How do we know?

The footprints of a Creator

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Introduction

Science is what scientists do – it is a practice rather than a philosophy. While science has emerged from western thinking, its roots are much wider and more universal and no one philosophical position embraces science or the views of scientists. For this reason scientists are sceptical about the attempts by philosophers to capture the essence of science. If Christians are not to be intimidated by science and need the tools to question science, it is not to philosophy or postmodernism that they should turn, but to science itself. Christians need to develop an understanding of science that appreciates its strengths as well as understands its limits.

Scientists are trained in the 'art of science' and, as many scientists have given little consideration to the limitations of science, matters of faith and belief often fall prey to the onslaught of what can be called 'scientism'- the assumption that if sense making is not scientific it has no value. The following story illustrates the weakness of scientific sense making and where its limits might be.

> *The physicist and the social scientist came home from a night on the town totally drunk As they were getting into their car to drive home one of them dropped the car keys. The social scientist fumbled round in the dark trying to find the keys while the physicist went over to the lamppost and looked for the keys there. "Why are you looking for the keys over there?" asks the social scientist. To which the reply was: "I cannot see where you are looking?"*

Like all stories this captures something, about how natural scientists think. Science[1] restricts its sense-making to areas where things can be seen, rather than what needs to be known. As the one time scientist, Baron Habgood, said:

> *Science achieved its enormous practical successes, by narrowing its focus, dealing primarily with things that can be measured or weighed, and excluding human values as much as possible[2].*

[1] In this paper science refers to the approach of the natural science. Social sciences' sense making is usually quite different and social science may have done itself a disservice by appropriating the word science to describe its activities.

[2] I have taken most of my quotes from writings prior to the advent of post modernism to show that, contrary to what many think, scientists themselves have been exploring the limits of science.

Stories and Models

Stories and Models capture our tentative understandings; they are our ways of making sense of things. The above story helps us to understand the differences between ways of science and other forms of sense making. However for a story or model to be effective it must check out or be consistent. While Karl Marx had a good story about how to create a better society, his story did not check out in practice as it was too simplified. However, if his story had a more realistic acceptance of human nature, Marxism might have well have been able to avoid the totalitarianism that dogged it in practice. It follows that if we are to have confidence in any form of sense making, plausibility is not sufficient- our confidence increases when the sense making can be subjected to evidential testing.

Science (see footnote 1) is a sense making activity that concentrates on checking out the story or model, restricting itself to fields of sense making where appropriate evidence is available, as Habgood points out above. If the conditions are not right for adequate testing it is not science in the sense used by natural scientists.

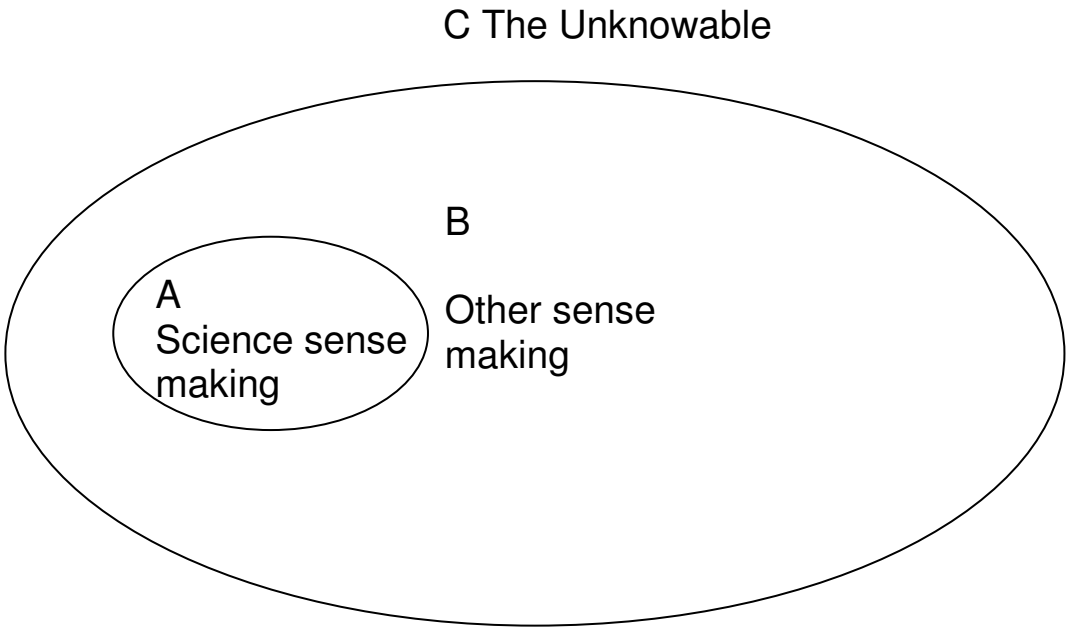

Figure 1. A picture of the sense making process.

Figure 1 shows how thinking about sense making can be organised. Science only occupies a restricted part of the whole area of sense making. Indeed other forms of sense making may well occupy us, as humans, most of the time. Furthermore, as will be discussed later, there are unknowable areas of speculation that we will be incapable of making any sense of at all. The 'unknowable' is likely to be so unknowable that we will not be able even to have even a glimpse of its reach. The diagram is off course simplistic- there are large areas of inquiry, where we can make some sort of sense; but this sense making is in no way complete or comprehensive.

The danger is that, because science is so effective in its restricted area of sense making, its methodologies are arrogantly used in areas where the conditions for effectiveness are not met.

Those who are called positivists see sense making outside of science as meaningless. For them, such as Richard Dawkins, the science area in Figure 1 virtually extends to all forms of sense making. This approach, which also is known as 'scientism', has no evidence to support it. Rather it is an ideological position that believes because science is so effective in area 'A' it, without any evidential support, is deemed as effective in all areas.

However, while some high profile scientists might have this view, as mentioned, there is no overarching philosophy of science. Indeed, the philosophical positions of scientists vary enormously from theism to Buddhism to atheism. This is where many of the critiques of science, such as those of postmodernism, fall short. Science is what scientists do - not what someone thinks they do. The following explores further limitations to the scientific form of sense making.

Issues with scientific sense making.

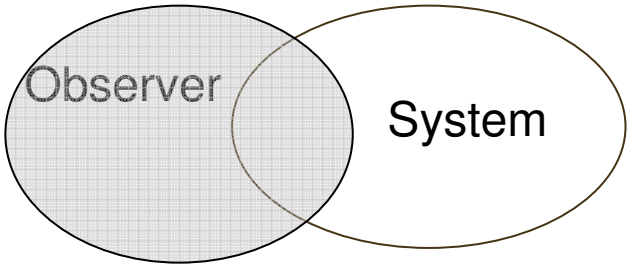

Figure 2. The observer and the observed

One of the first problems with any form of sense making is the effect the sense-making observer has on the system under study. Science tries to minimise this interaction as illustrated in figure 2 or, if this is not possible, to manage the effect of the observer. Nevertheless, the observer may unknowingly change the system by interacting with it, or, the observer can impose his or her own understanding on the evidence being gathered. Francis Galton, a supporter of the eugenics movement at the end of the 19th century, argued that eugenics concepts were scientific. This was not so, rather Galton used the label 'science' to justify what was primarily an ideological position. The danger can be seen in the following story.

> *The Irishman (I am half Irish so I feel I can tell this story without being racist), in response to the claims of his wife that he was drinking too much, did some experiments. He drank whisky and water and got drunk; he drank vodka and water and got drunk; he drank Guinness and water and got drunk. He then said to his wife that the evidence showed the water was the problem, and he would never touch another drop.*

Some argue that the areas of scientific interest are determined by the agenda of males, and that science would take a different shape if women could determine what was to be studied. This statement may have some validity at the boundaries of science. However science moves from areas of agreed understanding to areas where it might be possible to make some form of sense.

The directions that science can take at any instant of time are limited and not particularly influenced by social pressures. I should point out that creating an atomic bomb or putting a person on the moon is technological issue rather than a scientific one, as the necessary science was available at that time. The directions of technology are often strongly influenced by social drivers. While the technological path to put a human being on the moon was relatively predictable (but expensive) in the 1960s, a path to find the silver bullet for cancer was beyond the capability of science at that time. The best that could have been done would have been to expand significantly biomedical, biochemical and biological research. However this would have made little difference because of the shortage of leading edge scientists, and the primitive nature of the computers of the day. Over the last forty years, computer development has allowed greater understanding of the human genome and now there are many more leading edge scientists in relevant areas, but even so, it is generally accepted that no single silver bullet is likely to emerge.

Two areas of science have arisen as scientists have recognised and managed the interaction of the observer with the system understudy. Quantum physics recognised that the observer disturbs the system[3], rather like someone trying to find a golf ball in a dark room by swinging a golf club around. When the ball is found it is hit somewhere else. Relativity arose because it was seen that physical theories needed to be consistent irrespective of the motion of the observer.

Reductionism

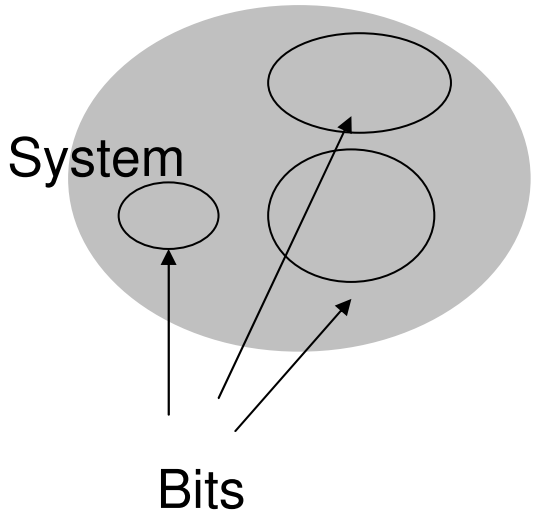

Figure 3 Reducing a system to its components

In addition to attempting to manage the effect of an observer on a system, scientists try and probe a complex system by breaking it into components. Figure 3 illustrates this. The process can be envisaged as splitting a system ABCX into A + B + C + unimportant bits X. Where this can be reasonably well done it can be deemed to be science. However there are dangers that

[3] At least one understanding of quantum theory sees it this way. Other understandings see measurement uncertainty as more fundamental.

some key factors will be missed and that reassembling A, B and C, after understanding how each works, may not capture the essence of ABCX. Am I a pile of atoms and electrons, or am I something more? A narrow reductionist approach, if followed unquestioningly, will claim that I am just a pile of atoms and electrons.

There are many examples of failed reductionism, both within and outside of science. Marx reduced a social structure to the capitalist bourgeois and the workers. Economists often envisage an economy as a market of producers and consumers and in so doing argue that understanding the market is sufficient to understand the economy. Some Greens, claiming to be holistic, will consider the bio system and its sustainability as being the major component, while ignoring the unimportant X component which is to do with feeding 6 billion people, rising to 8 billion in a few decades.

All sense making systems use a reductionist approach at times. For example, postmodernists often focus on the narratives of communities each with their own understanding of 'truth', but in doing so ignore how these separate communities, with their different understandings, can engage as part of a wider human society.

However science is more than just reductionist. Science has developed understandings such as energy, entropy, momentum to characterise system behaviour. These system measures constrain how the bits are put together. Successful science attempts to bring a top down, or phenomenological, understanding and merge this with the bottom up understanding of the components of the system. In the last twenty or thirty years the focus of science has shifted more to complex systems where the components cannot be studied in isolation from the whole. Examples of such systems are bio and ecological systems, agricultural systems and more general complex systems. A systems approach identifies key factors which impact on how the system can be deconstructed. An ant is part of an energy and nutrient flow in an ecology- it is part of the web of life. A scientist can look how the ant functions through, for example, its genetics but to understand it completely the scientists needs to study how the ant integrates into the whole ecology.

System boundaries

However it is not always possible to define a system in a way that it allows it to be studied effectively. Short term weather predictions are possible by identifying local climate trends over short time frames. However a long term understanding of weather is more difficult. The so called butterfly effect illustrates the difficulty. The argument is that the weather in Wellington today may well depend on a butterfly that flapped its wings in South America 18 months ago. It is impossible for humans to have sufficient detailed information to predict the weather long term. An accurate long term weather prediction would involve taking into account the interactions over the whole globe, including the sea and atmosphere, solar activity, the solar system and dust and meteors from space.

If the system is too narrowly defined, a particular outcome such as tossing a coin looks random. However if the system is extended to include the impulse on the coin, the brain

function behind the impulse and the air resistance etc, what appears to be random may well be predictable[4]. However where the system is too restricted, a random outcome is a reasonable description of what happens.

Where, a sense making activity, requires the system boundaries to be extended to an impossible extent, science is extremely limited in what it can offer. Nevertheless it can sometimes make some general comments such as: "if we continue emitting carbon dioxide at the levels we now do, unless some unknown effect saves us, the temperature of the globe will increase to impact negatively on our existence."

Science's effectiveness

Science works extremely well. No other form of sense making can touch science in its effectiveness. But it is because science restricts itself to question that are solvable that it is so successful. However as more and more of the simple scientific problems are solved, science needs to evolve to address the new and more difficult problems that remain. Many current scientific problems involve looking at complex systems and developing a better understanding of system boundaries. For example, scurvy had a simple cause- lack of Vitamin C in the diet. In that sense it was a simple problem to understand. However today many health problems have more complex origins and multiple causes. It is unlikely that any simple cause will be found for many of the remaining diseases. Modern medicine must take into account the whole human body and its external environment. Nevertheless, in contrast to popular holism, the scientific approach still requires a strong conceptual framework and must be supported by evidence and testing.

My work on Innovation Systems

I have been working in recent years on understanding innovation as a system. I have used a model called "The Viable Systems Model". This asks: "What does a system need to be to survive?" The approach shows that neoclassical economics (i.e. the market approach) is too limited to understand the innovation process- it restricts the system to areas that have little impact on an economy's capability to innovate. The broader systems approach to understanding innovation brings Government, education, the legal system into the picture.

More than that, the question about system boundaries arises and it is clear for the long term sustainability of innovation, the bio system and the socio economic system need to be part of the mix. A systems approach organises thinking differently from the traditional neoclassical economic perspective.

Science as the art of the possible

In principle, science avoids trying to address impossible questions. When this rule is broken, as it was when Galton looked at eugenics (see above), the activity is so unscientific that there can be no confidence in the conclusions. People who work outside the limits of science, and use the science label to claim credibility, need to be forthrightly challenged.

[4] The observed randomness of evolutionary processes would appear to be analogous- see later.

The deep problems of human existence are inaccessible to science as humans neither have the information or the intellectual ability to address such questions.

Positivism, as commonly articulated, believes science is the only way of approaching any question. A current example of this is that of Richard Dawkins who sees science as being able to pontificate on just about anything[5]. As the approach implies that science is everything, and anything outside of science is meaningless, it ultimately undermines science. Positivism makes assumptions about what the system is and the processes of sense making that are untestable, therefore positivism is ideological rather than an evidence based rational position. However, in general scientists are not positivists[6], despite the mistaken belief of many philosophers.

Science leaves room for Faith

Science is limited, both in its capability to provide answers for deep questions, and in the certainty of any understanding it provides. As Karp Popper, says:

> *Our ignorance is sobering and boundless. With each step forward, with each problem which we solve, we not only discover new and unsolved problems, but we also discover that where we believed that we were standing on firm and safe ground, all things are, in truth, insecure and in a state of flux.* ('The Logic of the Social Sciences' in The Positivist Dispute in German Sociology, 1976).

And

> *"But hardly anybody, not even the most uncritical and naïve rationalist, would contest the assertion that nothing of importance can be proved, and that all that can be proved consists, at most, of mathematical and logical truisms"*
> Popper K (1994) Epistemology and Industrialization in "The Myth of the Framework; in defence of science and rationality (Routledge London and New York) page 191.

While Habgood, who was a practicing scientist before going into the Ministry says

> *In science, you deliberately cut out all the interesting human things, 'so we are left with this hard, meaningless, valueless universe and we recoil in shock if we think that's all there is* (reference unknown).

> *We have already seen how the early scientists assumed that they were discovering the nature of reality. ….Many modern scientists take exactly the opposite view; they are not nearly so sure*

[5]However even Dawkins has his limits. He is reluctant to allow an evolutionary approach to human morality- with good reason.

[6] The views about science, but not about Christianity, in this paper would be generally accepted by scientists.

that they can say anything about reality at all. The regard their theories as useful guides, as tools which enable them to manipulate nature, whether they are true in any ultimate sense or not. According to such a view, truth is "what works" (Religion and Science, John Habgood 1964).

In addressing the issues that science poses, Christians should recognize the boundaries of science and affirm their position from this point of view. A retreat to postmodernism arguments to undermine science is a no-brainer as scientists see these arguments as ill informed rubbish. Neither is the claim that spiritual understandings are of the same nature as those of scientific inquiry particularly useful. The strength of the Christian position is to emphasise the limits of scientific inquiry. These limits can be summarized in the following way.

1. Humans have cognitive and intellectual restrictions on what they can actually process- the most important problems will always be beyond our understanding.
2. Humans have informational restrictions. Even if they had the intellectual ability to understand difficulty and complex problems, they usually have insufficient information to do so.
3. Finally even if the above limits could be overcome, humans are not free creatures, their human nature means that their own interests will override what should be seen as true. I.e. human sin perverts the sense-making process.

In summary where science works it works extremely well, but where science hits its limits, which is usually the case for the important questions of life, it is of little use. Worse, where scientists move beyond the limits, claiming superior insights, its conclusions are likely to be dangerous.

Complex Systems

The study of complex system illustrates that human understanding is limited even where it seems to be most certain. We may think that mathematics leads to certain truth. However even mathematics is limited. Kurt Gödel in 1936 showed that mathematical truths exist that are not provable. More recently, Gregory Chaitin demonstrated that there is even less certainty over mathematics. Using his approach of Algorithmic Information Theory, Chaitin showed that there are many **more** mathematical truths that are unknowable than those that are knowable. In effect most mathematics is beyond the capability of even the smartest mind to prove. It is not even clear which of the possible mathematical truths fall into this category. You can never know that you cannot prove something, as there is always the possibility you have not tried hard enough. If mathematics has great gaps of truths unknowable by reason, how much more does science have similar problems?

I have applied algorithmic information theory to problems of complexity. The theory argues

that a string of information such as '111……..111' is highly ordered whereas a string '10011000111011…10" which is random shows no order. A simple description exists for the first string; i.e. "PRINT '1" N times. Whereas the random string must be described by: PRINT '10011100111011…10' which is a much longer string. If N is the length of the string, the first can be described by a computer program a little longer than logN, whereas the second requires a progam longer than N.

However Chaitin argues that to understand a pattern requires computational power greater than the pattern to be described. On this basis there are truths that the human mind cannot grasp. And even if all the world's brilliant minds combined to understand more, there would be limits to what they could understand.

The universe is untypical

The approach of algorithmic information theory says that the universe is untypical. Its description is simple relative to other possible structures. The universe is therefore highly ordered. My work claims that, as the universe evolves, it follows an ordered path, one that simple computers, like our own minds can partially understand. This is completely surprising. If the universe were not so extra ordinarily simple, our computational ability would be utterly inadequate to grasp any understanding of it. But why should the universe be so simple that our puny minds can make some sense of it?

I claim that replication processes are key to order appearing in the universe. Replication processes such as cell replication; crystallisation, a laser etc, create simple ordered structures that to our minds are comprehensible. Or perhaps more correctly replication recycles existing order and packages it in simple clusters. Replicative systems are algorithmically simple and they can be described much more simply that other structures.

I am not a bundle of atoms. Indeed algorithmic information theory would see a bundle of atoms as random. Rather I am packaged in a highly ordered way and am much simpler to describe than a pile of atoms.

Algorithmic Information Theory demonstrates that a complex system can only be described by a computational system of significantly greater complexity. Only a bigger brain can understand the human brain, although our brains might understand simple bits of the human brain. I met the mathematician John Casti, the author of *Complexification*, *The Five Golden Rules* etc, for coffee earlier the day of this talk. At coffee he argued that all the human brains in the world, if coupled, might be complex enough to understand more than just one brain is able to. However, there would be limits as to what all the human brains could unpack. Most systems are therefore going to be beyond the human brain to understand. Where we do seem to understand apparently complex systems is because they are not all that complex.

The Surprise

The surprise is that the universe is partially understandable. It is incredible, literally that such a small part of the universe has the computing or cognitive capacity to make some sense of the

total. This can only be because the universe is extremely ordered- showing little randomness - at least in the areas we can make sense of. Science makes sense of highly ordered systems- particularly where order is nested in order. Where this happens, and, it is where science is so effective, simple brains can make sense of highly ordered structures. I am understandable at least in part because I am highly ordered. Yet there are going to be things about me that neither I, nor any other human, can understand because our computing or cognitive capability is too low.

Because the universe is highly ordered, it has direction. In a sense the path the universe takes in its evolution is one that conserves order at least over the short term- where one ordered structure is dismantled another arises. I think that replicating processes determine the order that eventuates over time. Variation and selection process maintain the stability of the ordered structures arising from the universe's evolution. In other words if the universe was rerun, something like me would still emerge.

An analogy is with a fertilized human egg. If that egg were replanted in another mother, virtually the same being would eventuate at the end of the process. The embryo has within itself the capability to seek out well defined growth paths.

Where is God

It follows that, the emergence of order is seeded in the physical laws of creation. God does not need to be there fiddling with the levers of power, but just as a human emerges from an embryo, so to do we, and other living systems, emerge from the seed of creation. We will never be able to grasp the totality of this and from our point of view we are still free and our lives are not determined robotically; yet there is overarching direction.

St Augustine captured this 1,500 years ago when he wrote.

> *In the seed (of a tree), then, there was invisibly present all that would develop in time into a tree. And in this same way we must picture the world, when God made all things together, as having had all things together which were made in it and with it when day was made. This includes not only heaven with sun, moon, and stars,...but it includes also the beings which water and earth produced in potency and in their causes before they came forth in the course of time as they have become known to us in the works which God even now produce.* St Augustine- De Genesi Ad Litteram.

We can never comprehend the unknowable, but because the universe is highly ordered we, as fragments of this order, can make some sense of it. As Einstein wrote:

> *The most incomprehensible thing about the universe is that it is comprehensible.*

It is as we ponder these things, our minuteness is overwhelms us, and the hairs on our neck stand up. We should know so little, yet much has been given to us to know. This is truly amazing.