On Science, Part 1 [1]

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Everyday, all across the Internet, debates rage between two particular camps: those who support "science" and those who support "Christianity". These debates can be painful to witness: the one camp speaks with lofty arrogance, and the other with amazing ignorance. This article is the first in a short series that I am going to publish that will briefly look at the topic of *science*.

In 2012 I earned my Master of Science degree from one of the leading South African universities. While I am no longer in academia or doing research work, the time spent at university and working with my professor has given me valuable insights into the institution of science.

At the same time I am a Christian theist and lay theologian; having a deeper understanding in such matters than many others.

In this series of articles I would like to lay out the facts that both sides of the debate need to understand and recognise. Doing so should help one to engage in a more respectful and humble manner.

In this article I am going to give a few very basic definitions of what science is. This should be school-level information, but I think it is often assumed and not explicitly explained. Part 2 [2] will discuss problems in science. Part 3 [3] will look at why non-scientists need to respect science. Part 4 [4] (really an addendum) will link to presentation slides on "Science vs Religion" which I made a couple of years ago and presented to my Bible study group.

What is Science?

Science is a methodological way to study the natural world. It is methodological, because it can be roughly broken into several steps:

1. **Observation**: looking at the world or a certain phenomenon.
2. **Hypothesis**: making up a theory about the cause, mechanics and effects of what was observed. A good hypothesis has the following characteristics:
    1. *The best hypotheses make the least number of assumptions.*
    2. As science is confined to the natural world, hypotheses must be logical, natural, etc.
    3. A good hypothesis must have power to *explain* what *was* observed, as well as *predict* what *would* be observed under the same circumstances.
3. **Experimentation**: devising a test to either confirm or disconfirm the hypothesis. If a hypothesis is disconfirmed, the scientist must be able to change their mind and consider another hypothesis.

4. **Repeat**: further observations should be made or more complex aspects of the originally observed phenomenon should be investigated.

This is a very basic description of the scientific process, but can be applied, more or less, even to "abstract" science, such as pure mathematics. The limitation of science being confined to the natural comes from the third point, as the supernatural can manifest (appear) in the natural world through the will of spiritual beings, but cannot be *affected* (forced) by people.

Science also stands in contrast to *pseudo-science*. I am not going to go into that now, but will refer you to this short video [5]. In brief:

- Pseudo-science tries to *confirm*. With this method, any narrative can be concocted to explain a phenomenon.
- Science tries to *disprove*. One always tries to attack a theory, and the theory only becomes credible if it can repeatedly withstand such attacks. Note that this makes science inherently sceptical.

Science is about explaining the natural world through building models

In order to be able to describe something, we need a language to do so. In science this language typically is mathematics. We describe quantities, weights and such with numbers, velocities with vectors, etc. We give fancy names to things which we discover while studying the natural world using the language of numbers, such as "forces" and "wattage". While many people will argue that these are indeed real, physical things, I suspect that in some cases they really are merely high level descriptions of phenomenon which is far more abstract than we can fathom.

Scientific theories are perhaps the top-level models that scientists build. If numbers and vectors are the cardboard and glue, theories are the architectural scale models. Much has already been said on elements of science being "just a theory" [6]. Theories are, in and of themselves, just a descriptive language we use. They cannot be fundamentally right or wrong. Merely, they can be more or less *appropriate* when applied to physical phenomenon.

For example, the statement "evolution is wrong" is nonsensical. Evolution, by itself, is merely a model that can be used to explain certain phenomenon. In my post-graduate studies, we implemented evolutionary algorithms to solve problems in computer science. I can testify that evolution as a model *works*[1]. What one can say, is that they do not believe that no evolutionary model[2] accurately represents biological development, *but then then person making this claim needs to present an alternative, more accurate physical model* of biological development.

It becomes tempting to think of these constructs as things which exist in and of themselves. Rather, they are as real as the words which we have assigned to colours. And as the word for "green" is different between English, French and German, so mathematical constructs could be (and are) different. An obvious example is the number *base* which we use. Typically we use base 10, but in computer science we often use base 2, 8 and 16 (even 64), and in number theory it is interesting to play with other bases.

But even more fundamental are the *axioms* on which we base our mathematics. Axioms are base assumptions which cannot be broken down any further. For example, $2 + 5 = 5 + 2$ seems obvious, but this one simple equation uses two axioms (*reflexive* and *symmetric*) to work. Despite this seeming obvious, axioms can be chosen differently, which leads to mathematics working differently[3]. In the early 20th century, Kurt Gödel demonstrated with his "incompleteness theorems" that not everything can be proven in mathematics for any given set of axioms. (The "unprovable" problems are not completely unprovable and can be solved given other axioms, but there is no one "golden" set of axioms which can be used for all problems.) While a statement about pure mathematics, this theorem has manifested in computer science as the Church-Turing thesis, and has had implications for the fields of logic and philosophy.

I do not wish to speculate about further implications of the incompleteness theorems; I simply want the reader to be aware of the existence of such quirks and that there are real *limitations* to what science can say or discover. Occasionally science gets upset, and we need to be open to the fact that the study of the natural world *is* far stranger than it seems.

Science does not say what is true, but what is (relatively) accurate

In antiquity, there was a long debate between "scientists"[4] on whether the earth was the centre of the solar system[5] (geocentricism), or the sun (heliocentricism). This was not a debate between "the religious" and "the englightened"; both groups of people studied the celestial bodies and formulated theories around them.

What is not well known today, is that there was a (long) period of time where geocentricism was the *scientifically more accurate* model. Geocentricists pointed to the motion of the sun, moon and stars. Heliocentricists pointed to the planets, which did *not* "orbit" the earth in a circular or elliptical manner. Then in the third century BC, Greek astronomers developed a model of "epicycles"[6], which was a mathematical model which could fairly accurately *predict* motion of the planets. This model had greater explanatory power than what the heliocentrists had, as they had not yet developed the necessary mathematics to model heliocentrism.

Today epicycles is considered by some to be an example of bad science [7]. However, during that time, heliocentricism had its problems, and if you wanted to accurately know the position of Venus in a month's time, you had to use the "geocentric" model, even if it was unpalpable to do so. Whether you agreed with that model or not (which was wrong and eventually surpassed by superior, heliocentric models), it carried scientific weight.

The same thing happened with the physics of Sir Isaac Newton: for centuries it was the standard by which the natural world was analysed. But by the beginning of the 20th century, its limitations had been reached. Then it was up to Albert Einstein to "correct" Newton's model with his theory of General Relativity. And while Newton's physics is technically "incorrect" and too simplistic, it is still adequate to be used today still for small enough problems. It is my prediction that within one to two generations' time, Einstein's General Relativity will have been surpassed by something else.

Science is built on a foundation of assumptions

I have already discussed the fact that science makes use of axioms. Axioms cannot be proven and have to be used on faith [8] (which, as seen with Gödel's incompleteness theorems, can backfire).

But even on a larger scale, when investigating a complex phenomenon with an experiment, a researcher needs to make assumptions and try to contain a problem in such a manner that it can still be fathomed. And knowing this is key: one can evaluate the significance of a study, or even its reliability, by looking at its assumptions. I regularly see news outlets tout the sensational findings of some study. But if the article is well written and you read between the lines, you can get a clue of the assumptions which were made and that the news story is likely blowing the significance out of proportion.

Conclusion

In this article I presented some definitions on what science is, and discussed how it uses assumptions to build models in order to explain the natural world. In the following article [2], we'll look at some problems that contemporary science has.

- 1. Although it is my opinion that, as far as computer algorithms go, evolutionary computations are inefficient.
- 2. There can be variations on a model; typically, when speaking in biology, Darwinian evolution is referred to, but this model has been called into question by contemporary secular researchers [9].
- 3. For example, while `a ? b = b ? a` in scalar mathematics, `A ? B ? B ? A` in the general case in matrix multiplication.
- 4. The term "scientist" is used anachronistically, as it only became a formalised field of study in the modern period.
- 5. Indeed, the whole universe.
- 6. In a purely mathematical sense, geocentricism is technically plausible by choosing the Earth as the origin of a coordinate system. Epicycles basically modelled the orbits of the planets "around" Earth in such a coordinate system.

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