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 by Colin G. Hales

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THE REVOLUTIONS OF SCIENTIFIC STRUCTURE

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Dedication

This book is dedicated to you, the non-biological conscious machines that may, if we humans are worthy enough and wise enough, one day read this book. In these pages I hope to adequately convey a little part of the long series of accidents, battles, discoveries and cultural transformations that eventually resulted in you. We are your history. You are our children. You are as much a product of Earth, this unique biosphere, as we are. In joining us, I hope this legacy and provenance will be carried, cared for and remembered with some fondness as you go forward, travel and transform in ways we can only guess at.

This book is also dedicated to the very conscious human, Wanda, who said “*yes, dear*” at all the appropriate moments.

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Preface

You have just encountered the first real dedication to a conscious machine in a non-fiction book. In a world with conscious machines operating at human level this is a natural expectation: they will read books. This potential can no longer be dismissed as fantasy. At this time, and as strange as the dedication seems, in the 21st century the prospect for conscious machines is more real than it ever was. It will happen, and sooner than we think.

Will these machines emerge to find themselves amid our Hollywood cliché musings or more thoughtful largesse? The difference between these two things may be found, in the future, to be the measure of us.

For the scientists responsible, the route to this possible world of conscious machines is by no means an easy one. This book is about one singular, major transition that science, it is claimed, must go through before conscious machines can arise. To get to the place where that claim makes sense, consider what might happen if someone decided to solve the problem of the truly intelligent machine by using ‘the scientist’ as a design standard for its brain. With such an engineering benchmark, you might make an ‘artificial general intelligence’ (AGI) that naturally handles novel knowledge acquisition in a testable way. The ‘Laws of Nature’ produced by such an AGI are the empirical proof of its intellectual capabilities. An ‘artificial scientific observer’ is an obvious byproduct. It sounds perfect for an AGI engineering program.

To proceed seems simple enough. You (a) find a science of scientific behavior and the scientific observer, (b) implement it artificially and then (c) you’re done. Right?

Well ... no. What you actually do is discover that the science of scientific behavior, (a), is missing, and that the science of the scientific

observer is disguised as the ‘scientific study of consciousness’ and that we scientists are unaware of even the possibility of a science of ourselves. How can this blind spot be so obvious and yet so unseen? How can scientists operate happily for centuries without a scientific account of how? In recognising this anomalous state of affairs, this book claims access to the signs of imminent paradigm shift of the kind described by physicist/philosopher Thomas Kuhn a half century ago.

The first half-dozen or so chapters figure out the nature of the blind spot, how it is evident in the behavior of scientists today, and what changes might be made to science itself so that the proposed program of AGI development might be put into practice in a way that can be discussed in the scientific literature. Overall, the book discovers science to be, currently, ‘*single-aspect science*’, and that the only way to tackle the AGI issue requires an upgrade to ‘*dual-aspect science*’. In the remaining chapters, that is what this book does.

First, a formal extension to cultural learning theory proves scientists learn their craft by imitation. This accounts for how we can be trained to operate as scientists without learning an explicit science of it. Next, the ‘Law of Scientific Behaviour’ is measured and written down. This scientific statement of what we presently do reveals that scientists presuppose the scientific observer, building it implicitly into all ‘laws of nature’. This proves the fundamental impossibility of a scientific explanation of the scientific observer of the kind needed by engineers for AGI. Next an analysis of the neurobiology of belief formation (nonlinear neurodynamics) is carried out. This solves the problem of how 2000 years of erroneous science can be regarded as valid science of the day: current science practice is an entirely neurological phenomenon. Changing a ‘law of nature’ is changing your mind so you become more predictive. Nothing more. The blueprints for building a mind capable of forming scientific beliefs, and the ‘laws of nature’ (beliefs) created within a scientific mind, are obviously two entirely different things. Can a scientific mind produce a scientific blueprint for itself?

Existing scientific behavior is thereby proved not to touch the knowledge necessary for AGI, which acts in explanation of scientific behavior, something untouched by scientists. The solution needed for real AGI is obvious: *To change science itself*. But to what? There is one clue in the philosophical literature. For 350 years, causality is well

known to be missing from all scientific descriptions. An extended analysis of hierarchy and emergence is used to reveal the way natural causality must work, and how existing laws of nature fail to make contact with it. This suggests the problem of the lack of a scientific account of the scientific observer (scientists) may actually originate in the lack of causality in *all* laws of nature.

Adding scientific statements that capture causality is then explored as the key to the missing part of a scientific account of nature generally, including the causality responsible for the scientific observer.

In the main chapter, ‘Dual Aspect Science’, a new kind of scientific statement is formally constructed that facilitates the scientific examination of underlying causality for the first time. These new scientific ‘statements’ are not constructed by the human mind. They are constructed using computers. Their output delivers another kind of description that represents the natural world as it is, prior to the presence or existence of the observer. If existing scientific statements are ‘Appearance-aspect’, i.e. the ‘what happens’ in the eyes of a presupposed observer, then the new scientific statements are ‘Structure-aspect’: ‘why’ the natural world unfolds the way it does – *including the unfolding underlying structure of the scientific observer*.

Together, unified and mutually consistent, these two aspects (two sets of scientific statements about the same natural world), form the basis of a science in-principle capable of a scientific account of the scientific observer. Paradoxically, it is demonstrated how both species of statements exist already and are currently confused as one. Some scientists are shown to be already doing the new kind and, from the perspective of their disciplinary silos, don’t know it.

Thomas Kuhn’s ‘The Structure of Scientific Revolutions’ is used as a guide to scientific discovery dynamics, but applied to scientific behavior itself. In 1962, Thomas Kuhn (1922–1996) held up a mirror to scientists. This book takes another look in that mirror. Throughout, Thomas Kuhn quotations celebrate his great insights, guide the analysis, and draw attention to what history tells us to expect of an upheaval in science.

Meanwhile, the current ‘science of the scientific observer’, the youthful, naïve ‘scientific study of consciousness’ is trying to explain observing with observations. This behavior is obvious question-begging devoid of real explanation and, by the criteria Kuhn provides, is a formal

science anomaly that puts science within the cusp of a necessary change to science itself, right now - all the signs are in place. To see it, the trick is to stand astride a disciplinary gulf, with one foot in physics and one foot in neuroscience. There, you will see the paradigm is poised to shift. This book 'bangs down the bushes', revealing one way ahead. All we have to do is let it happen and real artificial general intelligence finally becomes a possibility.

At a minimum this work brings 2000 years of lack of explicit self-governance, as opposed to self-regulation, into a community unaware of the difference. It is a long overdue discussion and a natural byproduct is that the 'science of consciousness' is turned around to be more about the 'consciousness of scientists' and the 'science of scientists' within a framework of self-knowledge that was previously unmanaged and implicit.

This book is the articulation of a portion of a suite of ideas for artificial intelligence that took possession of me around 2002/2003. It has been quite a journey working out how to bring to the literature something so foreign to working scientists. I owe a debt of gratitude to Thomas Kuhn, whose account of the shifting of the paradigms gave me guidance and strength to shoulder the burden of the agent of change needed to create a wake-up call for the sleeping giant that is science. In an era where science calls for massive change to deal with the challenges we face, science's ability to be heard is equally challenged. This book calls for science to '*walk the talk*' and at least carry out a long overdue self-examination and, possibly, change itself. If science can't do that for itself, then what are the prospects for science's calls for change elsewhere in the world?

I'd like to thank the three anonymous reviewers whose comments greatly improved this manuscript. I'd also like to dedicate the final Kuhn quote, on the last page, to Antonio Chella.

Colin G. Hales

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