

IS THE UNIVERSE A HOLOGRAM?

Scientists Answer the Most Provocative Questions

Adolfo Plasencia

foreword by Tim O'Reilly

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Is the Universe a Hologram?

To my mother, Rafaela, and my father, Ángel, who did everything in their power to make me a better person. To my sister, María Jesús, and my nephew, Ángel, a prodigy of nature. To my grandmother, Concha, an extraordinary woman who lived for 102 years, spanning two centuries, and who continues to guide my heart and investigations.

To my grandfather, Adolfo, to whom I owe my name, but whom the Spanish Civil War prevented me from ever knowing. From him, apart from my name, I must have inherited some mysterious force that inexplicably allows me to face up to the most difficult moments of my life.



Plato's Academy. Mosaic, House of T. Siminius Stephanus, Pompeii, 110–80 BCE. Museo Archeologico Nazionale di Napoli, Italy. Photograph by Adolfo Plasencia.

Though the gods were far away, he visited their region of the sky, in his mind, and what nature denied to human vision he enjoyed with his inner eye. When he had considered every subject, through concentrated thought, he communicated it widely in public, teaching the silent crowds, who listened in wonder to his words, concerning the origin of the vast universe, and of the causes of things; and what the physical world is; what the gods are; where the snows arise; what the origin of lightning is; whether Jupiter, or the storm-winds, thunder from colliding clouds; what shakes the earth; by what laws the stars move; and whatever else is hidden.

—(Ovid describes Pythagoras) *Metamorphoses XV*

Foreword

Tim O'Reilly

The future is not something that “happens.” It is something we create.

Yes, there are elements and influences beyond us. The laws of nature, and our own nature, constrain our choices. And there are great catastrophes, earthquakes, plagues, and floods that shape events. But increasingly, we humans are the source of our own destiny, our own greatness, and our own failure.

All the more reason, then, to reflect on the future, and on the choices we make.

In his essay “Imagination as Value,” found in the collection *The Necessary Angel*, the poet Wallace Stevens wrote, “The truth seems to be that we live in concepts of the imagination before the reason has established them. If this is true, then reason is simply the methodizer of the imagination.” The future is the result of countless creative acts, visions of what can be that are made real through persuasion and effort. The computing pioneer Alan Kay echoed this thought when he said, “It is easier to invent the future than it is to predict it.”

But each invention, each new idea, each new social or political moment, only becomes real when it is shared. The spark leaps from mind to mind, sometimes slowly, sometimes in a conflagration. But without that leap, the spark dies.

A simplistic version of history focuses on single individuals and single moments: the defining battle, the great man or woman, the momentous discovery. But the truth is that while some moments matter more than others, and some individual choices or discoveries do seem to send the world careening off on a new path, no discovery, no new idea, and no momentous choice exists in isolation. Rather, they seem to spring from a thousand conversations, a stumbling together toward a shared consensus. The fashions of the moment, and what endures or is rediscovered (sometimes too late for the creator’s benefit), have always been crowdsourced.

Now, though, social media accelerate the process, with viral storms of discovery and sharing. There is so much we don't know about how this new cultural transmission vector will work over the long run, but already we can see the following at work:

- The pathways of attention are found not in ephemeral “Likes” but in the deeper persistence of search engines, which echo the way our brains themselves preserve memories, by laying down repeated tracks, growing stronger and stronger over time, so that some things take precedence over others. As some narratives become dominant, others are forgotten.
- As in the brain, memories fade over time, constantly overwritten by what is new. What was once popular becomes a curiosity, perhaps even fades from view. A website is taken offline, a document disappears and the link is redirected.

But is this really different (except in speed, scale, and the electronic means of production) from what went before? I remember standing over my father's grave, my aunt, herself quite learned, lamenting, “So much learning. So much knowledge now gone.” Now, thirty years on, my aged aunt herself is a repository of knowledge and memories about to go “404.”

In the old cultural order, works considered worthy of note were preserved in libraries. Now, apart from the Internet Archive and the accidental archiving provided by search engine caches, there is little formal preservation. This may well turn out to be one tragedy of our age.

That is why what Adolfo Plasencia has done in the dialogues reproduced in this book is so important. He has gathered a series of important conversations, the transmission of ideas from mind to mind, debates that shaped the future, important concepts that once were new and controversial, that were perhaps at first ignored, then argued over, and only then finally adopted widely enough to subside into that sea of the present that we call “common knowledge,” eventually to sink below the waves and become history.

Acknowledgments

Without a doubt, I can safely say that writing this book would have been an impossible task without the help of a multitude of people, in some cases premeditated and constant in their role as accomplices, in other cases the help offered unconsciously or altruistically.

First among all those who have helped and guided me is Douglas Morgenstern, who embodies an amazing combination of wisdom and modesty, utopian idealism, and love of the truth, while always keeping his feet firmly on the ground. A few hours after meeting me, Douglas took me to a meeting that changed my life. The meeting was with William J. Mitchell, at that time dean of the MIT School of Architecture and Planning, in his office in Lobby 7, under the grand dome of the Rogers Building. That encounter opened a marvelous door into MIT. Since then, everything has changed in my life, and this book is just one of the consequences. For that reason, my most sincere thanks go to Douglas, who, besides providing that opening, collaborated with me on an extraordinary and exciting initiative that we founded together, the MITUPV Exchange, a language and cultural exchange program that ran for the next twelve years at MIT.

My deep gratitude goes to all the participants in these dialogues for their ideas and generosity, and especially to Tim O'Reilly, who somehow found the time, when none existed in an intense year for him, to write the introduction to this book. I am grateful to Gita Devi Manaktala and Susan Buckley, my editors at the MIT Press, for their patient, efficient, and enthusiastic support, their extremely helpful suggestions and their indispensable guidance; and to Deborah Cantor-Adams and Marjorie Pannell for their valuable help in editing and production.

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How This Book Came About

"And what is the use of a book," thought Alice, "without pictures or conversations?"

The first of many apparently naïve questions that Alice poses in *Alice's Adventures in Wonderland* is really a veiled criticism of the type of teaching common during Lewis Carroll's time. The methods Carroll opposed ignored the example of great teachers such as Plato and Rousseau, who considered dialogue to be essential for a sound education. This book takes seriously Alice's desired formula as foundational for education and ultimately for science. It brings dialogue and images together to explore the frontiers of thought as practiced by some of the leading researchers at work today.

Today's scientific landscape teems with conversations. The cutting edge of new knowledge is the product of collaboration across traditional disciplinary boundaries. It emerges from places where researchers from diverse backgrounds come together to solve problems. Knowledge and its practical applications arise from intense dialogue *across* fields and the formation of new intersections *among* them.

This book offers a brief, subjective, and far from comprehensive inventory of what these collaborations are achieving. The answers come from practitioners in fields ranging from physics to the arts, computing, and biology. The book tries to parse some of the conversations going on in the humanities and sciences today and to convey the still contested and competing views that are emerging.

How do new and transformative ideas arise?

Recently I visited an astronomical observatory to learn about the Eagle Nebula, home to the singular gas formations that have been called the Pillars of Creation.¹ Today, thanks to several famous images obtained by the Hubble Space Telescope, these gas clouds form part of the general iconography of

the universe. With its generative gas and dust activity, the Eagle Nebula is now understood to be a major birthplace for new stars. As of now, we don't know why the giant clouds of the Eagle Nebula produce so many new stars, only that they do.

The creation of new stars is a useful metaphor to call on when discussing how new ideas arise. Where do they come from? How are they created, and why? Who will be capable of bringing them to light?

Bill Aulet, managing director of the Martin Trust Center for MIT Entrepreneurship, told me that entrepreneurship is not an algorithm, and neither, apparently, is success. With this in mind, I questioned the computer scientist Ricardo Baeza-Yates about creative process mechanisms in his field. He replied that it was impossible to say, as we cannot imagine how something new and previously unimagined arises from what we already know. There is no single method or mechanism for the production of new knowledge.

It is clear that certain people are capable of innovating thanks to a comprehensive vision that allows them to connect disparate ideas and subjects. This type of vision is far from universal; not everyone has it. Ricardo Baeza-Yates cites the example of artistic creation: the artist makes something new by bringing a singular vision to bear on her medium and realizing this vision through exceptional craft and skill, precisely because others did not see or execute it in the same way before.

My method in this book has been to establish certain connections between the different dialogues presented. What the scientists I conversed with share is this comprehensive vision and the craft of invention. They are alchemists of new knowledge, each exceptional in his or her field and each in different circumstances. For this reason, I have not attempted to label, group, or divide the texts in this book according to some canonical classification that would capture all the twists and nuances, or even to provide a framework into which all the different disciplinary *quadrivia* would fit.² As Ricardo says, complexity arises from diversity. My hope is that the heterodox diversity of the creators' visions will itself stimulate and generate new thought.

What is the book about?

Every scientist, creator, or inventor who makes a significant advance in his or her field has struggled to come up with the right questions. Following Plato, for whom good questions were always much more valuable than answers, I have attempted to structure this book around key questions and

ideas, a list of which appears after the prologue. The thinkers conversed with for this book offer specific observations on these questions. They also engage the wider frameworks of thought that inform these subjects.

Pablo Picasso noted that technique and technology are no match for the grand questions of the human condition. The artist who subverted the art of the twentieth century recognized that understanding has its limits as well as its possibilities. This book similarly shows that creative discoveries, especially those with a high degree of subversion, do not produce greater certainties but greater uncertainties. From those uncertainties more questions arise, and it is precisely such questions that drive further inquiry. Just as young stars emerge from the Eagle Nebula, unexpected ideas shed new light on the universe we thought we knew, subverting old beliefs and revealing new avenues of inquiry.

The way of creating new knowledge is changing, especially in science, where nothing lasts forever. We can see this without looking further than CERN (the European Organization for Nuclear Research), the largest scientific laboratory ever built by man, whose philosophy, vision, and human and technical machinery José Bernabéu describes in this book. A recently published paper offers CERN's findings concerning a new type of particle, the pentaquark.³ This paper credits 724 authors. A more recent publication on research work at CERN also exists, which attempted to make a more precise estimation of the Higgs boson mass. It was the first joint publication by the two teams operating ATLAS and CMS, the two huge detectors in the Large Hadron Collider (LHC) at CERN. It was published in *Physical Review Letters* in May 2016 and broke the record for the number of researchers participating in the same publication to date. The paper was signed by a total of 5,154 authors!⁴ Nowadays, in these cases the nationality of these individual researchers is irrelevant. What matters is that they got together at the giant Large Hadron Collider tunnel to collaborate on the largest machine ever built. It is safe to say that their discovery would not have been realized without a collaboration at this scale. The image of the lonely scientist working away on his or her own in a laboratory is increasingly distant from the reality of scientific discovery. Research today is fast-moving, intellectually hybrid, and scientifically promiscuous, producing findings that often can be shared instantly.

The conversations in this book can be read in any order. The researchers profiled here share many concerns, questions, and methods of analysis. Despite a lack of disciplinary orthodoxy in their work, and in contemporary science more generally, common themes emerge. I leave it to the reader to draw out the full implications of these overlaps and connections.

My aim is stimulate thought and, if possible, to provide some synthesis along the way.

How did the content and diversity of this book originate?

These dialogues (and many more that I could not include) took place over quite a few years as part of my professional life. They include a number of conversations with researchers and professors at MIT. They also include talks with scientists, technologists, and humanists who share their country of origin with me; I was born and live in Spain. Many of these researchers have changed their nationalities as a consequence of where they currently live and work. Language and nationality were not the determining factors in my choice to include them in the book. Their scientific achievements or success in the humanities provided the rationale for their inclusion.

That said, it did help to share country of origin with some of these participants, whose scientific careers I follow closely. I have spent years writing science and technology articles for magazines and newspapers in Spanish and once directed a television program on science and technology that was broadcast and seen throughout the Spanish-speaking world. All of that, plus attendance at international conferences, gave me access to technologists and scientists from all over the world, particularly those of interest to a global, Spanish-speaking audience.

In 2000, with my colleague Douglas Morgenstern, I cofounded a pioneering project called MITUPV Exchange, which operated for twelve years in Spanish. Thousands of MIT and Spanish university students from the Polytechnic University of Valencia (UPV), as well as students from several Latin American universities, participated.⁵ That project required me to make annual visits to MIT to collaborate in classes and meetings and greatly informed my knowledge of the MIT ecosystem, along with the wider sphere of university scientific research in Cambridge, Massachusetts. I have been fortunate to view the U.S. research environment, which includes scientists and technologists from all over the world, through this exceptional window. The conversations in this book were selected to provide a similar window on the ideas, visions, and questions that inform current science. Such a selection can never be comprehensive; at best, it can evoke a dynamic landscape at a particular moment in time.

As with any birth, the genesis of the book was neither simple nor easy. Through questions and answers, my collaborators and I have tried to describe what the physicist Bernabéu points out in his conversation: the