

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

Author: Paul Davies, PhD

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Review by Jorge Fernandez, January 2021

**Preface**

I had heard about Davies’ award-winning book – *The Demon in the Machine: how hidden webs of information are solving the mystery of life* (hereafter simply ‘*Demon*’) – and that it had been named the top physics book of 2019 by *Physics World*, a publication of the UK Institute of Physics.<sup>1</sup> Knowing a little bit about Paul Davies, I wanted to learn more.

The Table of Contents in *Demon* listed Chapter 2: Enter the Demon, Chapter 6: Almost a Miracle and, Chapter 7: The Ghost in the Machine. Hmm... a “demon”? “Almost a miracle”? The “ghost in the machine”?<sup>2</sup> Curiosity grows.

Then there were these quotes: “Matter plus information equals life” and “Information pervades biology” and finally, “But to fully explain life, do we need a new law, one that couples information and matter at all levels of complexity? Schrödinger was prepared for it, and after many years of research I have come to agree. Biology demands a totally new kind of physical law, built on the theory of information.”<sup>3</sup>

Okay, I’m in! I decided to get a copy of *Demon* and review it with some Comprehensive Information Theory (CIT)<sup>4</sup> in the background. That is the main thrust in what follows.

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<sup>1</sup> <https://phys.org/news/2019-12-demon-machine-physics-year-uk.html>

<sup>2</sup> ‘The ghost in the machine’ is a phrase coined by Oxford philosopher Gilbert Ryle in 1949.

<sup>3</sup> <https://phys.org/news/2019-12-demon-machine-physics-year-uk.html>

<sup>4</sup> Comprehensive Information Theory (CIT) is a new information theory by me; expected to be published in 2021.

## What is 'information'?

As expected, almost immediately Davies begins using the term 'information'. Davies says,

“Schrödinger put his finger on the main issue. For life to generate order out of disorder and buck the second law of thermodynamics, there had to be a molecular entity that somehow *encoded* the instructions for building an organism, at once complex enough to embed a vast quantity of information and stable enough to withstand the degrading effects of thermodynamics. We now know that this entity is DNA.” *Demon*, pg. 6

A good place to start was to see how Davies defined 'information' and so I began to search for that definition in *Demon*. That search proved to be challenging. Davies speaks of

- “a vast quantity of information” (p. 6), without defining the entity - 'information' - that was measured to get that “vast quantity”
- “information as a unifying feature” [of multiple subjects] (p. 7), without describing exactly what that feature is
- “Biological information is stored” (p.19), without saying what biological information is (what is it that is being stored)
- “information about earlier generations is passed along” (p. 24), without telling us exactly what is it that is being passed along
- “information makes a difference in the world” (p. 35), without telling us what information is
- “living organisms ... manipulate information ... conjuring order from chaos ...”, without telling us exactly what is being manipulated
- “Organisms are awash with information” (p. 62), without telling us exactly what it is that organisms are awash with
- “The cell as a whole is a vast web of information management” (p. 64), without telling us exactly what is being managed
- “biological information is not merely acquired, it is *processed*” (p. 65), without telling us exactly what is being processed

and many similar instances where the term information is used without ever providing a clear, unambiguous definition of the term.

Ah, but wait. On page 41 Davies states: “... *information is the reduction in the degree of ignorance or uncertainty about the system being measured.*” This is, of course, the definition of information from the work of Claude Shannon.<sup>5</sup> If this is to be taken as the definition of information that Davies uses throughout, then it is not clear how that definition applies to the various uses of the term ‘information’ bulleted above. As a specific example, when Davies says, “Biological information is stored” (p.19), how does a biological entity *store* a ‘reduction in the degree of ignorance or uncertainty about the system being measured’?

Furthermore, Davies repeatedly conflates ‘information’ with *a measure* of information - an error reminiscent of one view of intelligence: “Intelligence is what is measured by intelligence tests.”<sup>6</sup> Davies is far from being alone in making this ‘categorical confusion’.

### **A Materialistic Darwinist**

Somewhere I had picked up the impression that Davies was sort of ‘on the ideological fence’ - a Materialist with reserved doubts about Materialism and therefore genuinely open to Theism. Maybe that was because Davies had been awarded the Templeton Prize. Whatever the reason, clearly my impression was wrong. As I progressed through *Demon*, I realized that if Davies was straddling the ideological fence this was being done solely for optics - perhaps to appeal to both camps. In fact, Davies is deep-seated in Materialistic Darwinism. Throughout *Demon*, Davies injects comments always in support of the Materialistic Darwinist position.

For instance, on page 61 Davies is speaking of RNA transcription and mentions the fact that there are occasional errors in that process. Davies comments, “Which is good: remember, errors are the drivers of Darwinian evolution.” Davies is referring to the Darwinist belief that errors generate variations and then natural selection ‘selects’ those variations that are ‘best fit’ (the “survival of the fittest” story). Let me pursue that trail for a moment.

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<sup>5</sup> Shannon, C. E., *A Mathematical Theory of Communication*. Bell System Technical Journal, Vol. 27, pp. 379–423, July 1948.

<sup>6</sup> Boring, E.G., Intelligence as the tests test it. *New Republic* 36: 35-37, 1923.

What Davies and the other Darwinists repeatedly fail to consider is that their story completely falls apart when used to account for the *origin* of what they observe. The logical argument goes something like this: Davies et al. acknowledge the immense complexity and sophistication of the biological reproductive system including the DNA/RNA copying process. But then, “Errors are good”, says Davies, “errors are the drivers of Darwinian evolution”.

Fine, so what accounts for the *origin* of that system? Was it by ‘errors’? No, that is impossible for two reasons. First, before a reproductive system can generate *erroneous* results (‘errors’), that reproductive system must be capable of generating *accurate* results – an effect cannot precede its cause.

Second, it is preposterous to even suggest that an entire succession of ‘errors’ generated an exquisite system of immense complexity and sophistication that is capable of reproducing countless sub-systems each also immensely complex and sophisticated. On the contrary, what went into that system had to be mostly accurate/error-free, properly integrated, and robust. Let us not forget that not only do we have an immensely complex and sophisticated reproductive system, but that system also contains error-*correction* mechanisms. So, how did that error-correction mechanism *originally* arise? What *corrected* the error-correction system?

Was it by chance or by successive trials? No, that option is mathematically excluded since in any realistic scenario the probability of that event is, in essence, *zero*. That alone demolishes their beliefs which is why they must find ways (such as invoking an infinite number of universes) to increase that ‘*zero*’ probability - to force the mathematically impossible to become ‘possible’. If that does not work, then how about invoking yet-to-be-discovered physical laws that are able to perform the necessary ‘magic’? This is what Davies suggests in *Demon*.

The upshot is that Materialists cannot account for the *origin* of their alleged “driver of Darwinian evolution” - their *origin* of species is a misnomer.

Another instance where Davies demonstrates that he wholly embraces the Materialistic position is on page 70 where he confidently states that, “... we know that human thoughts and actions are ultimately driven by brains that obey the laws of physics.” Thus, for Davies, ‘the mind and the

brain are one'. That is an expression of Materialism: there are not two distinct realms (material and nonmaterial); there is only matter: *everything* is mass-energy subject to physical laws.

*Demon* contains many other occasions where Davies' Materialism shines through - not that I think he was trying to conceal it. One, that I found humorous, is inside of Box 6 on page 89. Davies writes, "... if there is a third gene, Z, designed (by evolution!) to be switched on ...". Okay, so where is the humor?

Recall Richard Dawkins' famous quote, "'Biology is the study of complicated things that give the appearance of having been designed for a purpose".<sup>7</sup> The term "design" has since become anathema to any hardcore Materialist-Darwinist. So, I imagine a scene where Davies is proof-reading the *Demon* manuscript and comes to "... if there is a third gene, Z, designed to be switched on...". Horrified by his blasphemous Freudian slip ("designed") - which would surely have brought all hell upon him - Davies quickly inserted "**(by evolution!)**" to dodge that bullet. Note the exclamation point - Davies wanted to emphasize where his allegiance is.

Maybe because he was rattled by what *almost* happened, Davies does not notice that he had just labeled evolution a *designer!* But wait, 'evolution is driven by errors' (those are *his* words). Furthermore, evolution has no purpose, strives for no goal. So, how did purposeless errors *design* the exquisite computational logic that Davies describes in Box 6 on page 89? How are independent physical states and processes "strung together" (Davies' words) to form logic circuits that perform formal computations thereby transcending the material realm? In any event, and perhaps due to a dark sense of humor, I thought that section was 'funny'.

### **The Logic of Life**

Before the end of Chapter 2 I had been suspecting that Davies' 'demon' was 'information'. But then Davies ends Chapter 2 with the following: "Living organisms are not just bags of information: they are *computers*. It follows that a full understanding of life will come only from unravelling its computational mechanisms." (p. 66). Ah, so Davies' 'demon' was not just information but also the *management* information. This was the 'demon' introduced by James

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<sup>7</sup> Dawkins, R., *The Blind Watchmaker*, W.W. Norton & Company, New York, USA, p. 1, 1986.

Clerk Maxwell in 1867, a ‘demon’ capable of (hypothetically) violating the Second Law of Thermodynamics.

Davies begins Chapter 3: The Logic of Life by stating that “*Biological information is the software of life.*” (p. 74). To focus on other matters, I will set aside the issue that I had previously brought up (namely, what *exactly* is ‘information’? Overall, Shannon’s definition does not satisfy Davies’ many diverse uses of the term ‘information’.).

Davies goes on to describe a path of historical events that included David Hilbert (1862-1943), Kurt Gödel (1906-1978), Alan Turing (1912-1954), and John von Neumann (1903-1957). That path culminates with John Conway’s (1937-2020) cellular automaton called the *Game of Life*.<sup>8</sup>

Davies is fascinated with the emergent, unpredictable novelty that appears in cellular automata. In that reaction Davies reminded me of how Richard Dawkins was likewise captivated by how he was able to make ‘Methinks it is like a weasel’ ‘evolve’ in just 41 steps of ‘selective breeding’ – in *seconds* instead of millions of years – and how radically diverse and complex “biomorphs” emerged starting with just a few simple biomorph forms.<sup>9</sup>

Dawkins’ foolhardy arguments and conclusions in *The Blind Watchmaker* were not surprising given his technical background and fanatical devotion to Materialism-Darwinism. However, Davies’ reaction to the related situation (with cellular automata) was, to me, unexpected.

Both cases have the same general explanation: what was produced is entirely the result of what was inserted. Dawkins’ accelerated ‘evolution’ of ‘Methinks it is like a weasel’ was due to the directing information that was smuggled into the computed ‘evolutionary process’. That information acted as a guide, telling ‘evolution’ where to go. That was how this ‘evolution’ occurred millions of times sooner than it should have. Of course, Dawkins’ world is not

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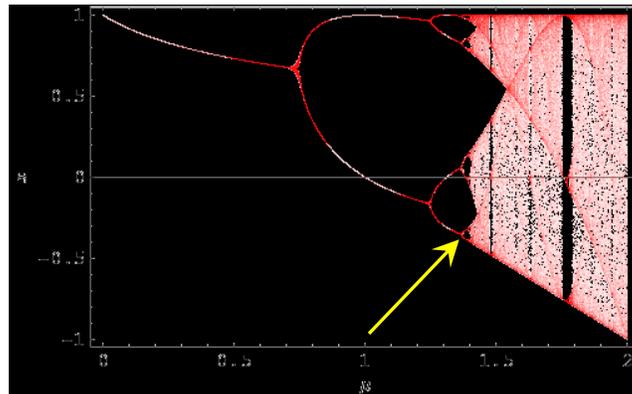
<sup>8</sup> A *cellular automaton* (CA) is simply a discrete model for computation. As an example, imagine a 3-by-3 grid containing nine equal boxes or cells. Each cell may be in one of two states (e.g., black, or white). Start with any initial configuration (e.g., any three cells black, the rest are white). Now establish some rules. Finally, set the process in motion – apply the rules over and over. Sometimes nothing exciting happens; other times incredible dynamic patterns emerge, some even ‘life-like’.

<sup>9</sup> Dawkins, R., *The Blind Watchmaker*, Chapter 3 and Appendix I, W.W. Norton & Co., Inc., 1996

supposed to contain any guidance - there is no ‘designer’. But Dawkins inserted a designer - *himself* - into the process. In short, *cheating* was involved.

In biomorphs and cellular automata, the results are due to the arbitrary formal conditions established at the onset and then applying the rules time and again - millions and even billions of times - on each successive state (each state represents a transformed entity). Indeed, that process can generate surprising results up to and including innovations and deep revelations.

Instances of this occur regularly in mathematics. In one case, when the products of a simple equation were graphed, something unexpected was revealed. I am referring to what became known as Feigenbaum’s Constant ( $\delta = 4.669\dots$ ).<sup>10</sup> Skipping over a myriad of technical details, when a relatively simple ‘rule’ (an equation) was applied iteratively - first to a starting condition and then to each successive result - and the results of those computations were graphed, a graph such as shown below was produced:



Starting at the upper left and moving to the right, we observe a graph that at first is a simple line. That line splits (bifurcates) into two branches and each of those two branches then splits into two branches and so on. At some points (e.g., where the arrow is pointing to) the graph goes from simple lines to a jumbled mess of points and lines. That transition indicates the onset of mathematical *chaos* - an unexpected revelation with profound, far reaching significance. Just as unexpected was a peculiar number (Feigenbaum’s Constant,  $\delta = 4.669\dots$ ) that was discovered in

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<sup>10</sup> For those interested in learning more, link to <https://www.youtube.com/watch?v=ETrYE4MdoLQ>

Last accessed 26 Dec 2020. Image is from Wolfram MathWorld, free license.

this picture - a number that connects countless mathematical results and physical phenomena. Again, surprising revelations and innovations often pop up in such analyses.

That is what occurred with the biomorphs and cellular automata. Then, the surprising, novel results can be viewed or interpreted as potential explanations for events in biology, even for life itself. However, a fundamental reality is usually missing from those views and interpretations.

What they seem to miss is that everything that occurs with biomorphs and cellular automata is the result of applying some formal system within an artificially restricted environment. With this they create a digital ‘cartoon world’ where everything is subject to a set of arbitrary definitions, axioms, and rules. Change any parameter in that formal system and the end results will change dramatically. There are two relevant points to consider here.

First, physical laws are not arbitrary, nor can they be postponed or changed by desire. Thus, the laws that govern gravity and electrodynamics are presumed to be and apply the same everywhere at all time - the Uniformitarian Principle (which is sacrosanct for the scientific establishment).

Second, formal systems never occur in unguided natural phenomena for the simple yet powerful reason that formal systems require free choices.<sup>11</sup> But unguided mass-energy is incapable of free choices since unguided mass-energy is always and wholly subject to physical laws, be those laws deterministic or probabilistic.

It is understood that the biomorphs and cellular automata are meant merely as *models* of reality, not reality itself. What I am pointing out is that these models are so far removed from reality - they omit so much of the real world - that they predictably lead to erroneous conclusions and false views - even to suggesting what is physically (not just computationally) impossible.

This is like the powers and actions of ‘superheroes’ (such as ‘Spider Man’) in movies. Those superheroes perform their feats *only* because they often violate laws of physics. That scenario is not too far off from certain OOL (Origin of Life) claims stemming from digital exercises

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<sup>11</sup> A *free* choice is a choice that is/was made *not* due to: situational restrictions, previously made by another entity, programming, or dictated by deterministic or probabilistic physical laws.

involving biomorphs, cellular automata and others<sup>12</sup>. Just as the superhero movies are fantasies void of physical reality, that is also the case for biomorphs, cellular automata, and evolutionary models.

So, while something may be gleaned from those digital exercises, care must be taken to mitigate the results lest we become detached from physical reality. Darwinist promoters such as Davies and Dawkins habitually violate that wisdom. They project the results of artificial ‘life’ - derived solely by computation in a fixed, sterile world - onto actual life which is subject to innumerable interdependent physical influences and constraints. That same oversight probably led Gregory Chaitin to say that, “Creativity in biology is not that different from creativity in mathematics.”<sup>13</sup> Let me suggest that the correct expression of that idea ought to be, ‘creativity in *computational* biology is not that different from creativity in mathematics’.

### **More of the same: a parade of errors**

At the top of page 75 Davies wishes to remind us that “Heritable errors are, of course, the driver of Darwinian evolution.” Davies then adds, “If a von Neumann machine<sup>14</sup> is to serve as a model for biology, it must incorporate the two key properties of self-replication and evolvability.”

Following Davies’ premises and logic, and since errors are the drivers of Darwinian evolution, then a von Neumann machine (VNM) would have to generate errors and propagate those errors to future ‘generations’ (replicas) of the VNM.

For the remainder of the book, Davies goes on to present a number of topics - most are quite fascinating - that involve information and the mechanical and *formal* processing of information. Each of these cases invokes, directly or indirectly, Davies’ ‘demon’. Among those cases are:

- John Conway’s Game of Life (p. 75)

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<sup>12</sup> Others include evolutionary models like EV and Avida, in which digital organisms are created and then they ‘evolve’.

<sup>13</sup> From a 2010 interview with Gregory Chaitin, quoted in *Demon*, p. 67.

<sup>14</sup> Here, a *von Neumann machine* refers to a Universal Constructor (UC) where a UC is a machine that, subject to a supply of all necessary raw components, is able to build anything that is in principle constructible *including itself*. In constructing a copy of itself the UC must include the *instructions* (the *information*) for building itself since those instructions are also a part of itself.

- Formal computation by cells (p. 89)
- Decision-making and intelligence in collections (p. 101)
- The mystery of morphogenesis (p. 104)
- Electricity and life (p. 111)
- Two-headed worms and Lamarckism (p. 115)
- Cancer (p. 131)
- Quantum effects in life (Chap. 5, p. 144)
- The (almost) miraculous origin of life (Chap 6, p. 166)
- Consciousness: a temporal ‘ghost’ in a machine (Chap 7, p. 184)

All throughout those discussions, in Davies one senses a man with heavy internal conflicts. On one hand, Davies cannot help but marvel at the things that he observes - things that his own knowledge and experience strongly indicate that something far deeper than mere mass-energy and physical laws at work.

On the other hand, Davies is totally committed to Materialistic Darwinism. Thus, as his ideology demands (not his *science* - his *ideology*), Davies cannot and will not allow a ‘Divine Foot in the door’.<sup>15</sup> Therefore Davies is obligated, “in spite of the patent absurdity of some of its constructs”, to propose other alternatives - *anything* - to what his own internal sense indicates is more likely the correct answer. In short, Davies is at war with himself (and will likely remain that way for as long as he remains faithfully attached to his present beliefs).

This is all summarized in the Epilogue of *Demon* (pp. 209-217). Davies began *Demon* by telling the readers that he wanted to investigate what life *is*, not what life *does*<sup>16</sup>. Ideologically, Davies

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<sup>15</sup> “Our willingness to accept scientific claims that are against common sense is the key to an understanding of the real struggle between science and the supernatural. We take the side of science in spite of the patent absurdity of some of its constructs, in spite of its failure to fulfill many of its extravagant promises of health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism. ... Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door...” Quote is by Richard Lewontin from, *Billions and billions of demons* (review of *The Demon-Haunted World: Science as a Candle in the Dark* by Carl Sagan, 1997), *The New York Review*, p. 31, 9 January 1997.

<sup>16</sup> *Demon*, p. 1.

is committed to answering that question *solely* in terms of material physics - after all, ‘there is nothing else’, right? Therefore, Davies proposes the only possible answer to his conundrum: *a new physics with new physical laws!*

If physical laws are thought of as ‘rules, then the essence of the new physical laws that Davies proposes must be capable of changing as a function of the state of the system. In other words, the rules must be *dynamic* and contextually dependent, not static, and contextually independent - p. 212 - (for example, Newton’s  $F = ma$  is static and contextually independent).<sup>17</sup>

Once again, Davies uses cellular automata to support his idea. However, Davies does recognize that these are but “cartoons” of reality (p. 213). Undeterred, Davies holds on to his belief that, “There is plenty of room at the bottom for novel physics to operate in a manner hitherto undetected ...” (p. 213). In other words, Davies believes that there are as-yet-undiscovered physical laws, or at least systematic regularities, that will explain the observations – observations that include ‘miraculous’ origins, ‘ghosts’ in machines, and ‘demons’ that seemingly oppose the second law of thermodynamics.

On pages 214-216, Davies presents some of the formidable challenges and questions that his proposal would face. As one example (p. 215), if there are new physical laws at work, how are these new laws integrated with the *known* laws of physics? Davies brings up several other obstacles/questions. Davies does admit that “all of this has to be worked out” (p. 216).

Davies then gives his readers (pp. 216-217) a Materialistic Darwinist sendoff typical of the likes of Richard Dawkins and Daniel Dennett:

- “Before Darwin, it was widely believed that God created life.”
- “Today, most people believe it [*life*] had a naturalistic origin.”
- “While it is true that scientists lack a full explanation for how life emerged from non-life, invoking a one-off miracle is to fall into a god-of-the-gaps trap. 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.”

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<sup>17</sup> My own Comprehensive Information Theory (CIT) contains something along those lines but certainly not the same as Davies’ notions.

Finally, Davies ends by mentioning two contrasting hypotheses of life's origin: one by Jacques Monod and the other by Christian de Duve. Of them Davies says, "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 of living, thinking being a type of cosmic-level meaning. It would be a universe in which we can truly feel at home." (p. 217)

Obviously, to Davies the creator God of Christianity would *not* bestow "cosmic-level meaning" to our existence nor would we be "in a universe in which we can truly feel at home" - even though the entire universe was created for our habitation, contemplation, and knowledge of our Creator. In this I find Davies' logic to be ... perplexing.

#### Footnotes:

1. <https://phys.org/news/2019-12-demon-machine-physics-year-uk.html>
2. 'The ghost in the machine' is a phrase coined by Oxford philosopher Gilbert Ryle in 1949.
3. <https://phys.org/news/2019-12-demon-machine-physics-year-uk.html>
4. Comprehensive Information Theory (CIT) is a new information theory by me; expected to be published in 2021.
5. Shannon, C. E., *A Mathematical Theory of Communication*. Bell System Technical Journal, Vol. 27, pp. 379–423, July 1948.
6. Boring, E.G., Intelligence as the tests test it. *New Republic* **36**: 35-37, 1923.
7. Dawkins, R., *The Blind Watchmaker*, W.W. Norton & Company, New York, USA, p. 1, 1986.
8. A *cellular automaton* (CA) is simply a discrete model for computation. As an example, imagine a 3-by-3 grid containing nine equal boxes or cells. Each cell may be in one of two states (e.g., black, or white). Start with any initial configuration (e.g., any three cells black, the rest are white). Now establish some rules. Finally, set the process in motion – apply the rules over and over. Sometimes nothing exciting happens; other times incredible dynamic patterns emerge, some even 'life-like'.
9. Dawkins, R., *The Blind Watchmaker*, Chapter 3 and Appendix I, W.W. Norton & Co., Inc., 1996
10. For those interested in learning more, link to <https://www.youtube.com/watch?v=ETrYE4MdoLQ> last accessed 26 Dec 2020. Image is from Wolfram MathWorld, free license.
11. A *free* choice is a choice that is/was made *not* due to: situational restrictions, previously made by another entity, programming, or dictated by deterministic or probabilistic physical laws.

12. Others include evolutionary models like EV and Avida, in which digital organisms are created and then they ‘evolve’.
13. From a 2010 interview with Gregory Chaitin, quoted in *Demon*, p. 67.
14. Here, a *von Neumann machine* refers to a Universal Constructor (UC) where a UC is a machine that, subject to a supply of all necessary raw components, is able to build anything that is in principle constructible *including itself*. In constructing a copy of itself the UC must include the *instructions* (the *information*) for building itself since those instructions are also a part of itself.
15. “Our willingness to accept scientific claims that are against common sense is the key to an understanding of the real struggle between science and the supernatural. We take the side of science in spite of the patent absurdity of some of its constructs, in spite of its failure to fulfill many of its extravagant promises of health and life, in spite of the tolerance of the scientific community for unsubstantiated just-so stories, because we have a prior commitment, a commitment to materialism. ... Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door...” Quote is by Richard Lewontin from, *Billions and billions of demons* (review of *The Demon-Haunted World: Science as a Candle in the Dark* by Carl Sagan, 1997), *The New York Review*, p. 31, 9 January 1997.
16. *Demon*, p. 1.
17. My own Comprehensive Information Theory (CIT) contains something along those lines but certainly not the same as Davies’ notions.