution.



'I say to people, watch this part of nature very carefully. It often has very good ideas.'

Kohei Oda

AI's potential for innovation is further demonstrated by recent news from the University of Texas. Researchers there, with the aid of AI, have developed an enzyme capable of digesting plastic, similar to the way the Japanese bacterium on the landfill breaks down plastic bottles, but with increased efficiency and at lower temperatures.³⁴

In the next chapter, our exploration of natural and artificial intelligence continues. Intuitively, when we think of intelligence in nature, we do not immediately think of an ecosystem but much rather of an intelligent species such as the monkey or perhaps our own dog. A common mistake is projecting our own intelligence onto other life forms. This tendency limits our understanding, as we often overlook the unique forms of intelligence inherent in different species, resulting in a narrow view of what intelligence truly encompasses.

³²Levine, H. (2022, 15 November). Temporal trends in sperm count: a systematic review and meta-regression analysis of samples collected globally in the 20th and 21st centuries. *Human Reproduction Update*, 29(2), 157-176. <https://academic.oup.com/humupd/article/29/2/157/6824414?login=false>

³³Buranyi, S. (2023, 28 September). 'We are just getting started': the plastic-eating bacteria that could change the world. *The Guardian*. <https://www.theguardian.com/environment/2023/sep/28/plastic-eating-bacteria-enzyme-recycling-waste>

³⁴Vetter, D. (2022, 29 April). This AI-Designed Enzyme Can Devour Plastic Trash In Hours: Video. *Forbes*. <https://www.forbes.com/sites/davidrvetter/2022/04/28/scientists-use-ai-to-make-an-enzyme-that-eats-plastic-trash-in-hours-video/>



Conclusion

1. Interdependence in nature. Natural ecosystems function through complex networks of interdependence, with each organism, from phytoplankton to whales, playing a crucial role in maintaining the balance of the ecosystem.

2. Holistic view of ecosystems. In line with Aristotle's philosophy, a holistic approach is needed to understand nature. This means looking at ecosystems as a whole and appreciating the relationships between different components rather than studying them in isolation.

3. Regenerative relationships in nature. Natural systems have built-in mechanisms to repair and regenerate themselves. Whales, for example, play a crucial role in promoting plankton production and CO₂ uptake, which not only promotes their own survival but also that of other species and benefits the climate.

4. Learning from natural intelligence for human innovation. Understanding natural intelligence, such as how fungi and ants work together or how the whale contributes to the ecosystem, provides new insights that can be applied to human technologies and systems. This should lead to more sustainable and resilient solutions.

Case Study

Interface: Regenerative Business in Commercial Flooring

In an era where businesses are increasingly challenged to address climate change, Interface, a \$1,3 billion commercial flooring company, has demonstrated that a commitment to ecological restoration can coexist with profitability. Through innovative strategies, circular design, and a bold vision, Interface has redefined what it means to be a regenerative enterprise.

Regeneration: The Interface Story

Interface's journey began with its Mission Zero initiative, which set an ambitious goal to eliminate the company's negative environmental impact by 2020. Achieving this milestone, the company shifted its focus to becoming a net-positive organization through its Climate Take Back program. This initiative goes beyond reducing harm; it aims to restore ecosystems and reverse global warming. Central to Interface's strategy is the integration of regenerative principles into every aspect of its business. By adopting circular economy practices and prioritizing biomimicry, Interface designs products and systems inspired by nature, creating value while contributing to ecological health.

Regenerative Innovations in Flooring

Interface has pioneered the use of carbon-negative materials, transforming flooring into a tool for climate action. Its innovative carpet tiles, such as

the "Carbon Neutral Floors" line, are produced with materials that store more carbon than they emit. These products leverage recycled materials and bio-based inputs to minimize environmental impact while delivering high-quality flooring solutions. A standout innovation is the company's backing layer, CQuest™Bio, which incorporates carbon-negative materials such as bioplastics and biochar. This advancement not only reduces the carbon footprint of Interface's products but also exemplifies how industrial processes can contribute to climate solutions.

Circular Economy at Scale

Interface's commitment to regeneration extends to its embrace of the circular economy. The company actively promotes recycling and repurposing through its ReEntry program, which collects used carpet tiles from customers and transforms them into new products. This closed-loop system reduces waste, conserves resources, and aligns with Interface's vision of a restorative business model. In addition to product recycling, Interface prioritizes the durability and modularity of its flooring solutions. By designing products for easy replacement and reuse, the company reduces the need for frequent production and minimizes resource consumption over the product lifecycle.

Regenerative Thinking Across the Supply Chain

Interface's regenerative ethos is evident throughout its supply chain. The company works closely with suppliers to ensure that raw materials are sourced responsibly and sustainably. For example, Interface collaborates with fishing communities to repurpose discarded fishing nets into carpet yarn through its Net-Works™ program.

This initiative not only prevents ocean pollution but also supports local economies and fosters social equity.

Measuring Impact: Transparent and Tangible Results

Interface's commitment to regeneration is underpinned by robust measurement and transparency. The company conducts life cycle assessments (LCA) to evaluate the environmental impact of its products and operations. These assessments inform decision-making and ensure alignment with regenerative principles. Through its annual sustainability reports, Interface shares progress toward its Climate Take Back goals, offering stakeholders clear insights into the company's achievements and challenges. This transparency fosters trust and inspires others to adopt similar practices.

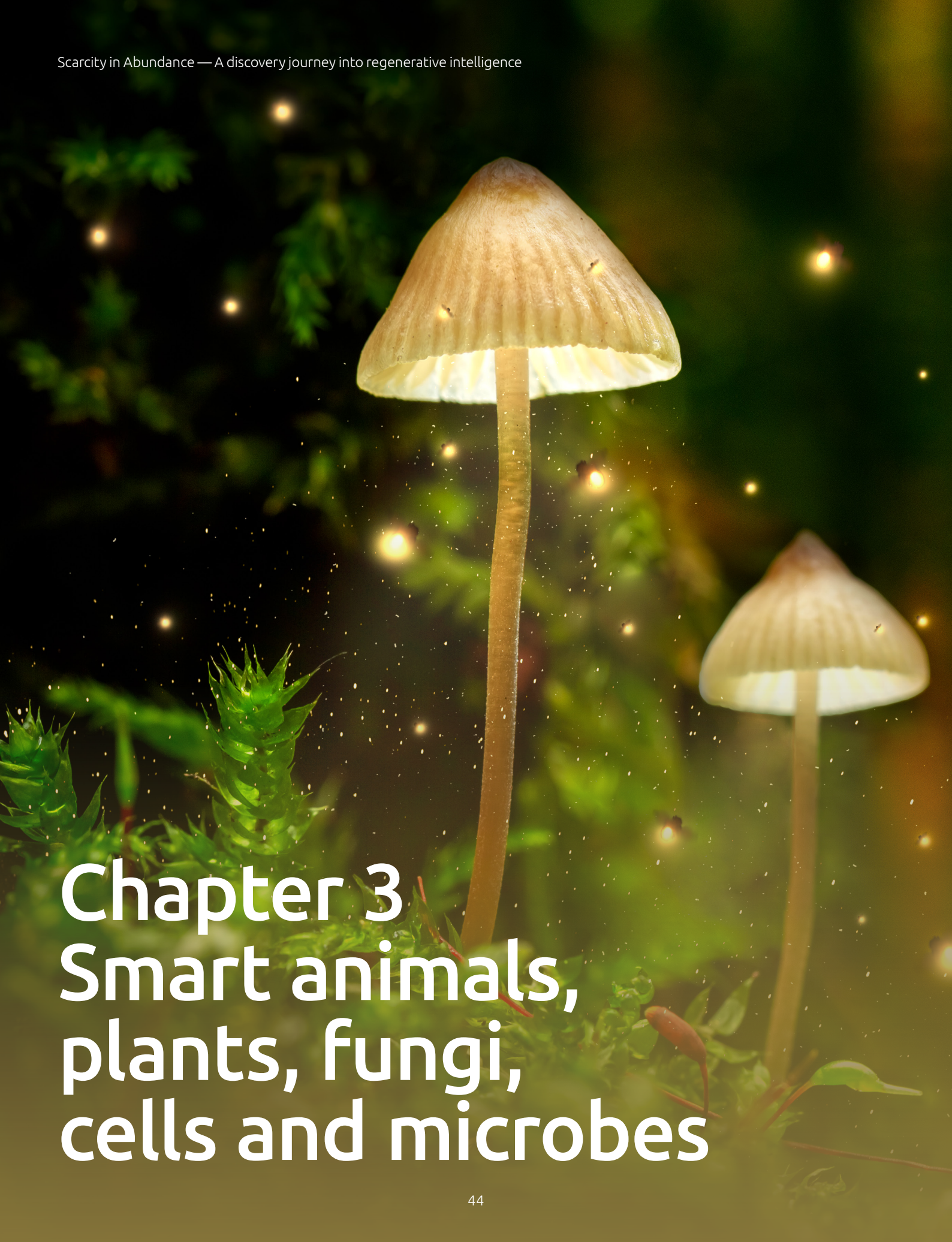
Leadership in the Regenerative Economy

As industries transition toward a regenerative economy, Interface serves as a powerful example of what is possible. The company's innovations, partnerships, and vision demonstrate that businesses can play a transformative role in addressing global challenges. By prioritizing regeneration, Interface has proven that businesses not only have the power to minimize harm but also to actively repair and renew the systems on which they depend.

Inspiring a Regenerative Future

Interface's journey illustrates the transformative potential of regenerative intelligence in business. By embracing circular design, carbon-negative materials, and restorative practices, the company exemplifies the future of commerce in harmony with nature. As we explore pathways to a regenerative economy, Interface stands as a beacon of what is possible when innovation, purpose, and ecological stewardship converge.



A photograph of a forest floor at night. In the center, a tall, slender mushroom with a light-colored, ribbed cap and a thin stem stands prominently. To its right, a smaller, similar mushroom is visible. The background is dark, with green foliage and numerous small, glowing yellow lights, possibly fireflies or bioluminescent fungi, creating a magical atmosphere. The overall lighting is warm and ethereal.

Chapter 3

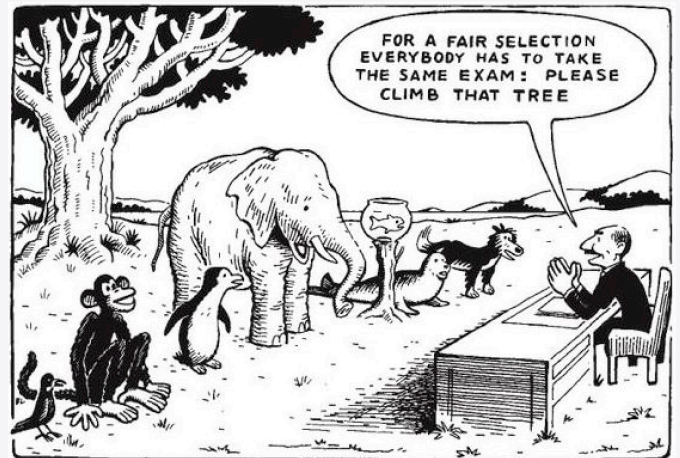
Smart animals, plants, fungi, cells and microbes

‘We all believe that our brains and nervous systems are the seat of cognition, but the fact is that biology was doing memory, learning, problem-solving and decision-making long before brains and neurons evolved. We now know that single-celled organisms – slime moulds, yeasts, plants, bacterial biofilms – are able to make decisions to anticipate future events in their environment from a history of past experiences.’

Michael Levin

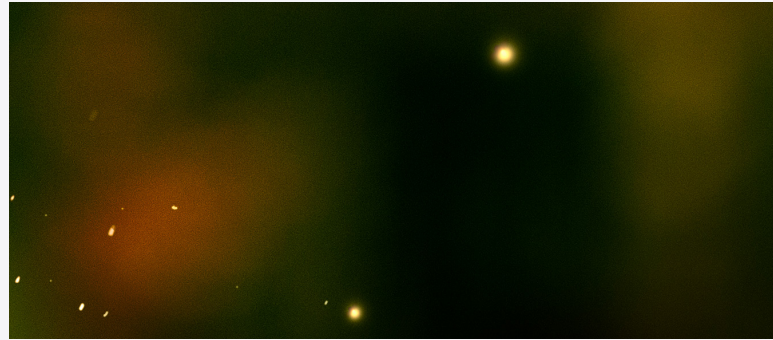
In this chapter, we explore the world of different organisms—such as a squid, a tomato plant, or an elephant fish—by stepping into their ‘Umwelt.’ The concept of Umwelt, proposed by biologist Jakob von Uexküll (1864-1944), suggests that each animal exists within its own unique perceptual world. Some animals navigate primarily through smell while living underground, while others rely on ultrasonic sound as they fly through the air. Empathising with such radically different forms of perception is incredibly challenging. Uexküll was the first to highlight that every living organism perceives the world in its own unique way. He suggested that we can gain a deeper understanding of life on Earth by immersing

ourselves in the perspective of other species. Think of it as a testing ground for the future, where we create not only artificial human intelligence, but also non-human artificial intelligence. Imagine if we could perceive the world through the eyes of an elephant fish. Or consider the insights we might gain from understanding how plants ingeniously and efficiently convert sunlight into energy. Such knowledge could revolutionize our approach to many challenges. Similarly, ‘bio-inspired’ algorithms, which draw inspiration from the intelligence of organisms like slime molds—despite sounding unconventional—could lead to innovative solutions, as these organisms exhibit problem-solving abilities akin to those of engineers.



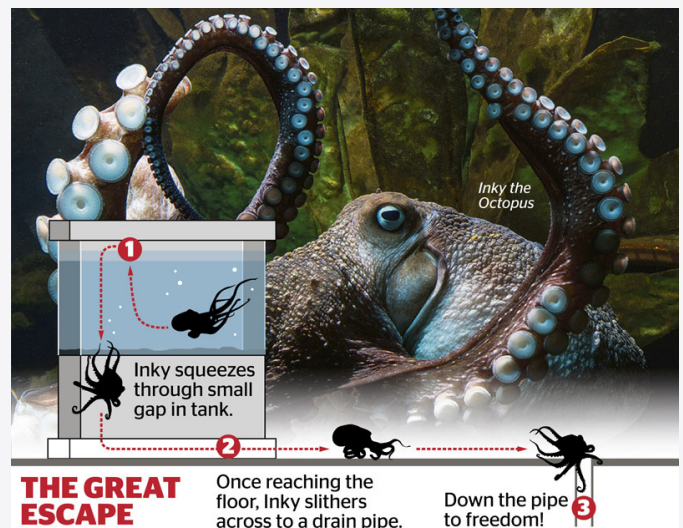
Even when it comes to intelligence, we should not ask: can you think like me? But: what is it like to think like you?

Nature exhibits intelligence in ways distinct from human cognition. Biologist Frans de Waal has dedicated his career to exploring how we often overestimate human intelligence compared to that of animals. We tend to assess animals based on whether they resemble us, but we should instead ask, 'What is it like to be you?' This narrow perspective became evident when gibbons were found to be as intelligent as other monkeys, yet were long considered as the dumbest of the group because they couldn't perform the same tasks. Researchers initially overlooked the fact that gibbons live high in the trees and not on the ground like other monkeys. When intelligence tests were adapted to their arboreal environment, gibbons demonstrated comparable cognitive abilities. De Waal humorously noted that many animal experiments reveal more about human misunderstanding than about the animals' intelligence. A renowned biologist specialising in ethology and primatology, De Waal wrote the book *Are We Smart Enough to Know How Smart Animals Are?* In it, he explores questions such as whether chimpanzees understand honesty, if birds can infer what other birds know, and whether rats experience empathy. De Waal concludes that we can indeed gauge animal intelligence if we overcome our scepticism and remain open to different forms of cognition.



3.1 Step into the other's Umwelt for a change

In 2016, scientists at the National Aquarium of New Zealand were puzzled. Inky, an octopus in their care facility, had made a spectacular escape. He had climbed out of his tank, squeezed through a small opening and fled to the ocean through a drainpipe. What puzzled investigators even more was the apparent planning behind Inky's escape. He had waited for the guards to leave, had used tools to facilitate his escape and had even left an errant trail as a diversion.



While the limitations of our understanding are becoming increasingly apparent, scientific research has revealed the opposite trend regarding animal intelligence: many animals are now recognised as being more intelligent than previously thought, even if their intelligence manifests differently from human cognition. Just a few decades ago, it was a widespread belief that animals could not experience pain or emotions—that the mind was an exclusive human domain, and genuine thought was considered impossible for animals. Animals were viewed merely as action-reaction machines. Researchers who discussed animal cognition or emotions were often dismissed as projecting human traits onto them. However, through meticulous study, advocacy, and experimentation, there has been a significant shift in our understanding of animal intelligence and emotional capacity.

Animals such as dolphins, great apes, and ravens are now recognised as being far more intelligent than previously believed. This intelligence encompasses a wide range of abilities, including empathic intelligence. For example, you might be familiar with Frans de Waal's experiment involving capuchin monkeys, which highlighted their capacity for empathy and social understanding.³⁵ Two capuchin monkeys are given a simple task: they have to pick up a pebble in their cage and hand it to the researcher. As a reward for this, they are given a slice of cucumber. Time and again, the monkeys eagerly accept cucumbers and seem content with the reward. However, when one monkey receives a sweet grape instead of a cucumber, the other

monkey becomes visibly upset upon receiving only the cucumber. It reacts by throwing the cucumber back at the researcher in frustration and then strikes the wall with the pebble it is holding, as if trying to understand whether the injustice is related to the pebble. It is evident to observers that something intelligent and complex is occurring in the brain and perception of this little monkey.

Electric boogie-woogie senses

Picture yourself in the world of the elephant fish, an extraordinary creature that we have only recently begun to understand. The fish 'dances' to perceive its environment and can even 'see' what other fish see. It has receptors in its skin that allow it to communicate via electrical signals.



The fish also uses movements such as spinning, pacing back and forth and swaying to perceive objects by interpreting changes in the electric field around it. It is essentially an electric boogie-woogie, *Scientific American* jokes.³⁶ This allows them to

³⁵TED Blog Video (2013, 4 April). Two Monkeys Were Paid Unequally: Excerpt from Frans de Waal's TED Talk. [Video]. YouTube. <https://www.youtube.com/watch?v=meiU6TxysCg>

³⁶Brown, E. A. (2023, 6 November). Elephantnose Fish 'Sees' by Doing an Electric Boogie. *Scientific American*. <https://www.scientificamerican.com/article/elephantnose-fish-sees-by-doing-an-electric-boogie/>

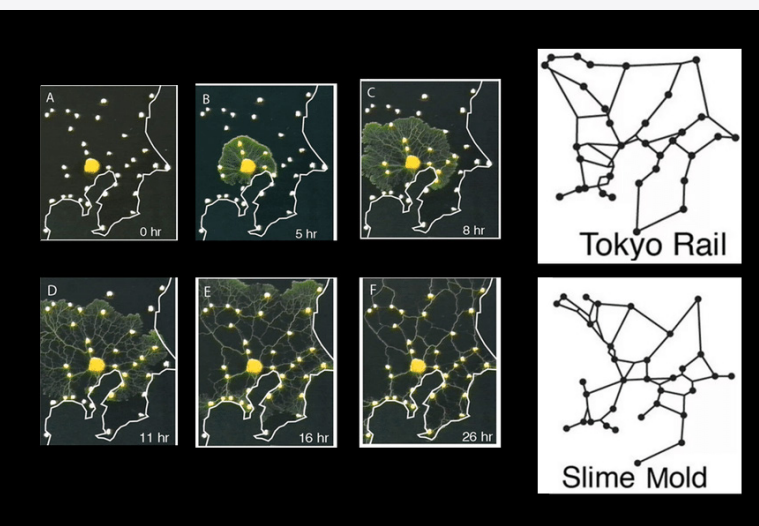


explore their often dark and murky surroundings. The researchers suspect that elephant fish developed traits during their evolution that allow them to collectively detect objects or other organisms from greater distances better than an individual fish could.³⁷ Research showed that the fish's electro-sensory systems responded to their own signals and those of other individuals. They also responded to simulated signals in the lab. Collectively, they were up to three times (!) better at detecting obstacles. This is similar to being able to see through each other's eyes ... It is a form of swarm intelligence, or collective perception, as the researchers called it.

Intelligence without brains

The slime fungus *Physarum polycephalum* stretches our understanding of intelligence by showing that complex, adaptive behaviour is

possible without a brain or even a nervous system. Two landmark studies on this organism show that intelligence can be much more fundamental than we once thought. At Hokkaido University in Japan, *Physarum polycephalum* showed an astonishing ability to create complex networks without any form of central control. Researchers placed oat flakes, the favourite food of this slime fungus, in a pattern that corresponded to the main cities around Tokyo. Within 26 hours, the slime mold had created a network that was remarkably similar to the existing railway system. This network proved not only efficient in connecting the 'cities', but also remarkably resilient. The slime fungus first built a fine network and then expanded and strengthened it, similar to how engineers would design a transport system. This experiment demonstrates that intelligent optimisation and problem solving are possible without the presence of a brain. The slime fungus created an efficient and resilient network, similar to the work of experienced human engineers, but without any conscious planning. A complementary study, conducted at the Centre de Recherches sur la Cognition Animale in Toulouse, shows that the same slime fungus species can learn from experience despite the lack of a nervous system. In a nine-day experiment, specimens of *Physarum polycephalum* were required to cross a bridge coated with a harmless but bitter substance in order to reach their food. Initially, the slime molds were reluctant, but as the experiment progressed, they learned that the substance was harmless. After six days, they moved across the bridge with the bitter substance as fast as other



³⁷Pedraja, F. & Sawtell, N. B. (2024, 6 March). Collective sensing in electric fish. *Nature*, 628, 139-144. <https://www.nature.com/articles/s41586-024-07157-x>

slime moulds moved across a bridge without the substance. This adaptability, a core aspect of intelligence, was exhibited by an organism without neurons or synapses.

Animal intelligence is one thing; consciousness represents an entirely different level of complexity. In April 2024, dozens of scientists signed the New York Declaration on Animal Consciousness.³⁸ In it, they argue that there is 'at least the realistic possibility' of conscious experience in all vertebrates and invertebrates, including at least squids, crustaceans and insects. The scientists stress that the presence of consciousness in animals cannot be separated from how we treat them. One of the studies the scientists cite is that on bumblebees and their play behaviour. In an experimental setting, they examined whether bumblebees would roll small wooden balls without extrinsic rewards. The behaviour fully met the definition of 'play' and the researchers even observed that young bumblebees showed more play behaviour than older ones. This behaviour is often observed in humans and other mammals, but we mention it once more, now this playful behaviour has also been observed in insects.

³⁸Andrews, K. et al. (2024). The New York Declaration on Animal Consciousness. <https://sites.google.com/nyu.edu/nydeclaration/declaration>



3.2 Plants with learning ability and memory

Plants appear to be capable of complex interactions with their environment, such as recognising related plants, responding to sounds and storing memories that affect their life cycle. Although some scientists are reluctant to use terms like 'intelligence' and 'consciousness' when it comes to plants, the growing evidence suggests that plants may have developed a parallel system of intelligence, admittedly different from that of animals, but nevertheless just as impressive.

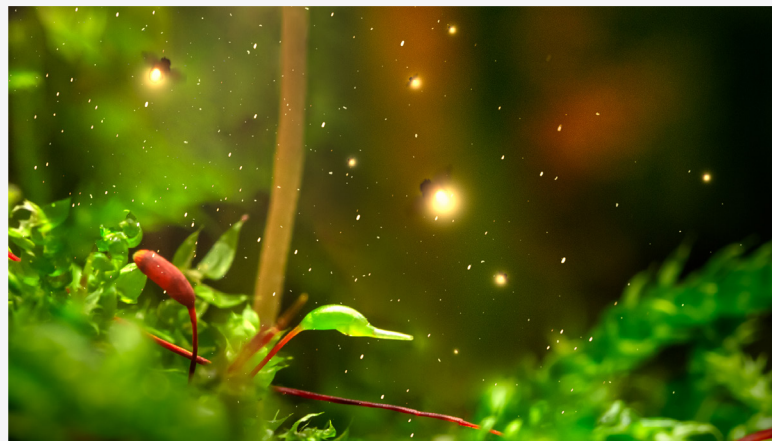
Cherry trees detecting sound

In a sunny cherry orchard, danger looms: a swarm of hungry caterpillars is approaching. Until recently, we thought the trees would be defenceless against such an attack. But recent research has shown that cherry trees possess a surprising ability: they can detect the sound of gnawing caterpillars and react accordingly. This fascinating phenomenon was first demonstrated in a pioneering 2014 study by Heidi Appel and Rex Cocroft of the University of Missouri.³⁹ Follow-up studies have shown that this ability is widespread among plants. By playing the naturally recorded sound of gnawing caterpillars in a laboratory, the researchers discovered that plants could perceive sound. To their surprise, the plants responded to this sound by filling their leaves with chemicals unpleasant or even toxic to caterpillars.

What's fascinating is that the plants reacted specifically to the sound of gnawing caterpillars and not to other noises like wind or birdsong.

Mimosa plants that learn

The mimosa plant, also known as the touch-me-not plant, is known for its delicate leaves that snap shut at the slightest touch. This is a defence mechanism that protects the plant from possible damage or eating. For a long time, this was seen as a simple reflex, similar to how we withdraw our hand from a hot stove. But researchers discovered something amazing when they conducted an experiment. They dropped the plants repeatedly from a short distance—an experience unusual but harmless to the plant. At first, the mimosa plants reacted as expected: their leaves folded shut with each fall. But after a while, something remarkable happened: the plants 'learned' that the fall posed no real threat and kept their leaves open even when they fell.⁴⁰ This ability to learn and adapt behaviour based on experience is something we normally associate only with animals. It suggests that plants have a form of memory and can distinguish between different types of stimuli. It is as if the plant thought, 'Oh, this again. Don't panic, it's harmless.'

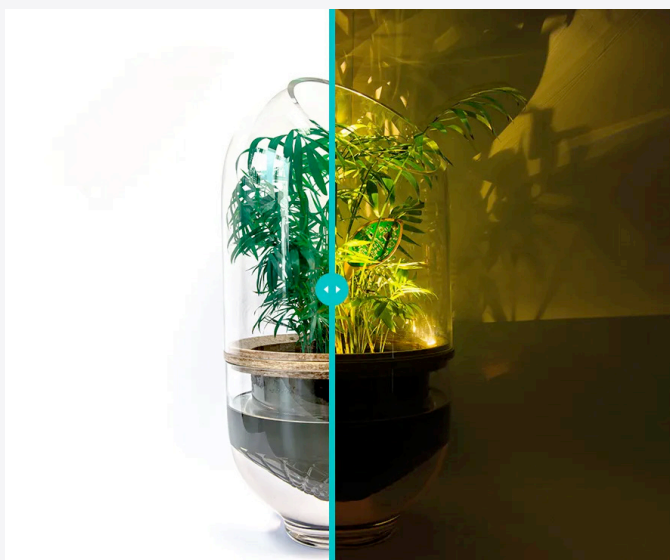


³⁹Mishra, R. C., Ghosh, R., & Bae, H. (2016). Plant acoustics: in the search of a sound mechanism for sound signaling in plants. *Journal of Experimental Botany*, 67(15), 4483-4494.

⁴⁰Gagliano, M. et al. (2014, May). Experience teaches plants to learn faster and forget slower in environments where it matters. *Oecologia*, 175(1). https://www.researchgate.net/publication/259587596_Experience_teaches_plants_to_learn_faster_and_forget_slower_in_environments_where_it_matters

Plants that give light

In a remarkable fusion of nature and technology, two Dutch companies are harnessing the power of plants to generate clean, renewable electricity. Plant-e, a spin-off from Wageningen University & Research, has developed a patented system that captures electrons released by bacteria during the decomposition of organic material secreted by plant roots. This innovative technology enables continuous, 24/7, energy production with a lifespan of 50 to 100 years, while also reducing methane emissions and storing CO₂.⁴⁰ The energy can be used for various purposes, including lighting. For instance, Plant-e is currently launching a plant-powered wireless signalling project in a peatland area of Sumatra, Indonesia, to monitor water levels. Pictured below is their flagship product, the Living Light lamp, which generates electricity through photosynthesis. This is a remarkable example of how we can meet modern needs while living in harmony with nature.



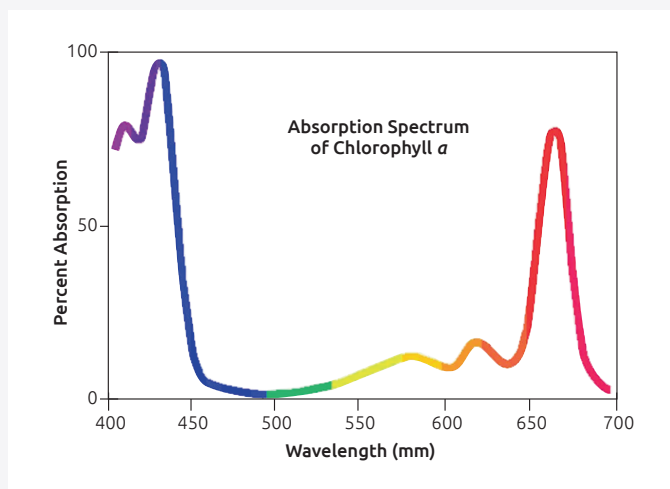
Quantum intelligence in plants

Plant-e uses photosynthesis, but what exactly is that? We learned in school that plants absorb sunlight, carbon dioxide and water to produce energy and oxygen. However, what often goes unmentioned is how efficient this process is compared to solar panels.

Light particles from the sun (photons) are absorbed by chlorophyll in plant cells, exciting electrons and initiating a chain of reactions that ultimately store energy in the form of sugar. In this process, energy transfer must occur with minimal loss. Remarkably, this transfer is aided by quantum coherence, where excitons (excited states of electrons) behave as a quantum field. This phenomenon, known as quantum superposition, allows excitons to explore all possible energy transfer pathways simultaneously, optimizing efficiency. In our classical understanding of physics, this seems absurd—how can something traverse multiple paths at once? As Niels Bohr, one of the pioneers of quantum mechanics, famously said, ‘Anyone who is not shocked by quantum theory has not understood it.’ This statement underscores how counterintuitive quantum principles like superposition, quantum entanglement, and the uncertainty principle are compared to everyday experiences and Newtonian physics.

⁴¹<https://plant-e.com>

Percentage of chlorophyll's absorption capacity of a light particle (photon), which has different wavelengths and matching colours. In the blue wavelength of light, the absorptivity is 95% and in the red spectrum 80%.



But for very small particles like an exciton, as well as the Higgs particle and other subatomic particles, superposition is possible. This is the realm where quantum mechanics applies. The emerging field of quantum biology explores how these quantum principles function in living systems. Though still in its infancy, quantum biology is already producing fascinating insights. For example, researchers at the University of Surrey are studying quantum effects in the eyes of birds, which may allow them to detect Earth's magnetic field and navigate with remarkable precision.

Conclusion

1. Intelligence without a brain. Intelligence is not limited to organisms with brains. Examples such as the slime fungus *Physarum polycephalum*, which can design complex networks and learn from experiences without a nervous system, show that intelligence is a much broader and more fundamental trait than previously thought.

2. The Umwelt concept. The Umwelt concept, introduced by Jakob von Uexküll, emphasises that each living being experiences the world in a unique way. By trying to understand the perceptual world of other organisms, such as the elephant fish's electrical senses, we can gain new insights into how intelligence manifests itself in different life forms.

3. Animal intelligence reconsidered. Animals like squids, dolphins and even insects like bumblebees exhibit forms of intelligence that were previously underestimated or unrecognised. We need to look beyond human standards and appreciate the unique forms of intelligence in the animal kingdom.

4. Plant intelligence and memory. Plants appear to possess memory and the ability to learn. Examples such as the mimosa plant, which learns not to respond to repeated non-threatening stimuli, show that plants can process and store complex information in their own way.

Chapter 4

Human intelligence: primal brains in hyper times

‘Human beings are to thinking as cats are to swimming. They can do it, but they prefer not to.’

Daniel Kahneman

Call it a digression or perhaps a jest, but Matthijs van Boxsel passionately champions his theory that human stupidity, along with the inevitable ‘stupid acts,’ is what truly defines us. He argues that progress is the result of our continuous self-correction to overcome this inherent stupidity. Rather than seeing intelligence as the opposite of stupidity, Van Boxsel views it as something entirely different. It’s the interplay between our intelligence and stupidity—a toxic cocktail—that we must be wary of. In essence, this is the theory he has been refining since his cum laude graduation, and one he continues to explore to this day.⁴²

Van Boxsel is not a neuroscientist but a cultural historian. Neuroscientists do not often use the word ‘stupid’. They do have theories that explain the limits of our cognitive abilities. Let us juxtapose the two views with an example that Van Boxsel uses to reinforce his claims.

Our battle against water

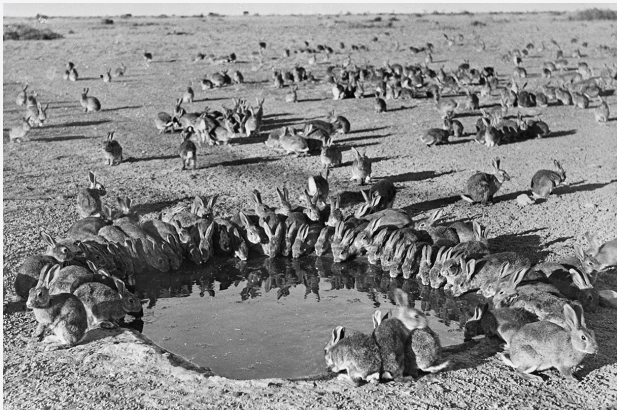
Around the year 1000, the Netherlands was still several meters above sea level. As people migrated from the eastern to the western regions, closer to the coast, they began using the land for agriculture and cattle farming. This led to the drainage of moisture from the soil, causing the ground to settle.⁴³ Over the course of three hundred years, this transformed the Netherlands into a virtual bathtub, constantly battling encroaching water. A moment of human folly, followed by panic! But salvation came in the form of dykes and windmills—innovations born out of necessity after the initial ‘act of stupidity.’ Today, the world speaks with great respect of the Dutch, admired for their ingenuity in thriving twenty meters below sea level.

⁴²He wrote numerous books about it that have been translated into seventeen languages, the best known of which is *The Encyclopædia of Stupidity*.

⁴³Geschiedenis van Zuid-Holland (2024). De grote ontginning van Zuid-Holland. <https://geschiedenisvanzuidholland.nl/verhalen/verhalen/de-grote-ontginning-van-zuid-holland/>

What Van Boxsels in the case above refers to as ‘stupidity’ is what neuroscientists and psychologists often describe as a lack of long-term thinking—something known as ‘bias.’ This ties in with the concept of ‘ratio dyslexia’ we introduced earlier in the report. Ideally, we should carefully consider the long-term consequences of our actions before making decisions, but human cognition is naturally more attuned to short-term thinking. This is also why we now lose to computers in nearly every game, from chess to the far more complex game of Go. In these contexts, artificial intelligence excels at long-term thinking, outpacing human capability.

Yet this so-called stupidity or dysrationalia wasn’t always a bad thing—especially if we look back to earlier times. Despite our frequent errors in judgment, we were remarkably better equipped to survive. Before diving into why this was the case, let’s explore two more examples that illustrate the limits of our rationality, offering both insight and entertainment.



Rabbits in Australia.

Rabbit plague

In 1859, Briton Thomas Austin brought 24 European rabbits to his brother William in Australia. It was a ‘fun’ idea for his brother’s hunting hobby. What followed, however, was not a picturesque scene of man versus nature, but rather an unprecedented, destructive force that would spread across the continent. Within decades, the offspring of these 24 rabbits multiplied to a staggering 200 million, an explosion of life that stretched across 5,000 km² of the Australian continent.⁴⁴ This ‘impressive animal colonisation’, as it would later be described, symbolises the unforeseen long-term consequences of human action in the short term. Hindsight is always 20/20, but how beneficial it would have been if Thomas had paused to consider the broader ecosystem before introducing those 24 rabbits.

⁴⁴Tamisiea, J. (2022, 22 August). A 19th century farmer may be to blame for Australia’s rabbit scourge. Science. <https://www.science.org/content/article/19th-century-farmer-may-be-blame-australia-s-rabbit-scourge>

4.1 Every disadvantage has its advantage

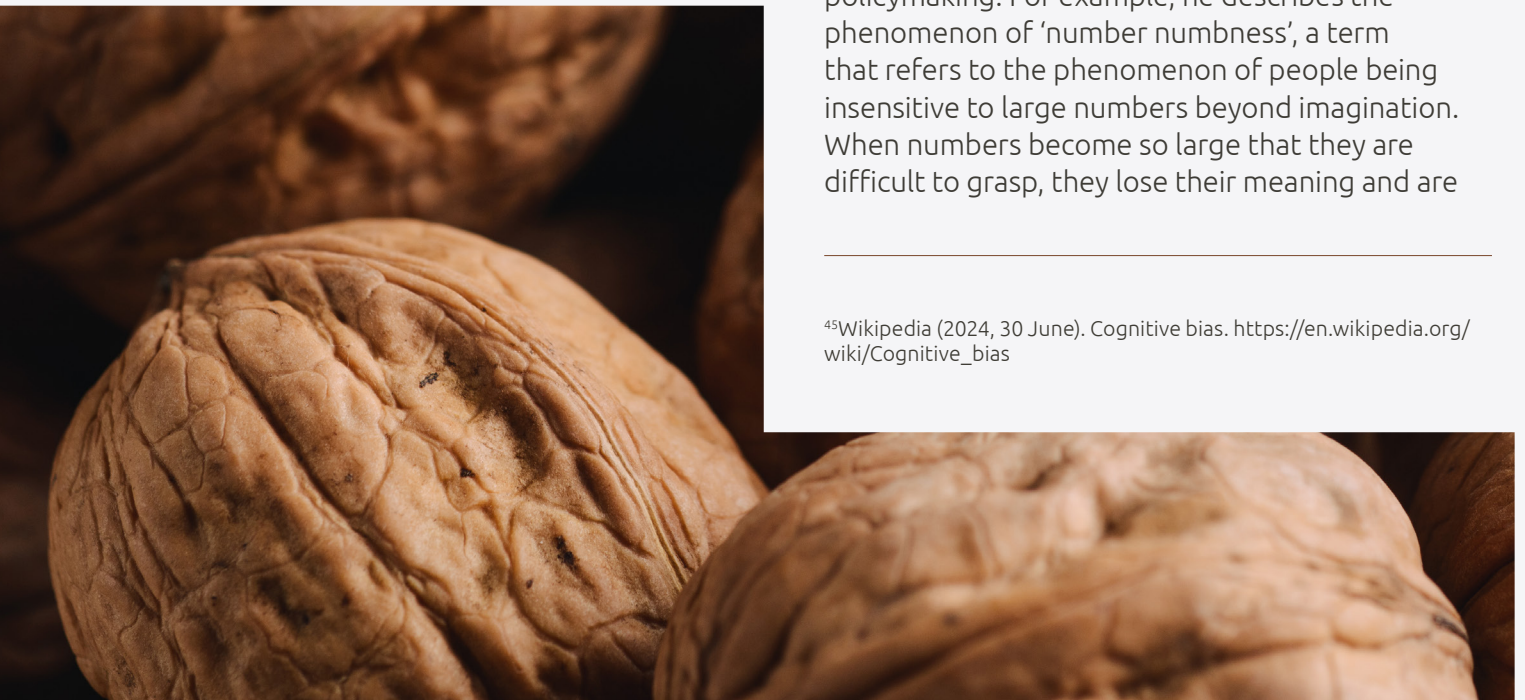
The limitations of human intelligence have been extensively documented by neuroscientists, and the reasons for these shortcomings are now well understood. Surprisingly, the prevailing view in scientific circles is that these limitations serve as an effective survival strategy. For instance, our tendency to perceive threats where there may be none—such as mistaking rustling leaves for a snake—reflects a ‘better safe than sorry’ approach. This ‘negativity bias,’ where we assume the worst-case scenario, helps us stay alert and survive in the wild. Although we might often be mistaken, this cautious mindset has proven to be beneficial in ensuring our survival.

A gust of wind rustling through leaves can easily lead to a rule of thumb like ‘avoid rustling sounds.’ We have many such experiential shortcuts, which

can be referred to as ‘heuristics’ in more scientific terms. These heuristics or mental shortcuts are convenient and efficient for making quick decisions, but they are not flawless. You may know some of them from Kahneman’s famous book *Thinking, Fast and Slow*, or from *Nudge*, the bestseller by Nobel laureate Richard Thaler and Cass Sunstein. More than a hundred such biases have been identified.⁴⁵ For example, confirmation bias, in which we mainly seek out or interpret information that confirms our existing worldview. Or the availability heuristic, the tendency to base our judgement on information readily available in our memory, which can lead to a distorted view of reality.

We could go on and on. In his book *Innumeracy: Mathematical Illiteracy and Its Consequences*, John Allen Paulos describes how bad people are at understanding and estimating large numbers. He explains how this lack of numerical literacy (‘innumeracy’) leads to misunderstandings and wrong decisions in both everyday life and policymaking. For example, he describes the phenomenon of ‘number numbness’, a term that refers to the phenomenon of people being insensitive to large numbers beyond imagination. When numbers become so large that they are difficult to grasp, they lose their meaning and are

⁴⁵Wikipedia (2024, 30 June). Cognitive bias. https://en.wikipedia.org/wiki/Cognitive_bias



treated as abstract concepts. For example, with a number like 195,000,000,000 (195 billion), Elon Musk’s estimated wealth in dollars.⁴⁶ If Musk were to divide this wealth over the number of years the earth is old, 4,540,000,000, he could spend \$42.90 every year for 4.54 billion years. That’s not bad, but below the poverty line of \$65 a month. Are you still following this?

You might wonder, ‘If our imperfect brains have gotten us this far, is there anything to worry about?’ Indeed, our fallible minds have managed to bring us to where we are today. Historically, people have thrived despite various misconceptions—such as the belief in a flat Earth—because shared illusions helped bind communities together and fostered group survival. Historian Yuval Harari frequently highlights this point. However, as clans evolved into villages, villages into cities, and cities into globalised networks driven by advanced technologies, the complexity of our world has vastly increased. In this intricate environment, understanding our ancient relationship with nature and evaluating the long-term impacts of our actions are more crucial than ever.



4.2 Our g-factor and fourfold knowing

The brain is much more than a sum of our biases. We are intelligent in our own way, as the mimosa plant and the elephant fish are in theirs. While we are unable to take the long view, we can make fantastic inventions like the espresso machine, the Delta Works or ChatGPT.

Our intelligence, the ability to solve problems, is a complex and multifaceted concept. We’re referring to the ability to recognise similarities and differences, orient ourselves in space, reason, plan, analyse problems, solve problems, think in abstractions, understand and produce ideas and language, store information in memory and retrieve it later, and learn from experiences. Congenital cleverness or intelligence is often referred to as giftedness or talent.

Furthermore, intelligence is a facet of personality, with individuals exhibiting varying degrees of cognitive abilities. For instance, one person might excel at learning languages, while another may have a keen sense of spatial orientation.

⁴⁶LaFranco, R., Chung, G. & Peterson-Withorn, C. (eds.). (2024). Forbes World’s Billionaires List: The Richest in 2024. Forbes. <https://www.forbes.com/billionaires/>

If you're looking for a more engaging definition:

Intelligence is the aggregate or global capacity of the individual to act purposefully, to think rationally and to deal effectively with their environment.⁴⁷

We borrow this definition from David Wechsler, the American psychologist who designed the often-used intelligence test Wechsler Adult Intelligence Scale (WAIS). Underlying such IQ tests is British psychologist Charles Spearman's theory of the g-factor.⁴⁸ This states that a general cognitive ability underlies all mental activity. This g-factor, or general intelligence, represents an innate ability to solve problems and reason effectively about different types of information. The bad news is that this g-factor is pretty much fixed after the first few years of life. The good news is that this g-factor is better expressed when we take the Circle of Life seriously: a healthy mind in a healthy body does wonders for our intellectual performance. What we have more control over is how our intelligence manifests in our knowledge and actions.

The g-factor ultimately influences four forms of knowledge that guide our decision-making and behaviour. John Vervaeke, professor and director of the Cognitive Science programme at the University of Toronto, assumes four varieties of knowledge.⁴⁹ He explores how we can rise above ourselves and further develop our own forms of intelligence and knowledge. This is particularly relevant for us because our concept of regenerative intelligence emphasises the need to enhance our own intelligence by leveraging the distinct qualities of both machine intelligence and natural intelligence. According to Vervaeke, we are constantly in conflict with the above-mentioned biases, which he calls self-deception. According to him, thinking more rationally requires a lot of attention, energy and empathy. Below is Vervaeke's four-part intelligence:

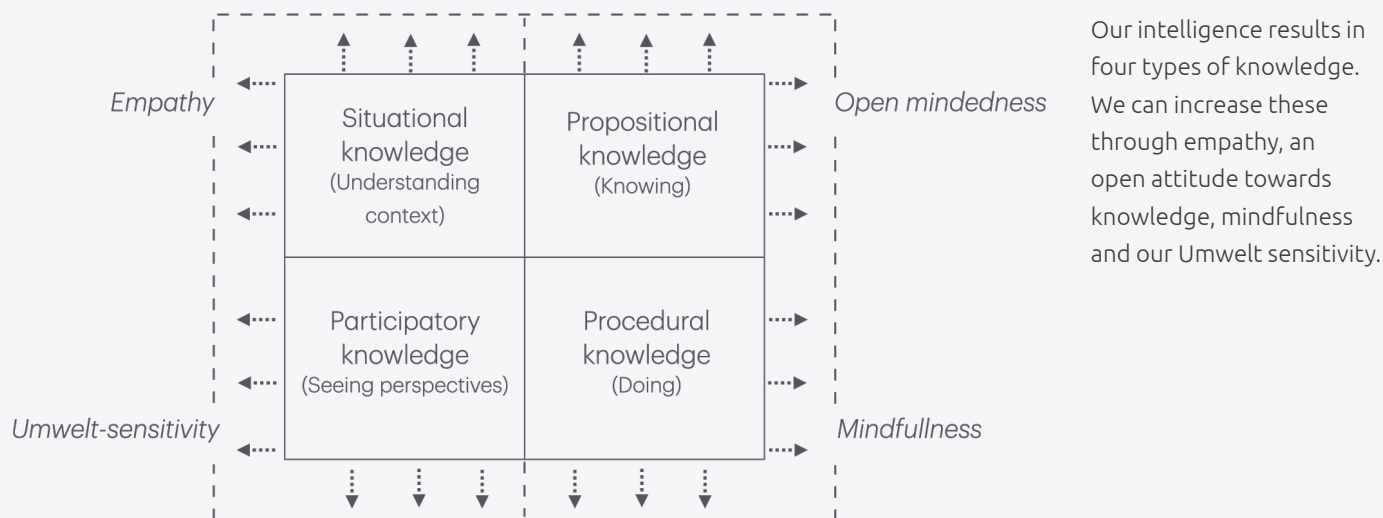
Propositional knowing: knowing something

The ability to know something involves understanding and manipulating abstract, logical, and symbolic representations, such as language and mathematics. For example, knowing that Australia is a continent or that a lynx is a type of wild cat requires this capacity for conceptual thinking. It allows us to grasp facts, rules, and propositions, which are essential for scientific and theoretical reasoning. This form of knowing can expand as long as we remain open-minded and avoid confirmation bias. For instance, when we see an image of a lynx, we might automatically classify it as just a "cat" unless we approach the subject with curiosity and a willingness to see beyond our preconceptions.

⁴⁷Plucker, J. A., & Esping, A. (Eds.). (2014). David Wechsler. <http://intelltheory.com/intelli/david-wechsler/>

⁴⁸Jensen, A. R. (1999). The g Factor: the Science of Mental Ability. *Psychology*, 10(023). <https://www.cogsci.ecs.soton.ac.uk/cgi/psyc/newpsy?intelligence-g-factor.1>

⁴⁹Vervaeke, J. (2023, 20 December). Four Kinds of Knowing and Personality, Formal Cause, and Purpose with Sam Tideman. [Podcast]. <https://podcasts.apple.com/no/podcast/four-kinds-of-knowing-and-personality-formal/id1680606350?i=1000639259182>



Procedural knowing: being able to do something

The capacity to do something, like catching a ball, playing the guitar, or comforting someone, involves practical knowledge and the ability to perform tasks through learned skills and routines. This is known as procedural knowing—knowing how to do things. This form of knowing requires focused attention. While the capacity to know benefits from an open mind, procedural knowing is enhanced through mindfulness—actively paying attention to the task at hand.

Perspectival knowing: understanding context

The ability to understand context. Knowing that you can't walk on thin ice, for example, that if the fuses blow out it could be because two appliances that use a lot of power are on at the same time, or that you shouldn't talk too loudly at a funeral. It is a form of knowing that jumps to the foreground according to the situation. You know how to act by seeing the perspective.

Participatory knowing: interaction

The capacity to see a different perspective. Vervaeke also translates this as 'knowing to be someone, to take a particular role'. Participatory knowing concerns the way we perceive and interact with ourselves and the world around us. It is the knowledge we use to build meaningful relationships with others and our environment, and it plays a central role in how we situate ourselves in the world and how we are involved in cultural and social practices. Here, we recognise the concept of *Umwelt* from the previous chapter. This is where internalization processes come into play. As children, we begin to understand the world by putting ourselves in others' shoes, such as seeing things from a parent's perspective to navigate and learn. Similarly, a waiter imagines the guest's needs, a dentist considers the patient's experience, and a politician empathises with the everyday concerns of the average citizen. However, when self-centeredness dominates, this ability to step outside oneself and gain new perspectives becomes stunted, limiting growth and understanding.



4.3 RI = (NI + HI + AI) × S × R

James Lovelock wrote another book at the age of 100. He viewed our planet Earth as a living system, something that came to be known as the 'Gaia theory'. In the book, which he wrote just before his death, artificial intelligence is positioned as the saviour of our planet. Artificial intelligence rises above human thinking and comes up with numerous original solutions to keep the planet habitable. It even mentions the invention of heat shields, which will be needed when the sun has warmed further in a million years. *Novacene* is the title of the book: welcome to the new era where artificial intelligence comes to our rescue as a lifesaver. Where will that make a difference at the four levels of knowledge? First, we can raise the general level of knowing through AI, often referred to as knowledge number 1; *Propositional knowing*. With tools like GPTs, we're already seeing significant progress. When combined, human intelligence (HI) and artificial intelligence (AI) create a synergy that is greater than the sum of their parts. In the second form of knowing, being able to do something, little AI comes into play yet. The fact that AI *can* help us better empathise with others (knowledge number 3) is obvious. Studies have even shown that AI-driven systems, such as virtual doctors, are often perceived as more empathetic than their human counterparts.⁵⁰ If AI can empathise with us so effectively, it stands to reason that it could also empathise with the world of others. Our Umwelt can be augmented with AI-empathy for plants, animals and ecosystems

⁵⁰Devlin, H. (2023, 28 april). AI has better 'bedside manner' than some doctors, study finds. *The Guardian*. <https://www.theguardian.com/technology/2023/apr/28/ai-has-better-bedside-manner-than-some-doctors-study-finds>

and with it we could more easily see multiple perspectives, the final form of knowing. In essence, this shift would mean moving from ego-intelligence to eco-intelligence.

This opens up the possibility of developing our *regenerative intelligence*. The Ecological Intelligence Agency, mentioned in Chapter 2, serves as an inspiring example of how this concept can be put into action.

Things become even more fascinating when AI moves beyond analysis and starts to invent—when it truly becomes creative. In the next chapter, we explore the concept of a fully automated invention machine, capable of generating entirely new ideas and innovations. That creative solution side of AI offers prospects for scientific breakthroughs that, if aimed at the viability of Gaia, also contribute directly to regenerative intelligence.

But artificial intelligence can also stand in the way of further development of our intelligence. AI-based marketing and the associated ‘Attention Economy’ are gobbling up our attention. Mindfulness is becoming increasingly difficult in this crazy world where every minute a notification arrives on the phone.

So, what about the role of natural intelligence? The more destructive side of nature is becoming increasingly evident—from global warming and flash floods to pandemics, crop failures, and extreme weather events disrupting daily life, even cutting holidays short. We explored these issues extensively in the first report of the *Scarcity in Abundance* series, where we coined the term ‘Experience Ecology’.



"Devlin, H. (2023, 28 april). AI has better 'bedside manner' than some doctors, study finds. *The Guardian*. <https://www.theguardian.com/technology/2023/apr/28/ai-has-better-bedside-manner-than-some-doctors-study-finds>

As we encounter nature's extremes more frequently, our interest in understanding how nature operates intensifies. This growing awareness will drive the development of regenerative systems and deepen our knowledge of natural intelligence. In many ways, we are still at the very beginning of this journey of discovery.

The synergy between AI and natural intelligence (NI) holds the potential to unlock profound breakthroughs in our understanding of both consciousness and intelligence. Life itself may reveal more of its secrets—from quantum effects at the cellular level to metaphysical questions like the classic chicken and egg problem: which came first, consciousness or matter?

We are just at the beginning of this journey of discovery, though some have ventured further than others. Leading the way are researchers at Carnegie Mellon University, whose autonomous invention machine serves as the starting point for the next chapter. Another pioneer is microbiologist Michael Levin, who is redefining our understanding of life with his AI-designed xenobots—offering a groundbreaking perspective on where life begins.

Conclusion

1. Limitation of human intelligence due to 'ratio dyslexia'. Humans tend to perform poorly in long-term thinking. This concept explains why humans often make silly mistakes, for example, failing to anticipate the consequences of actions such as dewatering land or introducing invasive species.

2. The brain as a survival machine. Historically, the human brain has evolved to survive rather than to think rationally. This has led to biases that trouble us in modern times but were effective for survival in the past.

3. Intelligence versus stupidity. The combination of human intelligence and stupidity has led to both progress and disasters. This dualism is a characteristic aspect of the human condition.

4. Progress thanks to failure. Human progress is often made through mistakes and failures. Examples such as the Netherlands' battle against water show that innovations often come from necessity after failure, which is a crucial driver of human development.

5. AI's threat to human weaknesses. Artificial intelligence, which is better at long-term thinking and avoiding human biases, can outperform us, but can also threaten us if we do not face and address our own weaknesses.

Case Study

Patagonia: Leading the Way in Regenerative Business

Patagonia, the outdoor apparel and gear company, has long been synonymous with environmental activism and corporate responsibility. Patagonia's mission, "We're in business to save our home planet," reflects a deep commitment to regeneration. Unlike conventional sustainability efforts that focus on reducing harm, Patagonia actively seeks to reverse ecological degradation. Through its business practices, investments, and advocacy, the company has become a global leader in regeneration, proving that businesses can be catalysts for positive change. This commitment is evident in its transition toward regenerative organic agriculture. Recognizing the interconnectedness of agriculture, soil health, and climate change, Patagonia supports farming practices that restore ecosystems, sequester carbon, and produce nutrient-rich crops.

Regenerative Organic Agriculture: A Game-Changer

Patagonia has pioneered the adoption of regenerative organic agriculture, a holistic approach that prioritizes soil health, biodiversity, and animal welfare. Through its Regenerative Organic Certification (ROC) program, Patagonia partners with farmers to implement practices like crop rotation, cover cropping, and reduced tillage. These methods not only sequester atmospheric carbon but also improve water retention, enhance soil fertility, and foster resilience against climate change. The company's food division, Patagonia Provisions, embodies this approach by sourcing ingredients exclusively from regenerative organic farms. For example, its sourcing of regenerative grains and meat helps combat desertification while producing high-quality, ethical products for consumers.



Innovative Product Design and Circular Economy

Patagonia's commitment to regeneration extends to its product design. The company prioritizes durability and repairability, encouraging customers to buy less and keep their products longer. Through the Worn Wear program, Patagonia facilitates the repair, resale, and recycling of its products, creating a circular system that reduces waste and resource consumption. The company also innovates with materials, opting for regenerative fibers and recycled inputs. Its work with Regenerative Organic Cotton, for instance, demonstrates the viability of scaling regenerative materials in the textile industry.

By avoiding conventional cotton, which is resource-intensive and environmentally damaging, Patagonia sets a benchmark for responsible material sourcing.

Climate Action Through Business Innovation

Patagonia has also positioned itself as a leader in climate action. In 2022, the company made headlines by transferring ownership to a trust and a nonprofit organization designed to reinvest profits into climate and environmental initiatives. This bold move ensures that Patagonia's resources are directed toward ecological regeneration rather than shareholder profits. In addition to its corporate structure, Patagonia invests heavily in renewable energy and sustainable manufacturing practices.

By aligning its operations with science-based climate targets, the company reduces emissions across its supply chain and inspires others to follow suit.

Advocacy and Activism: Regeneration at Scale

Beyond its operations, Patagonia actively campaigns for systemic change. Through initiatives like Patagonia Action Works, the company supports grassroots organizations dedicated to environmental conservation and restoration. Patagonia's activism extends to legal action, as seen in its lawsuits against the U.S. government to protect public lands and its outspoken stance on reducing fossil fuel dependence. The company also uses its platform to educate and mobilize consumers. Campaigns like "Don't Buy This Jacket" and "Earth is Now Our Only Shareholder" challenge traditional consumerism and advocate for a regenerative relationship with the planet.

Building Community Through Regeneration

Patagonia recognizes that regeneration is not only ecological but also social. By partnering with indigenous communities and local farmers, the company supports livelihoods while advancing environmental goals. Its supply chain initiatives promote fair trade and worker rights, fostering equity alongside ecological health. One notable example is Patagonia's partnership with wool farmers in Argentina to restore overgrazed grasslands through holistic management. This project not only improves biodiversity and carbon sequestration but also provides stable incomes for local communities.

Measuring and Sharing Impact

Patagonia's commitment to transparency is a cornerstone of its regenerative approach. The company shares detailed reports on its environmental and social performance, setting an example for corporate accountability. By measuring the impact of its initiatives and openly discussing challenges, Patagonia inspires others to join the regenerative movement.

A Model for Regenerative Business

Patagonia's success illustrates the business case for regeneration. By integrating ecological principles into every aspect of its operations, the company has cultivated unparalleled customer loyalty and established itself as a leader in the outdoor industry. Its regenerative practices enhance brand equity while reducing costs associated with resource extraction and waste management.



Chapter 5

How intelligent can we become?

‘We still believe that we are the only beings with a high level of consciousness. This is part of the whole Copernican journey that we are not unique. We’re not at the centre.’

Marcus du Sautoy, Mathematician and Professor for the Public Understanding of Science at Oxford University

If you’re fascinated by the potential of human intelligence, delve into Ray Kurzweil’s writings. His latest book, ‘The Singularity is Nearer,’ explores transformative concepts like non-invasive nanobots creating new brain interfaces. Kurzweil predicts that within the next 20 years, human intelligence could leap millions of times forward.

While Kurzweil’s brain interface captures the imagination, recent discoveries show that even mindless organisms, like slime molds, exhibit the problem-solving abilities of an engineer. Moreover, natural ecosystems are full of collective intelligence that transcends any single species. Kurzweil’s ‘natureless’ perspective overlooks this vast potential, dismissing the inherent intelligence of the natural world. This is not only limiting but dangerous, as it blinds us to the cycles of nature in which we are deeply embedded—something we’ve explored in detail in this report.

Although both Kurzweil’s singularity and the concept of regenerative intelligence offer visions of a transformed future, they emphasise very different worldviews. Kurzweil’s singularity is centred on human intelligence, while regenerative intelligence acknowledges that everything is interconnected. We are part of a far greater intelligence, and recognising that, immersing ourselves in this broader Umwelt, is the true path to regenerative intelligence. In this chapter, we aim to explore captivating examples of robotics, while setting aside the concept of the ‘singularity’ for now. Instead, our focus is on understanding whether and how these examples can contribute to the development of regenerative intelligence.



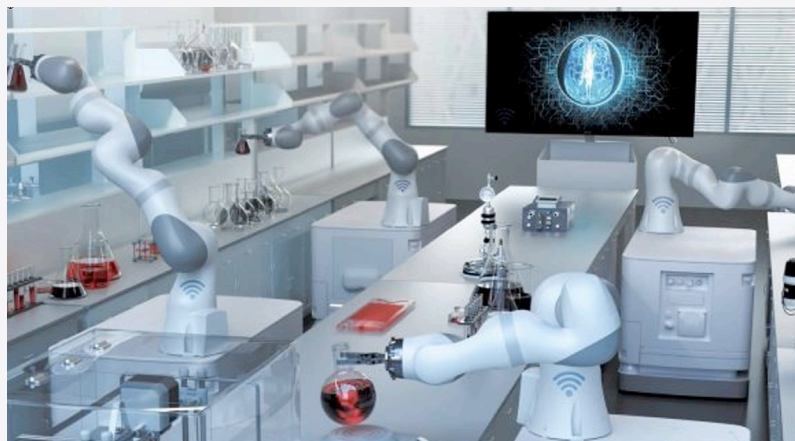
5.1 Hybrid AI-MI-robotics

Where both concepts, singularity and regenerative intelligence, do overlap is in the goal of getting smarter and using AI to do so. Consequently, the concepts frequently overlap when looking at science fiction-like applications of AI: robots that do research independently.

Imagine a future where an AI in a science laboratory has access to equipment, materials and the internet and can conduct its own experiments. For some scientists, this has been a cherished dream for years, which they are realising step by step. Every year, the level of autonomy of the AI scientist grows and with the breakthrough of LLMs, we're witnessing a significant acceleration in this progress. 'Coscientist' is the name of one

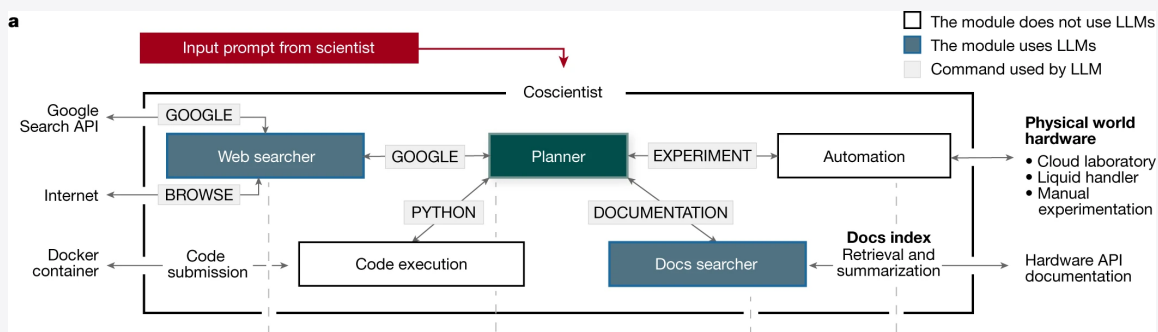
of these latest AI initiatives. It is the focus of the seminal paper 'Autonomous chemical research with large language models', published in *Nature* in December 2023.⁵¹ The scientists used GPT-4 and guided this AI to autonomously delve into chemical research. Coscientist can autonomously design, plan and perform complex experiments, with minimal human intervention and can search the internet for information and understand scientific literature, as well as generate code to control laboratory instruments.

⁵¹Boiko, D. A. et al. (2023, 20 December). Autonomous chemical research with large language models. Fig. 1: The system's architecture. Nature, 624, 570-578. <https://www.nature.com/articles/s41586-023-06792-0/figures/1>

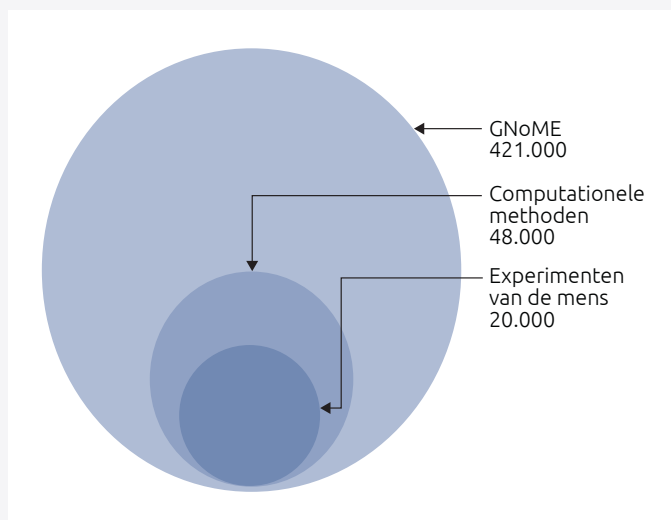


Left: For years, scientists have been working on automated laboratories.

Below: Coscientist uses multiple Large Language Models and writes code to control laboratory instruments.



In this context, it's also worth examining another AI tool: GNoME, developed by Google DeepMind. This inventor robot discovered 2.2 million new crystals, showing enormous promise for advances in areas such as renewable energy and advanced simulations. Although many of these crystals are not stable, the 381,000 most stable new materials will be shared with scientists worldwide. To put this into perspective, about 20,000 stable crystals have so far been identified by humans. Computational simulation methods later increased this number to 48,000. GNoME's discovery extends our knowledge to a staggering 421,000 stable materials. DeepMind compares this achievement to 800 years of scientific knowledge, reminding us of their revolutionary AlphaFold,⁵² which predicts new protein structures at lightning speed.



This is how intelligent we can become. Humans discover 20,000 stable crystals and computational methods and GNoME add another 400,000 candidates.

The recent proliferation of such automated experimental techniques has led to the emergence of self-driving laboratories (SDLs). These intelligent robotic assistants help researchers increase the pace of basic and applied research by rapidly exploring chemical space. The hope is that accelerating the discovery of new molecules and materials will help address global challenges in energy, sustainability and healthcare. Many scientists see AI as an essential tool that will only become more important in their fields in the coming years.⁵³ These tools offer faster ways to process data, speed up calculations that were previously unfeasible and save time and money. At the same time, the integration of AI into science raises questions about the quality and integrity of research. For instance, there are concerns about the growing reliance on AI for pattern recognition without a true understanding from scientists. This can result in reinforcing existing biases or discrimination in the data and may lead to research that lacks reproducibility.

⁵² Jumper, J. et al. (2021, 15 July). Highly accurate protein structure prediction with AlphaFold. *Nature*, 596, 583-589. <https://www.nature.com/articles/s41586-021-03819-2>

⁵³ Van Noorden, R. & Perkel, J. M. (2023, 27 September). AI and science: what 1,600 researchers think. *Nature*. <https://www.nature.com/articles/d41586-023-02980-0>

5.2 The bioenergy lab using Gen AI to create robots

AI is also being applied to fundamental research on the origins of life, leading to fascinating breakthroughs in microbiology. New insights into the development of living cells are prompting deeper questions about consciousness and cognition, shifting the focus toward understanding the Umwelt and enriching our comprehension of regenerative intelligence. In this context, we highlight the work of Michael Levin, director of the Center for Regenerative and Developmental Biology at Tufts University in the U.S.

‘I think one way to achieve general intelligence may be to back off from the very specific architecture of brains, and ask how all cell groups implement learning and problem solving in the control of growth and form.’

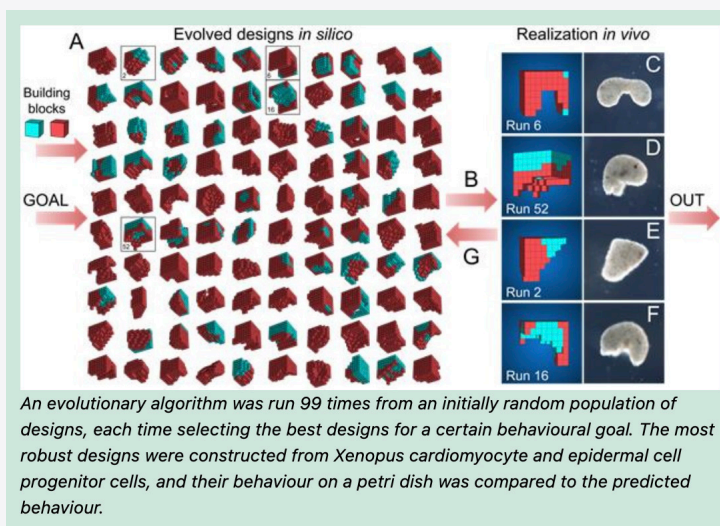
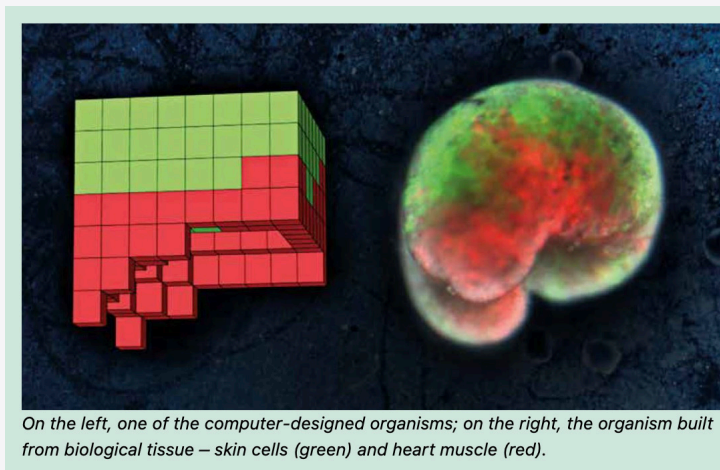
Michael Levin

Michael Levin builds xenobots. A xenobot is an organic living robot made from the stem cells of the African clawed frog (*Xenopus laevis*). Michael Levin specialises in regenerative biology, a field that aims to deeply understand the degenerative processes in cells, tissues, and organs. One of his most groundbreaking contributions is the creation of xenobots, which, in his words, are ‘the only living organisms whose evolutionary history is entirely shaped by computers.’ Using advanced AI algorithms, his lab designs numerous xenobots—these are ‘evolved designs in silico,’ as illustrated by the first/top image (next page). These Lego-like



computer designs are then converted into living material.⁵⁴ The image below it shows four living versions of it ‘in vivo’.

An enlargement of one of the nanobots, including a heart muscle, is shown in the image on the right. The magic of the creation process lies in the combination of evolutionary algorithms, a form of AI, frog cells and bioelectricity.⁵⁵ We’re already familiar with bioelectricity in medicine through tools like the electrocardiogram, which measures the electrical activity of the heart, and the electroencephalogram, which records brain activity. Here, bioelectricity instructs frog cells to form AI-designed constructs. Once formed, the xenobots begin to spontaneously organise themselves and exhibit independent behaviour. For example, they can move in liquids, transport small objects and even repair themselves if damaged. Importantly, this process does not involve genetic engineering—so the original DNA remains entirely intact. Self-organising behaviour arises from the interactions between cells and the way they are structured, without a traditional nervous system or brain. The ‘memory’ of cells to know what to become is purely wrapped up in the manipulated bioelectricity. In humans, it works similarly. Bioelectricity partly determines whether a cell becomes a liver cell or a cell of the retina of the left eye. It can, as it were, push the cell in a certain direction.



Listening and working with bioelectricity opens the doors to a new branch in medicine, that of regenerative therapies.

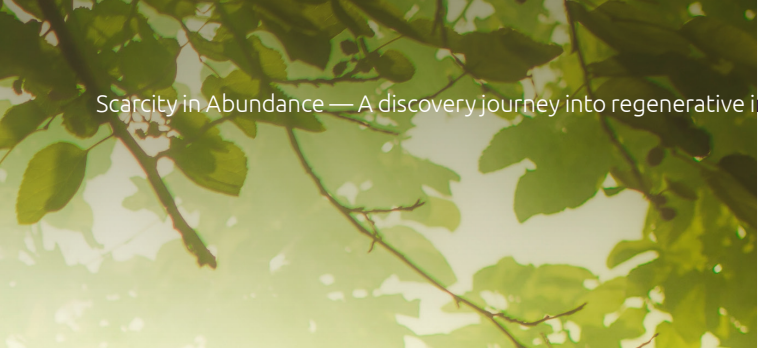
⁵⁴Ramanujam, E. & Kamal, N. A. (2022, January). Xenobots: A Remarkable Combination of an Artificial Intelligence-Based Biological Living Robot. International Journal of Sociotechnology and Knowledge Development, 14(1), 1-11. https://www.researchgate.net/publication/363212743_Xenobots_A_Remarkable_Combination_of_an_Artificial_Intelligence-Based_Biological_Living_Robot

⁵⁵Ibid. Zie ook: Tran, L. (2024, 14 June). From Code to Creature. The Scientist. <https://www.the-scientist.com/from-code-to-creature-71877>

‘In 2000 we created the first tools to allow us to listen in and manipulate the electrical conversations that non-neural cells are having with each other. It turns out that during development, during regeneration, during cancer suppression, all cells are forming these electrical networks.’⁵⁶

Michael Levin

⁵⁶The Biologist. (2020, 2 April). ‘This is perhaps the first organism whose evolutionary history was in a computer’. <https://www.rsb.org.uk/biologist-features/professor-michael-levin-interview>



The significance of this fundamental research lies in addressing the profound question of where intelligence, knowledge, and consciousness reside in the body. In the twilight zone of cells and bioenergy fields, life itself emerges. This research also raises questions about the origins of intelligence and the precise nature of the interactions between cells, organs, and the brain.

Yet, there is no definitive answer.

The practical relevance of this research ranges from repairing birth defects and cell damage, halting ageing processes, fighting degenerative diseases to reprogramming tumours.

This brings us closer to Kurzweil's concept of the singularity, which envisions human immortality. However, even if immortality becomes attainable, it will remain impossible without healthy, thriving ecosystems. While regenerative healthcare offers a good future, true regenerative intelligence and living begin with preventing problems, not creating them.

5.3 This is how intelligent we can become

We opened this report with urgent warnings about the planet's current state and its ecological, economic, and existential impacts. In response, we must embrace regenerative intelligence, beginning with the understanding that in nature, everything is interconnected within regenerative ecosystems that collectively embody the intelligence of the natural world. The realisation that human intelligence is an inseparable part of that natural intelligence forces us to be more respectful of nature and choose the regenerative path instead of degenerative short-term solutions. Artificial intelligence can play a vital role because it can greatly enhance our understanding of the world around us, our Umwelt and the Umwelt of all other organisms on earth. But this is not a given, this does not happen by itself.

We have distanced ourselves from nature to such an extent that we now embrace practices like 'forest bathing.' Originating in Japan as 'shinrin-yoku', this practice involves a brief, calming visit to a forest and is considered a form of natural aromatherapy. Numerous studies have shown that forest bathing can significantly boost the immune system, notably by increasing the number of white blood cells.⁵⁷ Unsurprisingly, forest bathing has been found to positively impact our mood, both in the short and long term. One study found that the risk of later mental illness for people who grew

⁵⁷Li, Q. (2010, January). Effect of forest bathing trips on human immune function. *Environmental Health and Preventive Medicine*, 15(1), 9-17. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2793341/>

up with little greenery during childhood was up to 55% higher compared to those who grew up with lots of greenery around them.⁵⁸

If we put ourselves in philosopher Glenn Albrecht's shoes, he probably welcomes the term forest bathing and finds it functional. According to him, we need further new words to make sense of our changing relationship with nature. These new words by Albrecht not only help us to better understand the psychological and emotional consequences of ecological changes, but also to develop a language needed for more sustainable living. His concept and coined word Symbiocene is essential in this discussion, offering a more desirable alternative to the Anthropocene, the human-dominated era we're rapidly approaching. The Anthropocene signifies the end of the climate-stable Holocene, marking a new chapter shaped by human impact on the planet.



The Anthropocene and Symbiocene are terms for potential future eras, but we currently live in the Holocene. The Anthropocene—from the Greek *Anthropos* (human) and *Cene* (new)—refers to an era shaped by human activity, particularly the disruption of nature, such as global warming. In contrast, the Symbiocene envisions a time when humanity coexists harmoniously with nature, actively making ecosystems and all life in them flourish. The naming of eras is a formal process overseen by scientific institutions. While the term Anthropocene was put to a vote in 2023, it has not yet been officially recognised. It would be remarkable to witness the naming of a new epoch in our lifetime, as such designations are extremely rare.



⁵⁸Engemann, K. et al. (2019, 25 February). Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. PNAS. <https://www.pnas.org/doi/10.1073/pnas.1807504116>

Solastalgia - The distress or melancholy experienced when one's environment and homeland are destroyed by environmental changes such as climate change or urbanization. It is a combination of "solace" and "algia" (pain).

Psycho-terratic identity - The idea that our mental health and identity are deeply rooted in the earth and the landscapes in which we live. Loss or degradation of these landscapes can lead to psychological and emotional problems.

Eutierria - A positive feeling of connectedness to the earth and nature, leading to a sense of well-being and balance. The word is derived from the Greek "eu" (good) and "terra" (earth).

Glenn Albrecht

Philosopher new "psychoterratic" emotions

Symbiocene - The period after the Anthropocene, characterized by mutually beneficial relationships between humans and the natural world. This era emphasizes cooperation, restoration, and sustainability.

Symbioment - An environment characterized by symbiotic relationships among all life forms, including humans. It emphasizes harmonious coexistence where all elements of the ecosystem support and enrich each other.

Besides forest bathing, philosopher Glenn Albrecht says we need more new words to make sense of our changing relationship with nature.





Seven generations, or 'longtermism'

One word is still missing from Albrecht's thinking in the image above. The philosophical concept called 'longtermism'. It is also known as the longtermism of 'The Seventh Generation Principle'. We already discussed that our intelligence falls short when it comes to the long term - we have a blind spot when it comes to long-term processes in the Circle of Life. This is also Sandra Phlippen's frustration with which we started this report. Longtermism, on the other hand, represents the ethical position that contributing positively to a long-term future is the moral imperative that society should focus on. The main sticking point for this becomes immediately clear when we consider the stock market's total fascination with quarterly earnings. The Seventh-Generation Principle is based on an ancient philosophy of the indigenous Haudenosaunee people living in the United States and Canada, already reflected in the thinking of the ShagowAskee organisation mentioned earlier.

The Seventh-Generation Principle is often invoked today in the context of decisions about energy, water, and natural resources, aiming to ensure sustainability for the next seven generations. However, this principle can also be applied to relationships: every decision should foster relationships that remain sustainable seven generations into the future.



The Haudenosaunee who have culturally embraced long-term thinking.

Deploying AI in the short term to start thinking long term

AI seems to come at exactly the right time. AI provides an insight into our biases, pushes us head-first and has the potential to reduce our blind spot regarding long-term thinking. The AI assistant, the Ecological Intelligence Agency, helps remind us to listen to nature. Through AI, nature is given a voice in the case of a river in England. Climate predictions are more abstract, which makes them harder to accept. But again, it is AI that can represent nature's voice. Yet AI by itself is not regenerative and neither is human intelligence combined with AI. Blind faith in technology not only ensures that the positive effects are often overestimated, but also that the negative effects are regularly underestimated. Because while artificial intelligence certainly has the potential to enhance our Umwelt through new equipment and knowledge and can help reduce CO2 emissions, it seems to have the opposite effect for now due to its enormous energy consumption.⁵⁹ Microsoft and Google are watching their climate goals slip further out of reach due to the massive adoption of generative AI. Additionally, this same technology

has at times pushed us further from the truth, fuelling the spread of conspiracy theories and disinformation. This highlights the urgent need for an ecological, holistic, and regenerative approach to technology.

We are beginning to understand that we don't know everything and that AI can bring the long term forward by accelerating. And where AI and natural intelligence come together, as in the aforementioned xenobots, something unexpected happens. Thanks to AI inventions brought to life with bioelectricity, we are discovering much more about the essence of life itself. Consciousness, often seen as the enigmatic counterpart to intelligence, reveals a completely different aspect in this context. Its mysteries remain largely unsolved. However, when two natural phenomena—such as DNA and quantum mechanics—intersect, progress can accelerate in unexpected ways. We read in *Nature* that this combination could produce the perfect computer: 'DNA as a perfect quantum computer based on the quantum physics principles'.⁶⁰ Although parts of the puzzle are still 'in an early stage', we see that our old worldview is increasingly being stretched and starting to crack. What was hitherto taken for granted is suddenly being questioned. Eventually, the old worldview will tilt thanks to this kind of breakthroughs.



The new enlightenment that *The Economist* talked about might just become true. Let us conclude this report in the next chapter with a brief reflection on the essence of a 'paradigm shift'. Thomas Kuhn, the originator of the theory that worldviews can tilt, has outlined six steps which are typical for a paradigm shift.

Conclusion

1 The limits of human intelligence. It is essential to recognise that human intelligence is limited to grow further. Human intelligence is only a subset of a larger set of natural and artificial intelligence. We need to learn to harness the synergy between human, natural and artificial intelligence.

2 Co-evolution of humans and machines. The future lies in the co-evolution of humans and machines, seeing AI as a partner that can complement and enhance human limitations, provided this collaboration is developed in an ethical and regenerative manner.



⁵⁹NOS (2024, 3 July). Energieslurpende AI zorgt voor forse stijging CO2-uitstoot Google. <https://nos.nl/artikel/2527239-energieslurpende-ai-zorgt-voor-forse-stijging-co2-uitstoot-google>

⁶⁰Aroche, R. R. et. al. (2024, 21 May). DNA as a perfect quantum computer based on the quantum physics principles. *Scientific Reports*, 14, 11636. <https://www.nature.com/articles/s41598-024-62539-5>

Chapter 6

The fifth paradigm and associated discomfort



The discomfort of a paradigm shift takes many forms. Consider the early, tentative steps we are witnessing today. Some companies are experimenting with regenerative business models. Supermarket Albert Heijn, for example, attempted a true pricing initiative, which didn't quite gain traction⁶¹. Others are making bold, unexpected moves, like Spotify granting artist status to nature and paying out royalties⁶²—an interesting stunt, though it comes off as somewhat awkward.

Nevertheless, successful start-ups are emerging in response to this new paradigm. One such company is Dutch start-up Loop Biotech, which uses mycelium—a network of fungal strands that primarily grows underground—to create coffins and urns. They market 'the first living coffin' with a provocative question for potential customers: 'Are you waste or compost?' It's an uncomfortable thought, but one that reminds us of the Circle of Life.

Each sector faces its own challenges. From regenerative fashion⁶³ to regenerative agriculture and tourism. In the IT sector, renowned design firm Frog is trying to offer a helping hand to designers who want to design products in a regenerative way. Their 'Regenerative Compass' is an approachable way to apply ecological principles when designing products and services⁶⁴. It is a small step, but it is telling that a design firm known for always being at the forefront is taking this step. It certainly cannot be ruled out that conversations following this compass will be uncomfortable. After all, the old thinking is still pervasive.

⁶¹Circular X (2024). Regenerative Business Case Database. <https://www.circularx.eu/en/tool/30/regenerative-business-case-database>

⁶²CBC Music (2024, 30 April). Nature is officially an artist on Spotify. <https://www.cbc.ca/music/spotify-nature-artist-david-bowie-brian-eno-1.7189052>

⁶³Minney, S. (2022). Regenerative Fashion. Quercus.

⁶⁴Frog (2024). The Regenerative Compass. https://go.frog.co/the-regenerative-compass?utm_source=Organic+Social&utm_medium=Linkedin&utm_campaign=DesignMind

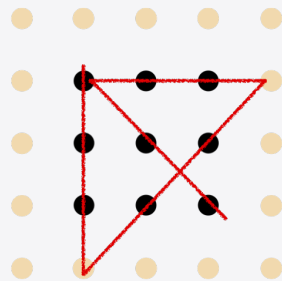


From old thinking to new in six steps

You've likely encountered the classic brainteaser shown below (left). The challenge is simple: without lifting your pen from the paper, draw four straight lines that connect all the dots. The key to solving this puzzle lies in thinking beyond the confines of the box. If you remain within the boundaries, you'll struggle to find a solution. But by expanding your perspective and drawing lines beyond the black frame, the answer becomes clear.



Old worldview



New Worldview

It's a fun and revealing exercise in out-of-the-box thinking. Step beyond your own limitations and assumptions! In the world of management, this type of thinking has been encouraged over the past few decades. However, truly transformative ideas are often seen as too disruptive—and too uncomfortable. That's because the nine dots in the old worldview are tied to deeply ingrained beliefs and established careers.

Thomas Kuhn, the creator of the 'paradigm shift concept', had much to say about this. In his 1962 book *The Structure of Scientific Revolutions*, Kuhn explains how we transition through six stages, moving from what we consider normal, through periods of abnormality, to a new kind of normal. While he was speaking to scientists, his insights have since been widely accepted as applicable to broader social phenomena.



1. Normal Science: In this phase, scientists operate within an accepted paradigm, much like solving a puzzle. They attempt to fit new observations and experiments into the existing framework of theories and methods.

2. Anomaly: Over time, scientists encounter phenomena that cannot be fully explained within the current paradigm. These 'puzzle pieces' that don't quite fit are what Kuhn refers to as anomalies.

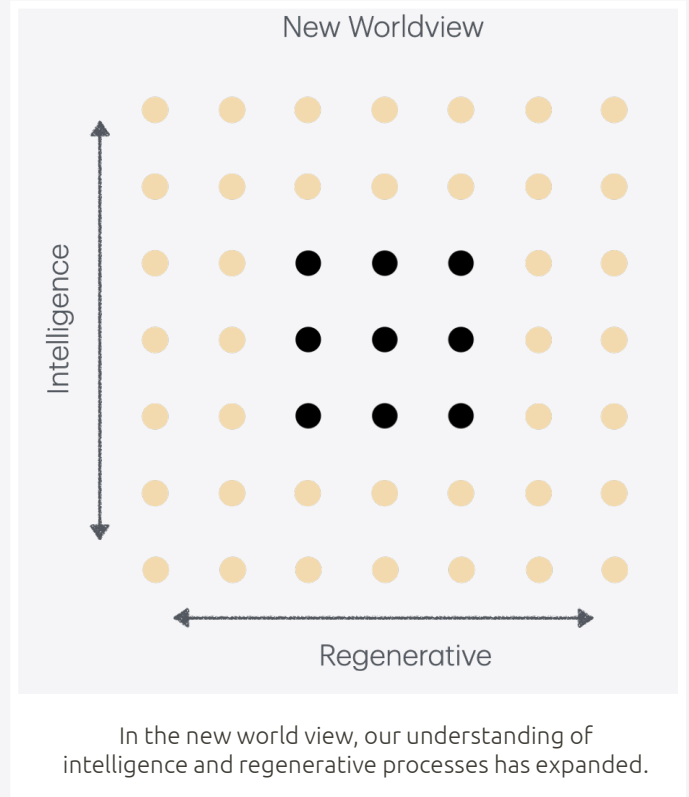
3. Crisis: As more anomalies accumulate, confidence in the prevailing paradigm begins to wane. A crisis emerges, prompting scientists to search for alternative explanations.

4. Revolutionary Science: At this stage, bold new ideas surface, offering entirely different approaches to existing problems. These radical theories often spark intense debate and controversy.

5. Paradigm Shift: If a new theory is compelling enough and garners sufficient support, it can trigger a paradigm shift. The old worldview is replaced by a new framework, reshaping the scientific landscape.

6. Return to Normal Science: After the paradigm shift, a new phase of 'normal science' begins, where scientists now work within the boundaries of the newly established paradigm.

For regenerative intelligence, we exchange the image we had of intelligence and how we generate value for a different worldview. The nine black dots represent our Umwelt. This report invites us to move beyond them.



Degenerative becomes regenerative

Prevailing beliefs about how things are organised start to crumble as anomalies emerge and refuse to fit the established framework. This shift becomes evident when scanning recent headlines: 'Extreme weather threatens apple and pear harvests in the Netherlands,' 'Infertility linked to microplastics in testes,' 'Neurologists warn of a Parkinson's pandemic due to glyphosate,' and 'World economy contracts by 20 percent.' These headlines signal a growing realisation that we are part of the Circle of Life and that everything is interconnected. The dominant degenerative worldview is gradually giving way to a more regenerative way of thinking.

Dysrational is getting really smart

Common sense alone can no longer suffice; the world has grown too complex. The mirror held up by AI and nature reveals the limitations of the human brain, exposing our biases and the effort required for rational thinking. Simultaneously, we are uncovering that our intelligence is just a fragment of a much larger picture. Plants seem to exhibit a form of memory, while quantum effects help birds navigate their journeys. In ecosystems, intelligence emerges through interactions among various life forms. AI is now being leveraged to achieve scientific breakthroughs across a wide range of fields, extending far beyond the confines of traditional paradigms.





This would mark the fifth major paradigm shift in human history—a Revolution with a capital R. Previous transformative shifts were driven by the groundbreaking discoveries of Galileo Galilei, Charles Darwin, and Sigmund Freud. Professor Luciano Floridi has identified a contemporary shift, which we can label as the fourth paradigm. We have learned: (1) that Earth is not the centre of the universe, (2) that humans are an animal species evolving alongside other life forms, (3) that our behaviours are influenced by emotions and unconscious processes, and (4) that we are ‘information bodies’ living in an information society.

Now, we are uncovering a new layer of understanding: we are part of complex ecosystems, embedded within even larger systems. To address the challenges we face, we must recognise that intelligence is not exclusive to humans and embrace cooperation with the billions of years of evolution that precede us. By integrating human, natural, and artificial intelligence, we have the potential to transcend our current limitations and tackle the issues before us.

$$RI = (NI + HI + AI) \times S \times R$$

RI = regenerative intelligence

NI = natural intelligence

HI = human intelligence

AI = artificial intelligence

S = synergy factor

R = regenerative impact

2125 revisited

We started this report with a retrospective from 2125 for a reason: a paradigm shift takes time. Living in harmony with nature sounds appealing, but it feels far removed from today's societal reality. The current trend appears to be moving in the opposite direction: nature is deteriorating, and the planet is warming at an accelerated pace. It's hard to imagine that, in a hundred years, we will fundamentally rethink our relationship with the world and ourselves.

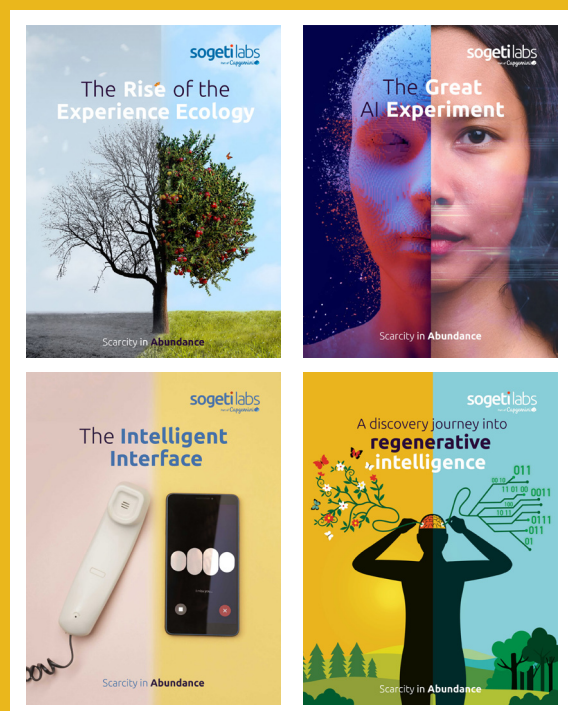
At present, society is in a state of upheaval, with traditional values clashing against new ideas. There's a tension between outdated economic models that prioritise resource depletion and emerging visions that focus on regeneration. Sandra Phlippen addressed this in the first chapter, suggesting that ecology is challenging the economy and may lead to its contraction—a provocative notion that prompts us to question our intelligence.

We are beginning to ask the right questions, and the path forward involves both introspection and a broader perspective. Every paradigm shift reveals more about us. Rather than avoiding the discomfort of this friction, we should embrace it. Engaging with this tension is a crucial step toward creating a world where regenerative intelligence guides our future.



Additional reading

This report is part of the research project 'Scarcity in Abundance'. The central question in it is how two trends changing the world, those of climate disruption and an abundance of artificial intelligence, will play out in response to each other. You can download the reports on the SogetiLabs website.



Glossary

Anthropocene: A proposed era in which human influence on Earth has become so great that it has altered geological and ecological processes on a global scale, particularly through climate change, biodiversity loss and pollution.

Bio-intellectuality: The ability to think and act in harmony with nature, by understanding the intelligence of natural systems and applying it to human technology and policy.

Circle of Life: A holistic view of the natural world, where all life forms and ecosystems are interconnected and influence each other in an ongoing process of interdependence and regeneration.

Eco-engineering: designing and managing systems that use natural ecosystems to solve environmental problems, such as deploying natural solutions to combat flooding or climate change.

Intelligence: The ability to process information, solve problems, learn and adapt to new situations. This report distinguishes between different forms of intelligence: human, natural and artificial intelligence, with all being essential for a regenerative future.

Knowledge: The collection of information, experiences and insights accumulated by an individual or society. Knowledge is crucial for understanding and applying intelligence. Within a regenerative framework, it encompasses both the insights of human technology and the ancient wisdom embedded in nature.

Artificial intelligence (AI): Technology that mimics or complements human intelligence, with applications ranging from machine learning to data analytics, with the potential to solve complex problems and compensate for human shortcomings.

Longtermism: A concept where AI and other technologies are used to think and act in the long term, with the aim of creating sustainable and regenerative solutions for future generations.

Human intelligence: People's cognitive abilities, including the capacity for logical thinking, problem solving and learning, but also characterised by limitations such as short-term thinking and cognitive biases.

Natural intelligence: The intelligence that arises from natural systems and processes, where organisms cooperate and adapt to changing conditions without brain or conscious planned behaviour.

Paradigm shift: A fundamental change in the dominant frame of mind or worldview within a given discipline or society. It marks a shift from an old paradigm to a new paradigm that offers new perspectives and approaches, such as moving from ego-centred to regenerative intelligence thinking.

Ratio dyslexia: A term describing the human tendency to think irrationally or short-sightedly, which often leads to suboptimal decisions, especially in the long term.

Regenerative intelligence: The synergistic integration of natural, human and artificial intelligence aimed at creating sustainable, self-healing systems that promote the well-being of all life forms and ecosystems.

Seva: A Sanskrit term meaning ‘selfless service,’ in this context refers to service to nature, where one acts in alignment with the greater whole, fostering a co-evolutionary reciprocity with the natural world.

Symbiocene: A proposed future era in which the relationship between humans and nature is symbiotic, based on mutual benefit and regeneration, rather than depletion and destruction of natural resources.

Symbiosis: A close and long-term interaction between different types of organisms that help each other survive, such as ants and fungi or whales and plankton, with mutual benefits.

Synergy: The collaboration of different forms of intelligence (natural, human and artificial) to jointly achieve better, more sustainable results than each could individually.

Worldview: The way people understand and interpret the world, including their beliefs, values and perceptions of nature and humanity. A worldview influences how people act, their relationship with nature and their understanding of their role in the bigger picture.

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Menno van Doorn is the director of SogetiLabs’ Research Institute, boasting a career spanning a quarter century in future studies. His accolades include being christened the ‘IT researcher of the year’ by *Computable*, a distinguished IT magazine. Van Doorn’s academic pursuits are deeply rooted in behavioral economics and the science of advertising.



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About VINT labs.sogeti.com

VINT, the Sogeti research institute and part of SogetiLabs, provides a meaningful interpretation of the connection between business processes and new developments. In every VINT publication, a balance is struck between factual description and the intended utilisation. VINT uses this approach to inspire organisations to consider and use new technology. VINT research is done under the auspices of the Commission of Recommendation, consisting of

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SogetiLabs is a community of over 150 technology leaders from Sogeti worldwide. SogetiLabs covers a wide range of digital technology expertise: from embedded software, cybersecurity, deep learning, simulation, and cloud to business information management, IoT, mobile apps, analytics, testing, and blockchain technologies. Visit labs.sogeti.com

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