

## The Island of Knowledge

The limits of science and the search for meaning  
Marcelo Gleiser (Basic Books, 2014)

### Prologue The Island of Knowledge

*What we observe is not Nature itself but Nature exposed to our method of questioning.*  
(W Heisenberg)

loc171 What we see of the world is only a sliver of what's "out there." There is much that is invisible to the eye, even when we augment our sensorial perception with telescopes, microscopes, and other tools of exploration.

193 The map of what we call reality is an ever-shifting mosaic of ideas. My perception of the world around me, as cognitive neuroscience teaches us, is synthesized within different regions of my brain.

232 The higher the energy of the collision, the deeper we see into matter. ... technology limits how deeply experiments can probe into physical reality

That being the case, what could we say with certainty about the properties of matter at energies thousands or millions of times higher than current limits?

Coupled to this technological limitation of how we probe the natural world, advances in physics, mathematics, and computation during the past two hundred years have taught us a lesson or two about the elusiveness of Nature. ... at any given time large portions of the natural world remain unseen or, more precisely, undetected.

262 If large portions of the world remain unseen or inaccessible to us, we must consider the meaning of the word reality with great care. We m

272 And I am refraining from equating ultimate reality with any of the several Eastern philosophical notions of transcendent reality, as in a nirvana-like state achievable through meditation, the Brahman from Hindu Vedanta philosophy, or an all-encompassing Tao. For now, I am only considering the more concrete nature of physical reality, which we can infer through the diligent application of science.

301 Consider, then, the sum total of our accumulated knowledge as constituting an island, which I call the gIsland of Knowledge.

we see that as the island of Knowledge grows, so do the shores of our ignorance the boundary between the known and the unknown."

it should be obvious that our approach is fundamentally limited in scope. This realization should open doors, not close them, since it makes the search for knowledge an open-ended pursuit, an endless romance with the unknown.

## **Part I**

### **The origin of the world and the Nature of the Heavens**

379 Can we make sense of the world without belief?

mythic explanations of natural phenomena were prescientific attempts to make sense of things that were beyond human control, answering questions that seemed unanswerable.

### **2. Beyond Space and Time**

459 The alternative, to leave natural disasters to chance, was just too scary to contemplate, as it would imply in accepting humankind's helplessness and utter loneliness in confronting the unknown. To have a fighting chance to control their destiny humans had to believe.

478 There is a comfort in repetition.

[C] Religious feeling should have had a long gestation period throughout metazoan evolution.

With the advent of the Abrahamic faiths, a radically different way to think about the nature of time made a triumphal entrance: instead of ongoing cycles of creation and destruction, of life and death, time becomes linear, with a single beginning and an end.... For Christians and Muslims, the notion of an after-death Paradise comes to the rescue, and time begets a dual role, linear in life and inexistent in Paradise.

517 The urge to know our origins and our place in the cosmos is a defining part of our humanity. Creation myths of all ages ask questions not so different from those scientists ask today,

### **3. To be or to become? That is the question**

537 A major shift in perspective happened sometime during the sixth and fifth centuries BCE in ancient Greece.

It is quite remarkable that even if the first philosophers of the West lived in a culture with a belief system that relied on a multiplicity of gods to do different things, they searched for a single explanation for reality.

566 Instead of a concrete material substance Anaximander went abstract, proposing that some primordial medium, the boundless (*apeiron*) was the source of all things:

Presocratic Atomists Leucippus and Democritus, and one of the most lucid defenses of atheism ever composed:

This terror, then, this darkness of the mind, Not sunrise with its flaring spokes of light, Nor glittering arrows of morning can disperse, But only Nature's aspect and her law, Which, teaching us, hath this exordium: Nothing from nothing ever yet was born. Fear holds dominion over mortality Only because, seeing in land and sky So much the cause whereof no wise they know, Men think Divinities are working there. Meantime, when once we know from nothing still Nothing can be created, we shall divine More clearly what we seek: those elements From which alone all things created are, And how accomplished by no tool of Gods.<sup>1</sup>

The sharp separation Lucretius advocates between a rational approach to understanding the world and a belief in active deities was not widespread.

623 the Pythagoreans believed that the path toward enlightenment was forged through an understanding of mathematics and geometry, the tools the architect deity used to construct the cosmos.

#### 4. Lessons from Plato's dream

Both Parmenides and the Pythagoreans deeply influenced Plato, who lived between circa 428 and 348 bce. In a sense, Plato unified their modes of thinking, since, like Parmenides, he despised sensorial experience as a reliable source to attain the truth while, like Pythagoras, he embrace geometrical notions as the bridge between the human mind and the world of pure thought, where this elusive truth was to be found.

717 Teleological cosmic view, a cosmoteleology, clashes frontally with the Atomistic motion of cosmic purposelessness.

727 From a scientific perspective, the main obstacle to any teleological explanation is our inability to determine whether it is right or wrong.

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Aristotle would posit that the natural bottom-up vertical arrangement of the four basic substances—earth, water, air, and fire explains why an object made of one of them, when displaced from its medium, would naturally move back to it.

Why should there be a Universe in the first place? What caused it to become? Religions resolve the issue by imposing the existence of a godlike First Cause that exists beyond the constraints of physical laws.

773 To claim that we know how the Universe emerged is both untrue and a great disservice to the public understanding of science. Like it or not, there is a horizon around every island. The Island of Knowledge is no exception.

Ptolemy and most of his Islamic followers never believed the epicycles were real. ...astronomy is not concerned with explanations about the nature of things, only with describing the motions of things celestial,

The question we need to address, then, is whether certain unknowables are here to stay or whether they can be dealt with in due course. Must every question have an answer?

862 The key difference between Copernicus and his predecessors was the attitude toward the reality of his vision: to Copernicus, the Sun-centered cosmos was not simply a computing device but the true arrangement of the world.

## **5. The transformative power of a new observational tool**

966 What Kepler thought would take him a couple of weeks took him almost nine years. In 1609, he proudly published his *New Astronomy*, where he declared that the orbit of Mars was not a circle but an ellipse.

Few examples in the history of science illustrate so clearly the power of high-precision data as a catalyst for a revolutionary shift in our collective worldview.... he had to provide a new physics to explain it.

In 1610, just a year after Keplers *New Astronomy*, Galileo published his *Siderius Nuncius*, usually.

For all of its modernity and revolutionary fire, Galileos astronomical work still showed marked conservatism. In particular, he never believed in Keplers elliptical orbits. Instead, he adapted ideas by the fourteenth-century Oxford scholar Jean Buridan to propose a strange law of circular inertia to justify the circular motions of planets around the Sun.

## 6. Cracking open the dome of heaven

- 1056 Galileo died in 1642, the same year Newton was born.
- 1101 To Newton, the mathematical principles of natural philosophy, the alchemical search for unity of matter and spirit, and Gods role as Creator and keeper of universal order were deeply related.
- 1125 In the General Scholium of the Principia, Newton expressed his belief that God and the Universe were one and the same: “[God] endures alway always and is present everywhere , and by existing always and everywhere he constitutes duration and space.”<sup>2</sup>  
“I am frightened, and am astonished at being here rather than there, why now rather than then. Who has put me here?”<sup>3</sup>

## 7. Science as Nature;s grand arrative

- 1154 We have seen how the game changed with Galileo, Kepler, and Newton, how science became increasingly tool-driven and how the limits of what we could know of the world were reflected in the efficiency of those tools.

## 8. THE plasticity of space

Why  $c$ ? Because *celeritas* in Latin means speed “speed.”

Once lights properties are taken into account, all sorts of bizarre predictions are unleashed: shrinking distances, slowing time, growing masses.... Remarkably, they have all been confirmed in countless experiments.

## 9. The restless universe

- 1338 Once again, a powerful new instrument triggered a revolution in our understanding of the cosmos . Even before Hubble...

In the 1960s physicists Stephen Hawking and Roger Penrose showed that, given reasonable assumptions about the properties of matter, any expading universe must have had a singularity in its past. ...

- 1387 The cosmic singularity points to the need for a new physics, beyond what Einsteins general theory of relativity can provide.

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<sup>2</sup>*Principia* 941

<sup>3</sup>B Pascal, *Pensées*205-6.

Nervous propagation speed is finite.

## 10. There is no now

1398 Now is a cognitive fabrication.

the present exists because our brain blurs reality...

1444 Now is not only a cognitive illusion but also a mathematical trick, related to how we define space and time quantitatively.

## 11/ Cosmic blindness

1583 Everything that we know (and can know) about the Universe comes from information within our cosmic bubble.

1611 Measurements indicate that the contribution to the density from normal atomic matter comes to only about 0.2 atoms per cubic meter, well below the critical value (4.8 percent of it, to be precise.

the amount of dark matter in the Universe comes to a little under six times that of ordinary matter, contributing to the cosmic density at about 25.9 percent of the critical value.

The current leading candidates for dark matter are particles predicted to exist from supersymmetric theories...As of the winter of 2014, no evidence for supersymmetry had been found.

If we only considered the total mass (and energy) from atomic and dark matter and radiation (radiation contributes almost nothing), the Universe would have an open geometry, with only about 30 percent of its critical density. But that's not the whole story.... something akin to a cosmological constant not only exists but dominates the stuff inside our cosmic horizon. The measurements were announced in 1998 and shocked the physics and astronomy communities. ... More remarkably, once the contribution of dark energy to the density of the Universe is computed, the number comes to a little under 70 percent of the critical density...The total adds to the critical density.... the total energy density of the Universe equal to the critical value with an accuracy of about 0.05 percent.

1650 Universes capable of harboring life must reach an old age so that stars go through several generations to produce heavy chemicals with high enough abundance.

## 12. Splitting infinities

1806 What would their final theory be like? It would be no doubt compelling to them , even if profoundly mistaken when viewed from our current perspective.

### **13. Rolling downhill**

### **14. Counting universes**

2042 Healthy science needs a combination of humility and hope.

### **15. Interlude: a promenade along the string landscape**

2067 The discovery of dark energy only happened in 1998. Before then, everyone expected the cosmological constant to be zero, and supersymmetry offered a way to explain how it could be so.

The eternally inflating string multiverse hypothesizes that countless many universes exist out there, unaware of one another. For the first time in the history of science, the unknowable gained the imprimatur of theoretical physics.... according to the Anthropic Principle, a subject of intense debate, our uniqueness is not predicted but postdicted,

2145 Objectors to the usefulness of the Anthropic Principle, including myself, state that it doesn't really help us learn anything new, offering at most a range of plausible values for a given variable by retrofitting what we already know. Anthropic reasoning narrows possible choices of physical parameters based on the properties of the known Universe, but it doesn't offer a pathway to explain why this choice and not others. It accommodates without illuminating. Here is an illustration.

is the multiverse a testable scientific hypothesis , or is it just idle theorizing?

### **16. Can we test the multiverse hypothesis**

2177 There are different ways we can infer that something exists, even if we can't see of touch it. [Multiverse collisions are discussed.]

2236 The inflationary hypothesis and the possible existence of the multiverse stretch the notion of testability in physics to the breaking point.

Our next task is to address the greatest question of them all, the origin of the Universe. For neither cosmic inflation nor the multiverse brings us any closer to an understanding of the ultimate origin of all things.

## **Part II. From Alchemy to the Quantum? The elusive nature of reality.**

### **17. Everything floats in nothingness**

2339 Through his vast body of work, Democritus created a formidable explanatory device

based exclusively on a materialistic description of reality. Still , he was wise enough to caution against the illusion of final knowledge: In reality we know nothing; for truth is in the depth.”

### **18. Admirable force and efficacy of Art and Nature**

2487 Boyles mechanical philosophy, in which he strived to show matter as being composed of particles having only properties of size, shape, motion, and texture, had its origins in late medieval alchemy.

### **19. The elusive nature of heat**

2613 Epicycles described the celestial motions with good precision, even if completely artificial ; phlogiston and, more so, caloric described combustion and heat flow , even if they were completely unphysical. The power of science to narrow in on ever more accurate descriptions of physical reality relies fundamentally on our ability to test hypotheses with ever greater precision.

### **20. Mysterious light**

2752 The constancy of the speed of light was the price that had to be paid to restore order to physics.

### **21. Learning to let go**

2893 There is no cause. In my eyes, this fundamental indeterminateness of the universe has not really been integrated into our worldview yet.  
[C] fundamental indeterminism may be the only logically self-consistent position if one wishes to be logical through and through.

### **22. The tale of the intrepid anthropologist**

### **23. What waves in the quantum realm?**

3056 explaining reality may be too much of a tall order, even for science. Especially if we attach to an explanation some sort of finality, which, as I have argued, is incompatible with the way science advances.  
[C] Perhaps finality is realizable if we go from our side step by step phenomenologically to the extreme states of ‘fundamental physics.f



The price of making quantum mechanics deterministic was to impose an endless web of influence between everything that exists.

#### **24. Can we know what is real?**

3110 Microscopic objects dont exist in the same way you and I exist; they are just constructions of our minds, descriptive devices we create to make sense of what we measure. Why go all metaphysical with it? The above paragraph reflects what sometimes is called the orthodox position.

Put it another way: existence, be it of a quantum or of a classical object, is contingent on minds to acknowledge it. In a mindless Universe nothing exists, since there are no conscious entities aware of what existence even means. The very concept of existence presupposes a mind capable of higher reasoning: existence as a concept is something we invented to make sense of how we fit in the cosmos.

3129 Given that there were no minds at the beginning of time , we must conclude that consciousness is not a precondition for the Universe to be.

I'd argue that the Copernican position hinges on the wrong axis: what matters isnt whether the Universe cares about us, for it clearly does't. What matters is how we fit into the Universe once we understand our uniqueness as conscious beings. I called this position "humancentrism".

3149 We are meaning- seeking beings, and science is one offspring of our perennial urge to make sense of existence.

EPR, etc. here

3259 In many applications physicists cant hide behind Bohrs conveniently pragmatic separation between a quantum system and its classical measurement.

More recently, they have extended their reach to include large biomolecules and intend to test if viruses can be put in a superposition of quantum states and interfere. As the objects size increases and its associated de Broglie wavelength decreases, it becomes much harder (and more expensive) to isolate objects from external influences and place them in a superposition of two or more quantum states. ... Still, the day will come when quantum interference experiments will attempt to pass a bacterium through double slits.

#### **25. Who is afraid of quantum ghosts?**

entanglement

## 26 For whom the bell tolls

Bell: however, no clear explanation or derivation given.

[C] The intelligent being requiring the size of so and so, and quantum entanglements may be fundamentally compemetaryD

Zeilinger experiments.

3474 It appears that nonlocality is more robust than most previously anticipated.

## 27. Consciousness and the quantum world

3515 Crookes, Lodge, and Thomson took part in hundreds of séances, each time with renewed hope that something life-changing would happen. Not so long ago science was still malleable enough to allow for some of its great masters to engage in such pursuits.

Wigner , like Heisenberg before him, realized that any measurement needs a mind to make sense of it.

delayed choice, many-world, Griffiths approach

## 28. Back to the beginning

3702 We identify a similar expectation when certain physicists pronounce that we know how to explain the origin of the Universe using quantum mechanics and general relativity. Of course we dont, and all we have thus far are very simplistic models based on a host of unproved assumptions. The expectation is not just hopelessly na?ve but also philosophically misplaced, given that any model in the physical sciences is built on a scaffolding of idealized concepts, such as space, time, energy, and conservation laws.

To explain the origin of all things we would need to start by explaining the origin of the physical laws that describe this Universe something that is beyond the jurisdiction of current physical theories, including those that ascertain the existence of a multiverse where laws can vary.

3730 The reason why the Moon is not at many places at once along its orbit is because the Moon is not an isolated system.

## Part III. Mind andMeaning

### 29. On the laws of humans and the laws of Nature

3814 We humans share a compulsion: to make sense of the world and to figure out how we fit in, individually and collectively.

Others see this romantic view of mathematics as a form of cryptoreligion  
As George Lakoff and Rafael E. Núñez wrote in the Preface of their thorough study on the roots of mathematical thinking, *Where Mathematics Comes From* “mathematics as we know it arises from the nature of our brains and our embodied experience. As a consequence, every part of the romance appears to be false.”

3875 Sir Michael Atiyah, agree, claiming that timeless truths exist, a background fundamentally there to be discovered. ... I find this sort of belief wholly unfounded.... There is no proof that such transcendent truths exist beyond human perception.

Prime numbers as a concept were an invention, but theorems about prime numbers were discoveries.

3897 As Lakoff and Núñez point out, only a complex mind can contemplate the notion of infinity.

[C] Infinity as the isomorphism to a subset might be primitive.

3906 However, Wigners perplexity, shared by many physicists, is not justified. First, as the great mathematician G. H. Hardy happily recognized, “The geometer offers the physicist a whole set of maps from which to choose. One map, perhaps, will fit the facts better than the others, and then the geometry which provides that particular map will be the geometry most important for applied mathematics,”

Second, even the most abstract mathematics takes off from perceived reality. ... As Lakoff and Núñez argue, to understand where mathematics comes from we must clarify its embodiment, that is, how our thought processes are the result of our cognitive makeup.

3951 The danger, and the origin of the Platonist fallacy, is to believe that the symmetries are an imprint of Nature instead of an explanatory device we conceived to describe what we see and measure.

[C] Symmetry is conceived because our brain is feeble. However, if not brains would not have evolved.

3960 I find myself in the difficult role of being a romantic having to kill the dreams of other romantics.

[C] It is pretty sure these authors do not think abstract to be primitive.

The discussion of mathematics being an invention or a discovery, like the discussion of the nature of physical reality, points more to the importance of the human brain as a rare and wondrous oddity in the Universe than to elusive truths written in some imponderable abstract realm.

### 30. Incompleteness

- 3996 After Gödel, the aura of perfection and beauty that defined thousands of years of Platonic realism in its many variations was lost. The dam may not have burst, but the cracks were visible for all to see.  
[C] However, this is just Heisenberg's uncertainty principle, imagining a dam was illusory. That was all.
- 4046 We can't always answer our questions by following a closed set of rules.

### 31. Sinister dream of transhuman machines: or the world as information

- 4090 The strong AI proposal, known as computationalism, assumes that the brain is essentially decodable, that everything comes down to how neurons communicate to one another and build operational clusters: there is no grand mystery of mind, just current ignorance of what the mind's operational principles are.
- 4156 Nevertheless, there is strong dissent among scientists and philosophers whether we humans are able to understand our own consciousness.  
A more nuanced view is espoused by Thomas Nagel, Colin McGinn, Noam Chomsky, Roger Penrose, and, to a lesser extent, Steven Pinker and others, dubbed collectively as the New Mysterians. Their view, in particular as McGinn has put it forward, is that we are "cognitively closed" to understanding the nature of consciousness. ... human brains have their own cognitive limitations, one of them being understanding consciousness.<sup>4</sup>
- 4164 Nagel explored similar issues in his famous essay *What Is It Like to be a Bat?*, arguing that humans are incapable of experiencing how a bat perceives reality through echolocation. In other words, borrowing from Kant's terminology, what is phenomenon to one sort of brain is noumenon to others: certain things are beyond our categories of understanding, the intellectual tools that serve us well in the study of phenomena.  
Echoing Chomsky and Nagel, McGinn's "transcendental naturalism" doesn't rule out that more advanced brains will understand consciousness: the problem is not unanswerable in principle, it is just unanswerable in principle, it is just unanswerable by us at this point in our evolutionary development.

The Mysterian critique of the computationalist view goes something like this: there is a clear confusion between the physiology of thinking—thinking the phenomenal choreography of neurons flashing and neurotransmitters flowing—and the substance of the thinking process, what the thinking process is about.

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<sup>4</sup>David Chalmers, *Facing Up to the Problem of Consciousness*, *Journal of Consciousness Studies* 2 no. 3 (1995): 200-219

4216 The question of consciousness is deeply related to the notion of reality...We exist in a world that we believe is real. By real I mean a world that is not a fabrication of our minds, that has an existence independent of how we perceive it.

4235 We have seen that what we call physical reality depends very much on how we look at the world and on what we know about the world.... At the most fundamental level, our scientific discoveries define what we call reality.

rmp4246 all of these foundational stones of what philosophers call our ontology, the conceptual entities by which we describe reality, are always transitional.... The best that we can do is to state what we know of the nature of reality today.

[C] However, how organisms live and die is 'universal or at least much more stable since the Origin of Life.

4256 Those who cling to the notion that one day we will arrive at the very fundamental essence of reality are victims of what I call The Fallacy Answers, which have plagued human knowledge since Thales first asked what the world was made of. [C] This author tends to forget evolution.

4345 Combining these arguments with the incompleteness proofs of G?del and Turing and the unavoidable limitations of self-referential logical system of which they are not a part. There is no perfect, seamless simulation. Furthermore, and most importantly, they would fail if they attempted to model a part of the world that includes themselves.<sup>5</sup>

### 32. Awe and meaning

4370 The view of science I presented here is a view of open-ended pursuit.

Science is more than just knowledge of the natural world. It is a view of life, a way of living, a collective aspiration to grow as a species in a world filled with mystery, fear, and wonder.

4408 Any scientific answer to the initial state of the Universe depends heavily on the conceptual scaffolding of the scientific framework—fields, conservation laws, uncertainties, and the nature of space, time, and gravity—and quantum nonlocality defies any hope of having a deterministic explanation of the world of the very small.

any scientific explanation is necessarily limited. ... It aligns science with the rest of the human creative output impressive, multifaceted , and imperfect as we are.

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<sup>5</sup>Paul Cockshott, Lewis M . Mackenzie, and Greg Michaelson, *Computation and Its Limits* (Oxford: Oxford University Press, 2012)