A Critique of Intelligent Design

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Intelligent Design (ID) has been critiqued many times before (Miller 2000; Collins 2006; Alexander 2008, 2009). The purpose of this chapter will be to review a more recent publication from an ID proponent on cell biology to determine whether there have been any significant advances in ID thinking since the movement first came to prominence, and to assess the arguments made from scientific, philosophical and theological perspectives. The book to be scrutinized is *Signature in the Cell* by Stephen Meyer (Meyer 2010).

A few initial comments on terminology may be useful. The term 'intelligent design', spelt all in lower case, is sometimes used to refer to the general argument from design familiar as part of natural theology in which the existence or even attributes of God are claimed to be inferred from particular properties of the natural world. For those speaking from this perspective, it would be unexpected to find any particular scientific theory in conflict with such 'intelligent design', given that it refers to the intelligibility of the universe and its properties that render the scientific enterprise feasible.

By contrast, Intelligent Design refers to a specifically anti-Darwinian movement, distinct from creationism, that emerged in the USA during the early 1990s. The flagship centre of the movement is the Discovery Institute of the Center for the Renewal of Science and Culture located in Seattle, Washington State, USA. Apart from the conviction that Darwinian evolution represents a naturalistic philosophy, and therefore should be opposed, the

other main theme uniting an otherwise somewhat eclectic group of ID proponents is that there are biological entities that are so complex, and so interdependent in their functioning as far as their components are concerned, that their existence cannot be explained by gradual Darwinian processes, pointing to 'design' as the best explanation for their coming-into-being.

The ambiguity of the term 'Intelligent Design' is deepened by the great range of meanings attached to the word 'design', a word commonly used with at least four distinct meanings in the English language. First, design can refer to 'an arrangement of form and appearance, with overtones of purpose'. Any living biological organism will fit such a meaning in a way that rocks and stars do not. It is this meaning that provides the teleological discourse for which biology is famous. Living things exist to feed, survive and reproduce. They are goal-oriented, which is one of the ways in which we distinguish life from non-life.

The second meaning implies a 'specific detailed plan'. This is the language of the engineer or the architect. The bridge is as it is because designed in the mind of the engineer; it could be no other. A third meaning of 'design' refers to the generation of a set of rules, as in chess or a computer game, in which there may be many different outcomes and moves in the game, but in which the designed constraints entail that only some things can happen and not others.

A fourth meaning entails the more general out-working of intentions and purposes. The Government 'designed' the national lottery for the express purpose of funding worthy enterprises in the arts and in sport, in the process extracting money from those least able to afford such expenditure. J.K. Rowling 'designed' seven Harry Potter novels to fulfill her intentions

and purposes for the character Harry Potter. Many details of character and of plot changed along the way as the novels were written, but the overall purpose of the series remained intact.

This list by no means exhausts the various nuances of the word 'design', but for our present purposes it is worth noting that in the term 'Intelligent Design' the word 'design' is being used by ID proponents in its second sense to refer to the design of a specific complex entity in biology, akin to the outcome of the design of an engineer or an architect.

The important role that the various meanings of 'design' play in the discourse of ID proponents will become apparent as we consider the main arguments presented in Stephen Meyer's book.

The Signature In the Cell

The author writes this book with a background in the history and philosophy of science and presents his work as a 'trade-book' that surveys the findings of others - biochemists and cell biologists - interpreting the science within the framework of ID arguments. The basic cell biology, of the kind that can be found in any undergraduate textbook, is in general presented accurately and only occasionally does the author's lack of scientific expertise become apparent in the text.

The first part of the book sets the scene with some historical and philosophical material that begins to introduce the author's stance towards the nature of scientific explanations and ideas about information in biology. Several chapters then describe our current scientific understanding of DNA and protein structure, the genetic code, the regulation of gene expression, protein biosynthesis, and the origin of life, underlining the present gaps in our scientific knowledge concerning the incremental, step-by-step processes

whereby such entities might come into being. Given the author's perception that these gaps are significant, he concludes this first section by surmising that there might be a "design hypothesis – that could be legitimately considered as a possible explanation for the DNA enigma" (page 135). The rest of the book is then focused on arguing for the plausibility of such a "design hypothesis".

Meyer did his PhD in Cambridge at a time when the late Peter Lipton was Head of the History and Philosophy of Science Department; it is therefore no surprise to find that his argument depends to a large extent on abductive reasoning involving 'inference to the best explanation' (Lipton 1991). In inductive reasoning a universal law or principle is established from repeated observations of the same phenomena. This contrasts with deductive reasoning in which a conclusion is deduced by applying a general law or principle to a new context. In abductive reasoning, however, unseen facts, events or causes in the past are inferred from data available in the present. Evolutionary theorizing, for example, is largely built on abductive reasoning, since the speciation events that led to our present understanding of the evolutionary bush of life are interpretations based on our present knowledge of anatomy, genetics, geographical distribution of species, fossil data, and so forth. We were not there to observe the speciation events; they are inferred from presently known data.

The question for Meyer is: what can we infer as the best explanation for the origins of the kind of biological information and complexity that we see in the structure and functioning of cells? In seven further chapters Meyer then surveys the various attempts that have been made by scientists to explain the origins of this complexity. This involves a discussion of the role of chance and the idea of 'specified information' (chapters 8-10), the origins

of the genetic code (chapter 11), complexity and emergent properties of systems (chapter 12), computer models for the origin of life (chapter 13) and RNA as the original information-containing molecule (chapter 14). Demonstrating via these seven chapters to the author's own satisfaction that none of these approaches provide adequate explanations, Chapter 15 then argues the case for ID as the 'best explanation' for the origins of specified information, drawing also on ID proponent Bill Dembski's 'design detection' approach to show how this produces the same conclusion (chapter 16).

Having invoked ID as an 'explanation' for the origins of certain forms of biological complexity, Meyer is only too aware of the kind of critiques that may be mounted against such a claim. Chapter 17 is thus committed to the important question as to whether ID counts as a valid explanation for anything, chapters 18 and 19 to the question as to whether ID counts as science and chapter 20 to the claim that ID represents a religious belief. A final Epilogue presents a smorgasbord of ideas about ID and an Appendix lists some predictions of ID that, the author suggests, thereby demonstrate that ID has the characteristics of a scientific theory.

In what follows our aim is not to critique all the various points raised in this wide-ranging book, but rather to focus on the main themes that are central to the author's argument.

Is ID science?

A consistent plea within *The Signature in the Cell*, and within the ID movement more generally, is that ID be accepted as science rather than as philosophy or theology. Media reports have often suggested that this is merely a political strategy to smuggle religion into US classrooms under the

guise of science. However, although there is some evidence to suggest that the attempt to present ID as science is connected with the radical separation of religion and state enshrined in the US constitution, there seems no good reason to accuse ID proponents of bad faith on this point, and the majority, perhaps all, clearly do believe that ID is science. It is therefore a fair question to ask as to whether the theory suggested in the present volume has the characteristics of a scientific theory.

Philosophers have generally rather given up on the earlier 'demarcation discussion' as to what does or does not count as science. The reason is that it can become a rather sterile discussion with different angels dancing on different pins in different disciplines. It is indeed striking how much science can vary depending on discipline. On the other hand there is no need to go to the other extreme of suggesting that 'anything goes', as in the more anarchic understanding of science presented in the Austrian philosopher Paul Feyerabend's book *Against Method* (Feyerabend 1975). And scientists do care a lot about what counts as science, because science as a body of reliable constructed knowledge comes at a high price, with a lot of grant-writing, a hard slog at the bench (in the case of the biological sciences), the sweat of writing papers, peer-review and publication, and the extensive social interactions within the scientific community that play such a key role in the advance of science.

From a practical perspective, it is also vital that scientists get things right. In the case of the biomedical sciences, this may mean the difference between life and death. In the case of genetic engineering, this could make the difference between a hungry population or a nutritionally healthy population. In the case of climate change, this could mean the difference between millions of people being displaced from low-lying areas with the

melting of the polar ice-caps, or not. So truth-telling in science is not some academic whimsy, but really does make a difference to our everyday lives, for good or for ill.

Given that fact, it is fairly obvious why scientists really do care about what counts as science. Contra post-modern claims that different language games have equal claims to assent, scientists actually believe that some things are true and other things are false. Somewhat self-serving claims by Meyer that the question as to what science represents is a "trivial" definitional problem, a "semantic" dispute (page 399), really won't do – the stakes are much higher than that. Each discipline has its own particular criteria for justifying its truth-claims and Christians of all people should be concerned to be truth tellers within the domain of science, given that the whole purpose of the scientific enterprise is to describe the properties of the created order as accurately as possible.

At a sociological level, one can define science as what is published in scientific journals. Mere publication does not of course guarantee its truth. Often the data are correct but the theory presented with its accompanying interpretations quite false, something that only becomes apparent with the benefit of hindsight. Science is a self-correcting process.

The definition of science as being what is published in scientific journals only pushes the question further back: what, then, are the characteristics that articles published in scientific journals have in common? And then the task becomes rather easy to simply list those characteristics. In practice very few types of science involve the complete list, but there should be a sufficient number of items from the list that no-one from the relevant scientific discipline is in any doubt that a particular piece of investigation

belongs to science rather than philosophy, theology, astrology, politics or cooking. The list includes the following:

1. Science in its methodologies excludes questions of ultimate purpose, value and significance. By contrast Aristotelian science included final causality as one of the explanatory features of nature. But empirical science only really began to take off in the 16th and 17th centuries as it became more modest in its ambitions and began to exclude final causes from its explanations.
2. Science looks for testable hypotheses.
3. Scientific explanations involve problem-solving but do not simply describe the problem using different words, but provide insights into how the physical world actually functions in ways that lead on to further empirical research.
4. The possibility of falsifiability raises the likelihood that an explanation belongs to scientific discourse.
5. Predictive success is the mark of a good scientific theory.
6. Science aims at formulating generalisations about the properties of things whenever possible; the highest levels of generalisation are called 'laws'.
7. Science values mathematics highly and is expressed in mathematical terms whenever appropriate and feasible.
8. Science aims at objectivity and down-plays the role of the scientific observer, deliberately excluding the personal.
9. Scientific knowledge aims to be publicly observable and repeatable; it is only taken seriously within the scientific community following publication in peer-reviewed journals.

10. Scientific theories are more valued when they lead to fruitful research programmes involving a growing peer-reviewed literature and, eventually, practical applications.

Here we will pick out just a few items from this list to see how ID fares as science, several of the listed items being discussed at some length in *Signature in the Cell*.

Starting with the last item first, we note that since ID was first seriously mooted in the early 1990s, it has resulted in a very meager crop of publications in the peer-reviewed scientific literature. ID proponents are quick to point out that there are at least some publications, but in reality the term 'intelligent design' or even the word 'design' are absent from such texts. Instead the publication typically seeks to show that a detailed evolutionary description of the origins of the protein folds that provide a particular enzymatic function, or of a complex biological system, or of the Cambrian explosion as revealed in the fossil record is, it is claimed, not explicable by Darwinian mechanisms, implying that some other kind of explanation is necessary. The authors of such papers will invariably claim that they are barred by reviewers and editors from using the language of 'design' in their papers, which might well be the case, but this in turn should help to focus the mind on whether the notion of ID provides any kind of satisfactory alternative explanation, as discussed further below. Given that the notion of 'design' forms no part of such publications, such as those from the experienced molecular biologist Douglas Axe, director of the ID-funded Biologic Institute in Seattle (Axe 2004; Axe, Dixon, and Lu 2008), this point in itself rather underlines the fact that the scientific data published can stand satisfactorily on their own without any need for interpretation along the lines of 'design'.

The criterion of generating a successful biological research programme may readily be illustrated by reference to an actual scientific theory, at first controversial, that was first published in the early 1980s (though with its roots back in the 1960s), suggesting that a misfolded 'prion' protein was the infectious agent in the disease scrapie that affects sheep and goats. This idea was in sharp contrast to all the other infectious agents that had been discovered to date, be they viruses, bacteria or parasites, that all contain either DNA or RNA in combination with proteins. The idea of a misfolded protein causing disease by conveying its misfolded state by a kind of domino effect to other proteins inside the cell, was and is a bizarre notion that remains a topic of active research. But that initial insight in 1982 has been immensely fruitful and it is now known that BSE in cattle ("mad cow disease") and Creutzfeldt–Jakob disease (CJD) in humans are likewise caused by prions. The initial characterisation of the prion was introduced to the scientific literature in a single paper (Bolton, McKinley, and Prusiner 1982), around a decade before ID came to public attention, but since that time there have been 5,396 scientific papers published with 'prion' in their title[1], illustrating the hugely successful research programme initiated by the prion theory.

The very fact that ID as an idea needs to be defended in trade-books, of which *Signature in the Cell* provides an example, immediately underscores the point that ID has not been found to be a useful idea within the scientific community. A useful scientific idea or theory is quickly picked up by laboratories around the world, so generating a vigorous new programme of well-funded research. ID is not in that category of ideas.

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[1] Data from PubMed. Accessed 21st April 2011.

What about testability as a way of assessing whether ID lies within the domain of science? And are there any ways in which it can be falsified? To assess those questions we need to consider a little more carefully the kind of ID explanation that Meyer offers. Cell biology, it is suggested, offers many examples of 'specified information', referring to complex systems such as the 64 triplet codons that specify the sequence of amino acids in proteins. It is the highly specific sequence of amino acids in proteins as specified by the information provided in the genes that gives each protein its unique functional properties. It is on the origins of such complex cellular systems that *Signature in the Cell* focuses.

The next step in the argument depends on the approach, already mentioned, of the 'inference to the best explanation'. Since the language of 'origins' immediately takes us into the realm of the 'historical sciences' such as cosmology and evolution, the only option open to us is to infer what happened in the past by reference to data collected in the present. This then leads on to what the author claims is an 'exhaustive' investigation of the various 'materialistic' explanations that have been offered. How satisfactory that 'exhaustive' investigation really is will be considered further below, but here we simply note the structure of the argument.

Given the presumed failure of other explanations, Meyer then suggests that the only option left to us is to infer that the complex cellular system in question displays ' intelligent design', "the deliberate choice of a conscious, intelligent agent or person to effect a particular outcome, end, or objective". The argument is made in a similar way to other ID publications by drawing attention to the way in which design is inferred in cryptography, archaeology or in the assumptions underlying the SETI programme. In short, Meyer claims that since we are quite good at inferring the products of

intelligent minds, namely human minds because these are the only ones we know about, so, by analogy, we can infer that all this specified information found inside cells is likewise the product of intelligence, and is therefore 'designed'. The way in which the word 'design' is used in this context is in line with its second meaning as summarized in the introduction above, referring to a 'specific detailed plan' as in the language of the engineer or the architect.

Does invoking 'design' count as a scientific explanation? Meyer draws attention to those natural philosophers of previous centuries such as Isaac Newton who did indeed invoke 'design' in their scientific publications. Newton famously maintained that God brought about an occasional 'reformation' in the movement of the planets to correct the irregularities that accrued from the supposed friction occurring as they passed through the 'aether' (an 'aether' which we now know does not exist). Even at the time the German Lutheran philosopher and mathematician Leibniz took Newton to task for invoking occasional miracles whereby God would remedy the deficiencies in his creation. Indeed, by the end of the eighteenth century the French mathematicians Laplace and Lagrange had shown that irregularities induced in planetary orbits could be self-correcting. Apparently there was no need for God's occasional corrections.

So the argument that 'design' is in some sense a scientific argument, on the grounds that there have been natural philosophers in past centuries who have invoked it as if it were a scientific explanation, turns out to be a hostage to fortune. The notion in each case has been unfruitful, readily displaced by explanations that refer to physical forces and realities. Indeed, as highlighted in the list given above, it was as early modern science began

to abandon the Aristotelian quest for ultimate causes in order to focus on proximal causes that the scientific enterprise really began to make progress.

Invoking 'design' as an explanation for the origins of specified complexity in biology therefore looks like a straightforward category error. A distal Aristotelian cause is being invoked to explain what really requires a better set of proximal explanations to give insights into the processes whereby complex biological systems come into being. Since the problem is one concerned with molecules, their properties, and their coming into being in certain kinds of assemblies, then we expect a scientific explanation that will address how this might occur. The problem with invoking 'design' as an explanation becomes particularly acute when we consider the question: "What further experiments should I now do based on this putative explanation?" The answer is that there aren't any. The situation is reminiscent of Peter Woit's critique of the proliferation of speculative multiverse models as exemplified by the myriad solutions of string theory. His book was entitled *Not Even Wrong* (Woit 2006).

It is this point that explains why the ID notion has not led to any kind of coherent research programme. The most it can do is to motivate research projects showing that explaining the origins of complex biological entities, like protein folds, is a challenging problem. But we knew that already; the notion of ID does not add anything to our absence of knowledge in this research area, except to highlight the challenge. Furthermore, there are laboratories all round the world working on scientific challenges, such as the evolutionary origins of protein folds, and making significant progress

(Zeldovich et al. 2007; Lin et al. 2008; Ferrada and Wagner, 2010) without any need to invoke the notion of 'design'[2].

Finding tests that would falsify the idea of 'design' as an inference to the best explanation for the origins of biological complexity is as problematic as understanding how 'design' counts as an explanation in the first place. Describing a complex system as 'designed' sounds more like adding an extra descriptive label than like a scientific explanation. So what experiment would falsify such a label? Meyer offers not a single possible experiment that would help in this respect. Instead he offers philosophical arguments that are presented as a type of 'testing' (pages 404-407) and as a type of 'falsifiability' (pages 428-433), but in reality are not.

The misunderstanding of the author concerning what counts as scientific testing, certainly in the arena of the biological sciences, is revealed in this comment: "Since empirical considerations provide grounds for rejecting historical scientific theories or preferring one theory over another, such theories are clearly testable. Like other historical scientific theories, intelligent design makes claims about the cause of past events, thus making it testable against our knowledge of cause and effect". The author then goes on to claim that "*historical* scientific theories typically do not make predictions that can be tested under controlled laboratory conditions…". But this is not the case. For example, natural selection can readily be shown to operate under controlled laboratory conditions, as can changes in reproductive fitness in controlled population experiments. Furthermore, evolutionary theory could readily be refuted by an accumulation of counter-

[2] See also: Dennis Venema, 'Evolution and the origin of biological information'. http://biologos.org/blog/evolution-and-the-origin-of-biological-information-part-4/. Accessed 24th April, 2011.

evidence. Rabbit fossils could be found in the pre-Cambrian. Human footprints could be preserved along with those of the dinosaurs in the mud from the same river-bed. Had the genetic code been different for all the different families of life, then the united Darwinian tree of life would have split into several different trunks with the inference that there were several independent origins for the first cells (in reality all living things examined so far share essentially the same genetic code). There are many other examples.

By contrast, Meyer's arguments about testing and falsifiability essentially boil down to different ways of re-phrasing the notion that 'design' provides the inference to the best explanation for the origins of biological complexity. 'Testing' in the author's vocabulary refers to 'testing' the validity of one historical inference against another, and 'refutation' becomes the possibility that a much better inference could be found than that provided by 'design'. But this is not what these terms mean in biological theories, historical or otherwise: they mean the ability to do actual experiments that will count one way or another in the assessment of a theory. Evolutionary theory suggests actual experiments that can be carried out to show how novel information comes into being, as described further below. But the notion of 'design' proposed in *Signature in the Cell* is so nebulous that it explains everything and nothing at the same time.

This point is well illustrated by Appendix A of the book (pages 481-497) headed 'Some Predictions of Intelligent Design'. The problem with these so-called predictions is that they are generally so vague that virtually any outcome could be lauded with the benefit of hindsight as a 'successful prediction'. For example, Bill Dembski's 1998 prediction is cited as an exemplar: "On an evolutionary view we expect a lot of useless DNA. If, on the other hand, organisms are designed, we expect DNA, as much as

possible, to exhibit function" (page 407). As it happens some organisms have a very high percentage of their DNA committed to protein-encoding genes, whereas in the case of our own genomes only 1.5% is designated for protein-encoding genes, another 3.5% or so to known regulatory elements, a massive 46% to transposons (segments of "copy-and-paste" DNA, sometimes known as "jumping genes" or "mobile genetic elements") and around 8% to retroviral insertions. The known functions of our genomes are currently restricted to the 5% that contain protein-encoding genes together with their regulatory sequences, although there is good evidence that other segments within the remaining 95% are functional in various ways. But the highly repetitive nature of much of that 95% renders it very unlikely that all of it will turn out to have a function. So what? It's not clear from the perspective of a 'design' argument why the outcome should matter either way. The human genome clearly does a very good job at encoding human bodies, just as genomes of other organisms that have much higher proportions of protein-encoding genes do a very good job at encoding those organisms as well. There are no doubt some good reasons why genomes are organized in different ways and the rapid pace of discovery should shed light on this in the coming years. For the present it's worth noting that the human genome gives us really brilliant insights into our evolutionary past (Alexander 2008, 2011), providing by far the best evidence that we have of our common descent with the apes. Those insights are real, but the question as to whether the human genome displays 'design' or not is scientifically sterile leading to no unambiguous predictions, interpretations or new experiments.

Much of the justification for 'design' as an inference to the best explanation in *Signature in the Cell* comes from the supposed inability of

other theories to explain the origins of biological complexity adequately. As Meyer comments in proposing ID as a rival 'scientific theory': "Despite the "thorough search" described in Chapters 8-14, I found no other causally adequate explanations for the DNA enigma" [page 330]. Given that the "DNA enigma" (meaning the origins of the genetic code) allied with other complex cellular systems do indeed represent significant arenas of scientific ignorance, although not quite as much as the author suggests, as we will consider further below, the most honest statement is simply to say "At present we don't know how such-and-such an entity came into being, although we have some speculative ideas". Science is about problem solving and there is nothing that scientists like better than a really big problem to solve. But science is also about the 'art of the soluble' (Medawar 1968) and picking an appropriate and achievable problem to solve is also a key to a laboratory's success.

Darwin had little idea in 1859 as to how inheritance occurred at the molecular level and the ideas he did have turned out to be wrong. In fact it took a whole further century before that molecular information became available. It's just as well that the scientists of Darwin's day didn't just throw their hands up in despair and say that "inheritance is all so complex and difficult that it must be designed" otherwise we wouldn't have the wonderful insights into the processes involved that we have today. Likewise it might well be the case that it takes another century or so to gain a complete understanding of the processes whereby the complex biological systems described in *Signature in the Cell* come into being. Simply labeling them "designed" seems unlikely to help in that scientific voyage of exploration.

The philosophical background to ID

It might seem odd that a theory presented as science should be propagated via books, such as this one, written for the general reading public, as well as via films and the media. As the author points out, the theory of natural selection was also first presented in book form in Darwin's *On the Origin of Species*. But there the similarity ends. Darwin packed his book with scientific data, much of it collected himself during his voyage on *The Beagle*. Furthermore, in 1859 science was less professionalized than it was to become a few decades later and the pressure to publish in peer-reviewed scientific journals was much less. Today that pressure is insistent and in the regular UK University and Research Institute assessment exercises that decide their funding allocations, books written by scientists are of no consequence, the only items that count as research outputs being peer-reviewed articles in scientific journals.

In contrast to scientific literature, *Signature in the Cell* also presents its theory in quite a polemical way as if much hangs on it, much more indeed than merely increased knowledge about the way that cellular processes come into being. Indeed, reading the book was somewhat reminiscent of reading the Appendix to Daniel Dennett's book *Breaking the Spell* (Dennett 2007) in which Dennett mounts a vigorous defence of the notion of the 'meme', a supposed unit of cultural inheritance. If the value of a scientific metaphor has to be defended in a popular book, then you know that it must be of little use to the scientific community for the simple reason that useful metaphors that do real work in the laboratory are quickly taken up spontaneously and used in any case by the community. Recourse to defence in popular books is a sure sign that the cause for the favoured metaphor is already lost.

The reasons for the polemical fervor in the literature of ID proponents,

which includes the present book, may be readily understood by the realization that Darwinian evolution, which is here the object of attack, is no mere scientific theory in the eyes of this author, but rather comes loaded with all kinds of philosophical baggage. Darwinian evolution is perceived as due to "wholly undirected processes such as natural selection and random mutations" which "alone can produce the intricate design-like structures in living systems" (page 4). ID theory "does not challenge the idea of evolution as change over time or even common ancestry, but it does dispute the Darwinian idea that the cause of all biological change is wholly blind and undirected" (page 4). On page 37 Meyer makes the important distinction between idealism (mind is the prime or ultimate reality), of which theism is a species, and naturalism, which maintains that matter is the ultimate reality. Whereas the definition of this distinction is unremarkable, what is contentious is the author's habit in the pages that follow to then describe what most people would simply refer to as scientific theories as 'naturalistic'. For example we read that "Darwin sketched out a purely naturalistic scenario for the origin of life" (page 43). The emergence of early ideas on the chemical evolution of life in the 1950s is referred to as part of a "grand materialistic story" and as a "naturalistic account" (page 57). The contrast made with ID is revealing: "…what natural selection and mutation lack, intelligent selection – purposive or goal-directed design – provides" [page 336]. It is the "inadequacy of proposed materialistic causes" that provides part of the basis for the author's ID argument [page 376].

In referring to scientific theories as *ipso facto* 'naturalistic' the author contradicts his own historical sections of *Signature in the Cell* in which he points out that many of the early modern natural philosophers who established modern science were people of deep Christian faith who saw the

whole universe as God's good creation. Given that naturalism refers to the 'view of the world that excludes the supernatural or spiritual' (Oxford Dictionary), it is therefore difficult to see how a theist could describe any of its properties as being "naturalistic". If we are existing within God's creation, then surely all scientific descriptions without exception must in some sense be descriptions of God's handiwork, an outworking of his will and purpose. Yet within the author's philosophical paradigm it seems that the universe is divided into 'naturalistic' and presumably 'non-naturalistic' domains, and it is the origins of these latter domains that the author wishes to explain by ID. We should not lose sight of the profound philosophical and theological ambiguity introduced by this attempt to divide the world into such radically different categories.

A similar problem arises with the description of straightforward scientific theories as 'materialistic', a word clearly used, as in the quotations cited above, with negative connotations. Indeed this is a loaded word. Christians, for example, are warned against the dangers of materialism, of becoming materialistic in their thinking, referring to the tendency to accumulate wealth on this earth and not lay up treasure in heaven. The problem of course in using this word to refer to science is that the negative connotations are carried over, quite unnecessarily, into that domain. Yet Christians of all people have a high view of the value of the created order. It has often been said that Christianity is a very 'materialistic' religion in this sense. God loves materials because he has made so many of them. In Genesis 1 the material world that God creates is continually declared to be 'good'. Christians should rejoice in the privilege of being able to explore God's material world through the techniques and approaches that science provides. Labeling scientific theories that describe God's materials as

'materialistic' is a misuse of language.

Where does biological information come from?

Much of *Signature in the Cell* is given over to a discussion of the origins of biological information in general and to the origin of life in particular. The two go hand-in-hand. Without specified complexity living organisms would be unable to organize themselves, to reproduce and to pass on their properties to their progeny, the defining properties of 'life'. It is information that renders a cell very different from a stone. Where does it come from?

Natural selection and the origin of information

Curiously Meyer dismisses natural selection as the source of new information without further discussion. Nor is the distinction made that most biologists make between classical neo-Darwinian processes involving genetic variation plus natural selection, and the very different kind of science involved in questions relating to the origin of life. In its strict sense Darwinian evolution can only occur when DNA exists that then varies, with differential reproductive success determining the chance of particular sets of beneficial variants being represented in subsequent generations. Even bacterial evolution is sometimes referred to as being "below the Darwinian horizon" (a phrase of Carl Woese) given the prevalence of bacterial lateral gene transfer that subverts merely 'vertical' processes for the transfer of information. And when it comes to the origin of life, with the challenge of explaining the origins of the first information-containing molecules, then more relevant than Darwinian theory *sensu stricto* is the work of chemists, biophysicists, biochemists and geophysicists. It is no accident that much of the current funding for origin of life research focuses on such disciplines and

comes from NASA with its interest in finding life on other planets.

Genetic variation coupled to natural selection provides a constant flow of new information into populations of living organisms. For a trivial example, we only need to look around us at our fellow humans in a crowded street to see hundreds of examples of differential information before our eyes. The tall and the short, the curly hair and the straight hair, the blue-eyed and the brown-eyed, the fair skinned and the dark skinned, the small footed and the large footed – all the different features provide visual exemplars of the generation of new information in our inherited genomes, that encode such diversity, over the past millions of years. Some of the diversity is due to neutral mutations that are not subject to natural selection, but other differences are clearly selected for, depending on environmental context. It is no accident that East Africans make such great marathon runners. The short, stocky legs of the Inuit contrast with the long lanky legs of the Kenyan, the former adapted to retain heat, the latter adapted to rapid heat-loss and the challenge of chasing game for long distances over the Serengeti. Neanderthals coping with the European ice-ages likewise developed shorter stocky legs as an adaptation to the cold.

For more dramatic examples of the acquisition of new biological information, one only need to walk out into the local park, countryside, or back garden with eyes open, and admire the huge diversity of life-forms in both the plant and animal kingdoms. As Meyer points out, many ID proponents believe in common descent, so the thousands of different forms of variant genome that underlie the rich collection of species before ones eyes are all illustrations of the ways in which novel genes or variant forms of known genes undergo natural selection to create the varied array. New information appearing in evolutionary biology is not some esoteric notion

that requires intensive study of information theory to appreciate; it is there for all to see every time we look out of the window.

Of course when we look at biological diversity in this way we are seeing the outcome of millions of years of evolution. Since the process of acquiring new information generally takes many generations, the acquisition is most readily investigated in the laboratory in organisms with rapid replication times, such as bacteria which can divide every 20 minutes under the right conditions. Rich Lenski and colleagues, then at the University of California, started an experiment of this type on February 24, 1988. They started growing a series of twelve populations of the bacterium *Escherichia coli*, all derived from a single bacterium and fed using glucose. The evolution of different strains of these bacteria from the original parental cells has now been tracked for a period of more than twenty years (Barrick et al. 2009). Each day about half a billion new bacteria grow in each flask, involving the replication of the same number of bacterial genomes, and in total about a million mutations occur in each flask as the bacteria divide. Since there are only about 5 million base-pairs in the bacterial genome, this means that every few days virtually the whole genome will be subject to genetic analysis to see whether any of the new mutations might be useful. In practice the vast majority are not, but new mutations occasionally come along that provide some growth advantages.

Every night the bacteria run out of their glucose food source and become dormant, so bacteria that cope best with this changing environment have a big advantage. The next day about 1 percent of the culture from each flask is used to start a new culture with a new supply of glucose. Most of the beneficial mutations that occur provide up to a 10 percent growth advantage, and such mutations spread rapidly through the population as the progeny

carrying the mutation have this modest growth advantage. What Lenski found was that the evolution of the different flasks of bacteria, as measured by their growth, developed not in a smooth trajectory but in a series of abrupt jumps as advantageous mutations took over the population.

After more than a decade of subculturing the twelve flasks, something rather extraordinary happened at generation 33,127. One of the cultures "discovered" how to use citrate as a food source, a chemical used to stabilize the pH and so present in all the flasks since the beginning. This gave this population a huge growth advantage as it was no longer dependent upon glucose as a food source. Further analysis revealed that the capacity to use citrate could not evolve all in one step, but took three different mutations to achieve. The two "background" mutations had to occur first, and the third critical mutation then enabled the complete ensemble of three mutations to allow the use of citrate, thereby opening up a whole new way of living for the colony. Such experiments provide a striking example of the way in which new information can be generated by the Darwinian process of genetic variation plus natural selection.

Much evolution occurs by the process of gene duplication. Normally during DNA replication and cell division the same number of genes are passed on to the daughter cells. But occasionally a segment of DNA is duplicated twice and passed on in the germ line cells, and occasionally this segment may contain one or more genes. Gene duplication provides an important way of generating new information during the course of evolution because, with time, the duplicated gene can accumulate other types of mutation that provide it with new functions, different from those of its original parental gene. An interesting example of this genre involving

receptors and their ligands may be found in an on-line article by Dennis Venema, a biologist from Trinity Western University in British Columbia[3].

The idea that new information cannot arise from normal Darwinian processes is fallacious and there are hundreds of detailed examples in the scientific literature showing how this has in fact occurred. In fact a very similar process involving the generation of new information by random genetic variation followed by selection occurs in our bodies every time we fight of a foreign invader, known as an 'antigen' (for example those coming from bacteria or from noxious chemicals). This process takes place in the antibody-making cells of our bodies, known as B cells. Through a process of random gene shuffling a vast array of B cell antibodies are produced so that each B cell has specificity to a particular antigen. When the antigen invades it binds to that tiny population of B cells that recognize it, leading to their selective reproduction. This is accompanied by further random gene mutation and selection until antibodies are produced that have much higher affinity for the antigen than in the first wave of recognition and binding. Genuinely new information has been produced by random variation and selection. And this is going on in our bodies all the time.

The Origin of Life

The particular focus of *Signature in the Cell* concerns the origins of the biological information required to operate the basic processes of cell biology, including the genetic code and the molecular mechanisms required to convert the information encoded in DNA into the specific amino acid

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[3] D. Venema. http://biologos.org/blog/evolution-and-the-origin-of-biological-information-part-3-csi-on-steroids/. Accessed 25th April 2011.

sequences of proteins. Certainly this is a tougher problem to crack than the question as to how new biological information is generated once the genetic code has been established. One of the reasons that it's so tough is the immense time-scale involved. There is tentative evidence for life by 3.8 billion years ago and firm evidence for cellular life from the period 3.0-3.5 billion years ago. This means that the basic molecular mechanisms of the cell have remained virtually unchanged for the past 3 billion years or more and it is really hard to see from this great time distance how those mechanisms may have come into being.

Space does not allow a thorough critique of Meyer's survey of the various theories that have been broached since the 1950s to elucidate the origins of the first cells. Suffice it to say that the survey focuses largely on historical theories that have not got very far (described in 123 pages) and very little attention is given to the contemporary state-of-play (only 28 pages). This gives the false impression that very little progress has been made in this field. It is certainly the case that there is as yet no convincing series of molecular steps leading from non-life to life – very far from it. But on the other hand more progress has been made than the author's account suggests. Furthermore, there is little discussion concerning the several current theories about the origins of the genetic code, and some of the information that the author does provide on this point is wrong.

For example, Meyer suggests that the chemical binding of any given amino acid to a transfer RNA (tRNA) is the same, and it is only the enzymatic assistance provided by the aminoacyl-tRNA synthetases that ensures that the correct amino acid binds to its specified tRNA [page 248]. Although the synthetase enzymes are indeed now crucial in this respect, it is interesting to note that preferential direct binding of some amino acids to

their cognate tRNAs does indeed occur, even in the absence of help from a synthetase enzyme, and it is this which has given rise to the so-called 'Escaped Triplet Theory' which proposes that it was amino acids that originally selected the primitive genetic code (Yarus, Caporaso, and Knight 2005).

To appreciate this discussion one needs to know that each of the twenty amino acids that make up proteins has its own designated tRNA. Each tRNA includes an acceptor "arm" that attaches by a chemical bond to a specific amino acid. At the other end of the tRNA molecule is another arm, and right in the middle of it is a triplet sequence of nucleotides known as the anticodon. The anticodon corresponds exactly to the codon in the messenger RNA (mRNA) sequence, just as a plug fits into a complementary socket, and the sequence of mRNA triplet codons in turn is specified directly from the DNA of the cell. In this way the genetic information of the DNA is 'translated' into a specific sequence of amino acids during protein biosynthesis.

The 'Escaped Triplet Theory' is based on the fact that if we take a large number of randomised RNA sequences and determine experimentally which ones interact preferentially with a certain amino acid, then we are far more likely than mere chance would allow to pick out precisely those RNA molecules that contain the triplet codon, and in some cases the anticodon as well, that we know specifies that particular amino acid. In other words, the 3D structure of the RNA molecule is influenced to a considerable degree by the presence or absence of a particular sequence of three nucleotide bases. This amino acid tends to bind to those RNA molecules that have certain triplet bases and not others. For example, in one randomised binding study, the amino acids arginine, isoleucine and tyrosine bound preferentially to

RNA molecules containing either their known codons or anticodons (Rodin, Szathmary, and Rodin 2011). In the present translation system, as used by all cells today, such differential binding affinities are irrelevant because the tRNAs act as adaptor molecules to bring each amino acid into its correct position. Rather the idea in the 'Escaped Triplet Theory' is that we are seeing some molecular characteristics that are remnants of an earlier more primitive system for synthesising proteins using RNA as template. The greater affinities of a sub-set of amino acids for RNA molecules containing precisely the 'correct' codons and/or anti-codons does seem to require some kind of explanation, and an 'inference to the best explanation' points to a role in an evolutionarily early coding system.

Unfortunately *Signature in the Cell* contains no discussion of the 'Escaped Triplet Theory', nor of the very substantial scientific literature on the origins of the genetic code. Why is this particular set of 64 triplet codons used and not another? There appear to be some very good chemical and evolutionary reasons why this should be the case, reasons that lie beyond the scope of this chapter to survey. If and when life is discovered on other planets, it would not be surprising to discover that the triplet codon system for exoplanetary life looks similar to the one with which we are familiar here on planet earth.

Meyer considers the 'RNA world hypothesis' for the origin of the first self-replicating system in a rather brief chapter. This is the idea, important in contemporary origin of life research, that the first information containing molecule was RNA rather than DNA. RNA has the same nucleotide base structure as DNA except that uracil is used in place of thymine. One of the reasons for preferring RNA for life's origin is because certain types of RNA molecule, known as ribozymes, can act as enzyme catalysts as well as

replicators, thereby potentially getting around the chicken-and-egg situation posed by the need for a molecule to replicate itself in the absence of a protein enzyme catalysis. Today the task of replication of both DNA and RNA is helped along by polymerase protein enzymes, but if RNA came before proteins in the origin of life, then clearly something else would need to act as the catalyst. In the RNA world idea, that 'something' is RNA, and it is now known that ribozymes can catalyse all the different steps needed for a self-replicating system, albeit with efficiencies much less than the protein enzymes that cells now use.

Meyer briefly reviews some of the difficulties with the RNA world hypothesis. Certainly there are plenty of challenges for the theory, as there are for all origin of life scenarios. But his chapter on the 'RNA world' hypothesis well illustrates the dangers of placing one's argument upon current weaknesses in any particular theory. Science has a habit of speeding ahead very fast. Even in the brief time since *Signature in the Cell* was published, further results have been accumulating that render some of Meyer's critiques less potent.

For example, the author points out that the ribozymes engineered with polymerase activity are highly limited in their actions. But in 2011 a paper appeared describing a more sophisticated RNA polymerase ribozyme able to synthesise RNAs of up to 95 nucleotides in length (Wochner et al. 2011). Furthermore, using this new ribozyme, an RNA was synthesised which itself had a different enzymatic activity. These types of 'proof-of-principle' experiments are important in establishing that such molecules can exist with these particular functions. There are currently about 50 new papers being published every year in the scientific literature with the word 'ribozyme' in their title, and many other papers beside which report new findings on this

burgeoning field. It would be unwise to predict at this stage just how many properties these fascinating molecules might be able to demonstrate.

The author also suggests that protein synthesis requires a transition from the RNA-based proposed early world to the 'modern' system that uses protein enzymes. But this is not actually true. The ribosomal RNA that plays the key role in today's cells to catalyse the formation of the peptide bonds that link amino acids to make proteins, is itself a ribozyme, an RNA enzyme and not a protein enzyme (Ramakrishnan 2008). Proteins are used to stabilise and direct peptide bond formation, but the enzymatic role is mediated by RNA. So in this case the earlier putative RNA world, in contrast to Meyer's claim, never made the transition to a protein enzyme.

Origin of life research is tough and even if a completely coherent and convincing set of molecular steps can be worked out in the laboratory, showing how living reproducing entities can come into being starting with basic chemicals, we could not be sure that this is how life actually began. The author asks: "Are there physical or chemical forces that make the production of information-rich molecules inevitable under plausible prebiotic conditions?" [page 232]. Maybe so, but does our present scientific ignorance of such processes have any philosophical or religious implications?

Christian creation theology and ID

My first meeting with the author of *Signature in the Cell* was at a bar-b-q in the back garden of friends in Cambridge. We soon got down to a vigorous discussion about evolution. This was my very first exposure to the ideas of what is now known as ID. The term was quite unknown at the time. I was very soon struck by the thought that this sounded very like the old god-of-

the-gaps idea only dressed up in new clothing. My suggestion of this possibility was not greeted warmly. But *Signature in the Cell* does seem to represent essentially the same idea, except that it may be more accurate to label it 'designer-of-the-gaps' in this case. *Plus ça change, plus c'est la même chose*.

There is little overt theology in *Signature in the Cell*, though the author does occasionally promote a strong form of natural theology, and the theological implications of the book's main thesis do run strongly counter to the traditional creation theology espoused by the Abrahamic faiths. The author states that "Though the theory of intelligent design does not identify the agent responsible for the information – the signature – in the cell, it does affirm that the ultimate cause of life is personal" [page 450]. All theists will agree that the ultimate source of everything that exists is personal, namely, God. However, the attempt to localize the actions of the "creative intelligence" to particular aspects of the created order, specifically those aspects that science is presently not very good at understanding, is deeply problematic.

The author makes a strenuous attempt to claim both that current science does not explain the origins of cellular complexity and that this will *never* be the case even in principle. For example, in discussing the present inability of science to provide a complete understanding of the molecular processes describing the origin of life, the author claims that "…it is probably more accurate to characterize this supposed "absence of knowledge" as knowledge of absence, since it derives from a thorough search for alternative materialistic causes and a thorough evaluation of the results of numerous experiments performed over several decades" [page 376]. But this is a hostage to fortune. In science we learn to say "never say

never". As already illustrated, today's gap in our knowledge is tomorrow's paper in *Nature* or *Science*. The problem with a "thorough search" is that it can only apply to this particular moment in the history of science, which is a very long history indeed, with hopefully much further to run. And as already indicated, for example with theories about the origin of the genetic code and the 'RNA world' idea for the origin of life, the author's search even on the recent scientific literature does not seem to have been that "thorough".

Further problems come with the author's claim that "New laws will *never* explain the origin of information, because the processes that laws describe necessarily lack the complexity that informative sequences require" [page 268, author's italics]. Again, this claim wishes to carve out a permanent gap for the intelligent designer, but the claim itself is quite fallacious. New information is being generated all the time in billions of genomes in organisms across the planet, a generation that is well described in dependence upon the laws of chemistry and physics. Just because we currently have no detailed explanation of how the first RNA or DNA molecules came into being is no guarantee that we will not understand those origins much better in the next few years, or a century's time, or two centuries' time – the time-scale is not that important because even a century or so is a mere drop in the history of human acquisition of knowledge about the world. One of the curious features shared by ID proponents is their tendency to treat current science as if it were some static body of knowledge, when in reality millions of peer-reviewed scientific papers are pouring off the press each year. Science is an incredibly dynamic and fast-moving enterprise.

For those holding to the traditional Christian understanding of God as creator, the question of whether or not we are currently able to understand

some component of the created order in scientific terms is theologically irrelevant. Within a theistic world-view, God is the ground and source of all existence. All the materials and energy of the universe have the properties that they possess due to God's faithfulness in sustaining and upholding the created order moment by moment. If there is a multiverse, then the same theological point applies to the multiverse, it makes no difference. Christians, of all people, have no hidden investments in scientific ignorance.

This emphasis in Christian theology is often referred to as the 'immanence' of God in creation. As the prologue to John's Gospel has it: "Through him all things were made; without him *nothing* was made that has been made" (John 1:3, my italic). In Colossians Chapter 1, Paul speaks of the Son being 'the image of the invisible God, the firstborn over all creation' (verse 15), and then writes: 'For by him all things were created: things in heaven and on earth, visible and invisible, whether thrones or powers or rulers or authorities; all things were created by him and for him. He is before all things, *and in him all things hold together*' (verses 16–17, my italics). The point is further underlined by the writer to the Hebrews when he writes that 'The Son is the radiance of God's glory and the exact representation of his being, *sustaining all things by his powerful word*' (Hebrews 1:3, my italics). God is the one 'for whom and through whom everything exists' (Hebrews 2:10). If God did not keep on willing the created order to exist by his powerful Word, then it would stop existing. Creation is about ontology: why does something exist rather than nothing?

Calvin wrote about the immanence of God in the created order in this way: "For it is the Spirit who, everywhere diffused, sustains all things, causes them to grow, and quickens them in heaven and on earth….In

transfusing into all things his energy, and breathing into them essence, life and movement, he is indeed plainly divine' (Institutions 1, 13-14).

Once we grasp the biblical insistence on the immanence of God in the created order, then we will be wary of the use of descriptions of the created order as being 'naturalistic', as already discussed. It is clear that those who disavow that particular philosophy will not wish to refer to scientific descriptions as being 'naturalistic'. In an attempt to address this problem, it is common to refer to 'methodological naturalism', meaning that there is no need to bring theological language into our scientific descriptions of the world. Whilst that point is perfectly valid, it might be simpler, in order to avoid misunderstanding, to drop the redundant phrase, and simply speak of our 'scientific' descriptions of the world.

The rhetorical identification in *Signature in the Cell* of 'scientific explanations' with 'naturalistic explanations' helps to explain the angst that is always present in the writings of ID proponents. For them it is clear that scientific explanations carry overtones of autonomy, as if once the clouds of scientific ignorance have been blown away, then this represents a triumph for naturalism. For the Christian, however, nothing could be further from the truth. All increases in our well-validated understandings of the created order are causes for thanksgiving and worship to the God who is the creator of all.

Concluding Comments

Signature in the Cell is but one of a cluster of books by ID proponents that present essentially the same arguments, albeit using a range of different examples. It is difficult to see how the ID position can be developed any further, given that its core idea depends on our present scientific ignorance concerning the origins of various complex biological processes. As the cloud of ignorance gradually dissipates with the passage of time, one can only imagine that the central ID argument will in turn likewise gradually fade away. But, for the moment, the investment of evolution with the ideological rhetoric of atheism by a small albeit vocal sub-set of biologists will no doubt continue to provide the cultural and political energy that the ID movement needs to keep going.

In the interim one can only express regret that so many sharp minds, acting from sincerely held convictions, can expend so much time and energy on what can only be described as a distracting Red Herring as far as Christian faith is concerned. There are, however, some grounds for optimism. If Christian ID proponents, such as the author of *Signature in the Cell*, could be encouraged to adopt the kind of robust theism that characterizes the traditional Christian understanding of creation, then it is not impossible that the ID movement, perhaps by small evolutionary increments, might eventually merge with the Christian mainstream, which sees the intelligibility of the universe as consistent with a God who has designed all of it with particular goals and purposes in mind.

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