

Without God the universal cart must come before the cosmic horse

The Demon in the Machine: How hidden webs of information are solving the mystery of life

Paul Davies

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Multi-award-winning physicist and science writer Paul Davies is currently Regents Professor at Arizona State University and Director of their *BEYOND: Center for Fundamental Concepts in Science*. His awards include the Templeton Prize (1995), the Kelvin Medal (2001), the Faraday Prize (2002), the Order of Australia (2007), and the Klumpke-Roberts Award (2011). His research interests include cosmology, quantum field theory, biology, and astrobiology, and he is chairman of the *SETI: Post-Detection Science and Technology Taskgroup* of the International Academy of Astronautics. He also serves on the Advisory Council of *METI (Messaging Extraterrestrial Intelligence)* and is an adviser to the *Microbes Mind Forum*.¹

In his *Preface* Davies begins with the question ‘What is Life?’ following Nobel Prize winning quantum physicist Erwin Schrödinger’s 1944 book of the same name:

“I’m not a biologist, I’m a physicist and cosmologist, so my approach to tackling big questions is to dodge most of the technicalities and home in on the basic principles. ... The huge gulf that separates physics and biology ... is unbridgeable without

fundamentally new concepts. Living organisms have goals and purposes—the product of billions of years of evolution—whereas atoms and molecules just blindly follow physical laws. Yet somehow the one has to come out of the other” (pp. 1–2, all page numbers refer to Kindle edition).

And what are these “fundamentally new concepts?”

“The unifying concept that underlies this transformation is *information*, not in its prosaic everyday sense but *as an abstract quantity which, like energy, has the ability to animate matter. Patterns of information flow can literally take on a life of their own, surging through cells, swirling around brains* and networking across ecosystems and societies, displaying their own systematic dynamics. It is from this rich and complex ferment of information that *the concept of agency emerges, with its links to consciousness, free will and other vexing puzzles. It is here, in the way living systems arrange information into organized patterns, that the distinctive order of life emerges from the chaos of the molecular realm [emphases added]*” (p. 2).

The book is a good read—telling us about the latest research into the wonders of life—but by the end, all he has to offer is what he says here, that ‘somehow’ disembodied ‘surging’ and ‘swirling’ of information flow patterns becomes the ‘agency’ which brings chemicals to life and brains to consciousness (see figure 1).

For a scholar of Davies’ stature, it is a rather dismal ending to a stellar career.



Cognitive dissonance

As a self-styled ‘astrobiologist’ (they are all self-styled as they have no subject matter to justify that appellation) perhaps Davies has become so used to living with cognitive dissonance that he simply forgot that information flow patterns—even if they can “literally take on a life of their own”—still require the *hardware* of life to *flow through*. Ignoring the hardware of life (the intricate and irreducibly complex molecular structures in cells) is an egregious error of “basic principles”. It is not only Davies who has made this error, but so too have the many colleagues and reviewers whom he lists on two-and-a-half pages as having helped him review the book!

It is a fundamental characteristic of many complex systems that the whole can become more than the sum of its parts. It is especially true of living organisms, but it is also true of many man-made machines. A classic example is the aeroplane—which is made of parts that cannot fly but when assembled and operated in the correct manner *can* fly. Indeed, that is why we create machines—because the package-as-a-whole can do things that the separate parts cannot. And it is crucially true of living cells or they

would not survive! Life can exist (and persist) only when all parts of cells are present and functional to maintain and repair themselves and endure through procreation. But whatever ‘the whole’ can achieve above and beyond what the parts cannot, that special achievement crucially depends upon the parts and *cannot* exist without them (or at least a functional subset of them).

In his haste to solve the problem of the origin of life and the origin of consciousness Davies has ‘put the cart before the horse’. Information can indeed “surge” and “swirl” through living systems but *only* because they have been designed, constructed, and operated in such a way that enables and uses such information flows. Without the intricate molecular *structures* that make up living systems there would be no *function* which could involve and utilize information flows!

What is life?

Having put the cart before the horse, Davies nosedives into an entirely inadequate definition of life (p. 24):

“Life = Matter + Information”

He expands upon the definition by highlighting reproduction as the crucial point:

“The essence of biological reproduction, then, is the replication of *heritable information* [emphasis in original]” (p. 24).

This is a standard neo-Darwinian error—viewing heredity as genetic rather than cellular²—so we cannot blame Davies for it. However, its erroneous corollary (that evolution is open-ended) is peppered in its consequences throughout the book.

If, as Davies claims, information flow was an *agent* in the origin of life then it must have existed prior to life’s origin. This is another fundamental error in “basic principles”. But, as a physicist, he would have no problem with information existing before life because he knows that he can conjure up any amount of physical (statistical) information from any given mucky

mess of chemicals because it can be mucked about with in infinitely many different ways. That is how physicists calculate the information content of any system—by working out how many different configurations of particles it can be arranged into. All you then have to do is suppose that just one of those ways happened to form a living cell.

But the information that drives and maintains living organisms is far more sophisticated, precise, and durable than that. Life uses *coded* information—a fact that Davies acknowledges but is completely unable to derive from his statistical understanding based in physics. As a result, in his subsequent discussions of life and information, he is doing nothing more than ‘driving blind.’

Life is ‘demonic’

The ‘demon’ in the book’s title is, of course, Maxwell’s demon. Imagine a sealed box containing gas molecules at equilibrium, having a wall dividing it into two halves and a sliding door in the wall allowing single gas molecules to pass freely, one at a time, between the two halves. Now imagine a tiny ‘demon’ standing by the door ready to open and shut it at will. If the demon chooses to open the door when a faster-than-average gas molecule approaches from one direction, and closes it when slower-than-average molecules approach, and *vice versa* with molecules approaching from the other side, then after some time he could violate the second law of thermodynamics and turn a box of gas at equilibrium temperature into a box with just hot molecules in one end and cold molecules in the other end. That ‘demon’ if it ever existed would be a Maxwell demon!

Note, crucially, that Maxwell demons are *intelligent agents*—a point that Davies must deliberately ignore to justifiably reject an intelligent designer of life.³

Lo and behold, Davies reveals that life runs on Maxwell demons!

Yes, the machinery of life ‘steals’ energy from the random jiggling (called ‘thermal energy’) of the atoms and molecules in all its parts in much the same way that an electric bicycle or a hybrid gasoline/electric car draws energy from its environment to supplement its primary power source (a battery).⁴

Having established this fact, Davies then highlights the role of information in life and evolution:

“Evolution operates on biological software just as it does on hardware; we don’t readily notice it because information is invisible. Nor do we notice the minuscule demons that shunt and process all this information, but their near-thermodynamic perfection is a result of billions of years of evolutionary refinement” (p. 109).

Here we see another fundamental error of “basic principles”. As a Darwinist, Davies must subscribe to the ‘slow-and-gradual, simple-to-complex’ model for the origin of life, yet here he admits that it runs on mechanisms that are thermodynamically “near perfect”. In chapter 5 Davies will tell us that life’s ‘demons’ work by drawing on the power of quantum mechanics, but to achieve this they must act extremely quickly and within “stringent design requirements” or they will be overwhelmed by thermal noise. Correspondingly, first life must have also been thermodynamically “near perfect” or it would not have survived, so the supposed “billions of years of evolutionary refinement” had nothing at all to do with it!

To explain the information connection, Davies draws an analogy with computers. He begins with a history of computing, the development of Shannon’s statistical theory of information, its relationship to entropy, attempts to build a Maxwell demon machine, and why computers generate heat. It turns out that Maxwell’s demon doesn’t violate the second law of thermodynamics because the information-processing

required—when repeated over and over again—uses energy and generates waste heat so that overall entropy is increased.

At this point Davies nails both his feet firmly to the floor as he describes the work of Rolf Landauer who,

“... calculated the minimum amount of entropy needed to erase one bit of information, a result now known as the Landauer limit. ... By demonstrating a link between logical operations and heat generation, Landauer found a deep connection between physics and information, not in the ... abstract ... sense ... but in the very specific (that is, dollar-related) sense in which it is understood in today’s computing industry. From Landauer on, information ceased to be a vaguely mystical quantity and became firmly anchored in matter” (p. 46).

By jumping onto Landauer’s work as evidence that information is “firmly anchored in matter” Davies gives himself an excuse to ignore the “vaguely mystical” multiple dimensions of coded information that lie beyond its statistical properties (i.e. semantics, syntax, pragmatics, and apobetics).⁵ He refers back to Landauer’s work later when driving home his message about human consciousness:

“... we cannot disconnect mind from matter. As Rolf Landauer taught us, ‘information is physical’, so minds must perforce also be tied to the material goings-on in the brain” (p. 192).

His commitment to materialism is absolute.

The logic of life

Davies begins chapter 3 as follows: “The story of life is really two narratives tightly interwoven. One concerns complex chemistry The other is about information ...” (p. 67).

Another fundamental flaw in “basic principles”! The “complex chemistry” (a huge challenge to explain

in its own right) must be carried out within an intricately structured system of compartments because many of them are incompatible (e.g. oxidation and reduction) and most of them require single-molecule precision in their reaction sequences. Even the tiniest bacterium—which has no internal ‘walls’—still contains molecular structures which constrain and control the complex chemistry. The *structure* of life is therefore an irreducible foundation for the *function* of life,⁶ but Davies entirely ignores it. Despite this, in a long exposition of mathematical logic, he does come to a useful insight:

“Life’s ability to construct an internal representation of the world and itself—to act as an agent, manipulate its environment and harness energy—reflects its foundation in the rules of logic” (p. 72).

And as one of several examples, he commendably cites the award-winning work of Eric Davidson in painstakingly unravelling the Boolean signalling networks that control the early stages of embryo development in the purple sea urchin (p. 106).



Figure 1. Jupiter’s Great Red Spot is Paul Davies’ ‘favourite example’ of spontaneous structure formation in non-equilibrium systems, which he offers to show that similar phenomena could be precursors to life. But this is a ‘tornado in a junk yard’ compared to the minuscule mechanisms in photosynthesis which can take single photons of light and turn them into food using quantum weirdness (at ambient temperature) boosted by thermal noise (using Maxwell demons).

Quantum demons

In chapter 5 Davies introduces quantum mechanics and demonstrates from several examples that life uses quantum ‘spookiness’ to achieve things that would otherwise be impossible. The challenge is that quantum effects occur on such a tiny scale that they are easily overwhelmed by the thermal noise that constantly assails all parts of a cell at ambient temperatures. That is why quantum physics experiments are usually carried out at exceedingly low temperatures where interference from thermal noise can be reduced to almost zero.

The key to life’s success in garnering energy from the quantum realm at ambient temperatures is to do it extremely quickly before thermal noise destroys the ‘magic moment’. In fact, life goes one better and ratchets thermal noise into the quantum transaction to make it go even faster and thus even more efficiently! However, to achieve such marvels of molecular engineering:

“Stringent design requirements must be met to transport charges rapidly and efficiently along specific pathways and prevent the off-path diffusion ... and the disruption of energy flow” (p. 150).

How was this achieved? It was, of course, “honed by evolution” (p. 150). But this argument is self-refuting because he just told us that life doesn’t work (so evolution doesn’t happen) if its mechanisms are either slow or sloppy!

Almost a miracle

In chapter 6, Davies addresses what he sees as his central challenge:

“In his Dublin lectures Schrödinger identified life’s ability to buck the trend of the second law of thermodynamics as a defining quality. ... By coupling patterns of information to patterns of chemical reactions, using demons to achieve a very high degree of thermodynamic efficiency, life conjures coherence

and organization from molecular chaos” (p.166).

How does life do this?

“Chemistry alone, however complex, can never produce the genetic code or contextual instructions. Asking chemistry to explain coded information is like expecting computer hardware to write its own software” (p. 167).

What then?

“What is needed to fully explain life’s origin is ... the organizational principles of information flow and storage and the manner in which it couples to chemical networks, defined broadly enough to encompass both the living and non-living realms. And the overriding question is this: can such principles be derived from known physics or do they require something fundamentally new (p. 167)?”

Davies rules out probability as an explanation:

“You cannot determine the probability of an unknown process! We cannot put any level of confidence—none at all—on whether a search for life beyond Earth will prove successful (p. 177).”

He then considers experimental attempts to create artificial life and what the conditions might be for a successful outcome. He rejects an intelligent designer, but he comes up with a commendable formula:

“What would swing the debate is if, by synthesizing life many times and in many different ways, scientists uncovered certain common principles which could then be applied to real-world conditions” (p. 179).

This makes sense. If these conditions were ever met, then there would be a case for estimating the probability of life occurring elsewhere in the universe. But, of course, it will never happen.^{7,8}

The ghost in the machine

In his seventh and final chapter Davies considers the enigma of consciousness. He gives an instructive

outline of contemporary thinking based on research outcomes, including theories that include quantum mechanics (e.g. the Penrose–Hameroff theory, which incorporates the effects of anaesthesia [unconsciousness], p. 206). However, he ends up despairing that the question may never be answered.

Epilogue

In the Epilogue Davies finally shows his cards.

“While it is the case that biological information is instantiated in matter, it is not inherent in matter. ... it is impossible to derive the laws of information from the known laws of physics. To properly incorporate living matter into physics requires new physics. ... nothing less than a revision of the nature of physical law itself (pp. 209–210).

Since “What a system does depends on how a system is”, Davies argues that we require a new set of self-referencing state-dependent laws (of physics) that exert top-down system-level causation (p. 212). I don’t think he actually knows what he is talking about here because this description fits an intelligent design scenario. However, he disdainfully rejects a creator God because:

“It would imply a type of cosmic magician who sporadically intervenes, moving molecules around from time to time but mostly leaving them to obey fixed laws” (pp. 216–217).

His conclusion:

“These speculative notions are very far from a miracle-working deity who conjures life into being from dust. But if the emergence of life, and perhaps mind, are etched into the underlying lawfulness of nature, it would bestow upon our existence as living, thinking beings a type of cosmic-level meaning. It would be a universe in which we can truly feel at home” (p. 217).

Conclusion

Although this readable book reports a great deal of important progress in our understanding of life and consciousness, its conclusions are unavoidably silly. Davies does not understand biology well enough, nor does he understand biological information well enough, to do justice to his subject matter. The “Demon” in the title of the book is real (Maxwell’s Demon), the “Machine” is real (the awesome molecular mechanisms that use Maxwell Demons), but disembodied “information flows” are certainly *not* “solving the mystery of life.”

Biological errors⁹ (plus others noted at [Amazon.com](https://www.amazon.com)) further reduce the credibility of the book and its conclusions. Astrobiologists should get their facts straight about Earth life before they presume to speak about alien life.

References

1. Paul Davies, en.wikipedia.org/wiki/Paul_Davies, accessed 14 May 2020.
2. Williams, A.R., Heredity is foundationally cellular, not genetic, and life’s history is discrete, not continuous, *J. Creation* 28(3):73–79, 2014.
3. The only known intelligent agents are living organisms and man-made information-processing machines.
4. An electric bicycle uses pedal power and downhill running to recharge its battery; a hybrid car uses deceleration and downhill running to recharge its battery.
5. Gitt, W., *In the Beginning was Information*, CLV, Bielefeld, Germany, 1997; updated as *Without Excuse*, 2011.
6. Williams, A.R., Life’s irreducible structure—part 1: Autopoiesis, *J. Creation* 21(2):109–115, 2007.
7. Williams, A.R., What life isn’t, *J. Creation* 29(1):108–115, 2015.
8. Williams, A.R., What life is, *J. Creation* 29(3):62–70, 2015.
9. E.g. “human DNA contains about 1 billion bases” (p. 38) when it is more like 3 billion; “the human genome codes for about 20,000 proteins” [i.e. assuming ‘one gene = one protein’] when the number is more like 80,000 to 400,000 according to the *Human Proteome Project*; “entomologists” instead of “entomologists” (p. 102); “When an embryo develops from a fertilized egg, the original single cell (zygote) starts out with almost all its genes switched on (p. 105)” when in fact the opposite is true.