SCIENCE OR MAGIC?

The Hard Truth About Fact

At sixteen I finished studying science and mathematics at school and pursued literature and art instead. Then at 26 I married an engineer – all physics and Calculus. Imagine my surprise when he told me that although he spent his days working with radio waves, no-one actually knew for certain what they were.

"We can't see them or touch them," he said. "We can't even prove they exist. All we can say is that something is happening which seems to behave like this. Then we design transmitters and receivers on that basis. It's like magic, really, but it's working so far."

This did not fit my conception of a scientist. Science, after all, deals with facts, doesn't it?

My sons at fourteen were told by their chemistry teacher, "All that stuff you learned before this year? – Forget it, it's not true. This is how it really is." Two years later, about to start the sixth form, they were told by the same teacher, "That stuff you learned two years ago? – Forget it. *This* is how it really is." And later he said, "All this stuff you're learning now? When you get to university they'll tell you how it *really, really* is."

(And at university? You've guessed!)

Scientific thinking depends upon pragmatic models which emerge from hypotheses based on observations. Theories evolving from hypotheses which appear to work are often assigned the grand title "Law" – hence Newton's Laws of Motion – and it would be fair to say that a scientific Law is about as fundamentally true as any other man-made law. The model works while it predicts how physical phenomena will occur in future situations *until we find a situation it fails to predict.*

Science teachers, when using models to describe and predict physical phenomena, unfortunately often omit to tell their pupils that these are in fact models and not the Absolute Truth; or perhaps they deliberately do this in order not to confuse their innocent charges' immature brains.

So, in this way a student learns that electrons, using the Niels Bohr model, are some sort of negatively-charged lumps of matter which orbit an atomic nucleus in the same way that we understand a planet to orbit a star (and more about that later). Next, they are taught that an electron can be persuaded to part company with its atomic nucleus parent and move elsewhere, so that we can produce electric current and also so that 'shared' ownership will result in chemical reactions.

As a student progresses towards university, he or she might become aware that this simple planetary model for the electron is not entirely supported by quantum physics.

The next step is the dual-nature description of the electron, in which it sometimes appears to behave like a wave. This gives rise to the obvious question "Is it a particle or a wave?". Sometimes the answer is "Both", sometimes the answer is "Well, at times it behaves as a particle and at other times it behaves as a wave."

A better answer, rarely supplied, would be "The 'electron' is a model which enables us to predict physical phenomena. Unfortunately the model is both inexact and muddy. The particle description is simple and works well for some phenomena, but the wave description is better for certain calculations."

I guess you do need to be mindful of the maturity of your pupils before you lay that one on them.

As if this murky existence for an electron is not bad enough, a student may then find that the stationary electron must now be considered to exist everywhere in the universe *at the same time*. Not bad for a little lump of matter we cannot even see.

Personal point of view interferes too. Returning to the planetary orbit question, how correct was Galileo in asserting that the Earth orbits the Sun?

To an observer on Earth that statement is patently absurd as we see every day that the Sun rotates around the Earth. The only problem is that when using the Earth as the frame of reference, describing the motion of the Sun mathematically is pretty messy and describing the motion of the other planets is a nightmare. The maths becomes far easier if the Sun is taken as the frame of reference.

So Galileo might have been well advised to assert, "Of course the Sun rotates around the Earth, but I have a pretty neat

mathematical shortcut which can quickly compute the position of the other planets. *Of course we all know this is only mathematics!"*

(And by the way, neither the Sun nor anything else is actually stationary in the galactic frame of reference.)

So where does magic fit in?

The Shorter Oxford English Dictionary (5th edition) defines 'magic' as: "*The supposed art of influencing the course of events and of producing extraordinary physical phenomena"* or *"An inexplicable and remarkable influence producing surprising results"*.

That's the point just after the current model gets left behind, isn't it? As Arthur C Clarke is credited for having said, "Any sufficiently advanced technology is indistinguishable from magic".

My husband maintains that when engineers are asked to produce something unheard of which is in defiance of current knowledge and experience, most will say, "That's impossible". The more creative ones will say, "We don't know how to do that". But the creative and optimistic engineer will say, "We don't know how to do that *yet*."

What you don't know how to do (yet) often looks like magic when done by someone who does. From the 17th until the early 20th century, 'horse whisperers' were able to calm and train dangerous horses apparently by whispering the "Horseman's Word" into their ears. Well, I'm a horse whisperer, and I know that the Word had nothing to do with it.

For sure the horsemen were using eye contact and body language that the horse instinctively understands to persuade horses that they were capable, trustworthy leaders, which is what I do now. The only difference is that they protected their livelihood by whispering into the horses' ears first and telling everyone it was magic, whereas I explain what I'm doing and teach the owners to do the same.

Once you know how the trick is done, it's easy, whether understanding horse psychology or watching the Ace of Spades vanish. Point of view is paramount. It might be magical to us that a salmon can find its way back to its birth place to breed and a swallow doesn't get lost over the Atlantic, but to the salmon and the swallow it's easy-peasy. How can a dog detect that an epileptic fit is soon to happen? The dog would probably say, "Why, can't everyone?". And

how could Connor pick up these visions? Same answer – the ability is just part of him because of his ancestry.

And finally, the quantum bit…

I took liberties here, but quantum computing and quantum entanglement are strange concepts and bear being messed with.

Quantum computing

Conventional computers evaluate arithmetic operations typically one after another, and current encryption systems often rely heavily on the fact that the huge number of possible combinations needing calculation would defeat even the most powerful computers working on the task for a lifetime. A "quantum computer" is proposed to have the ability to work as if it were in many possible states simultaneously and therefore able to evaluate all possible combinations in a tiny fraction of the time a conventional computer would take.

Quantum entanglement

This is the term for a strange (to say the least) phenomenon which would permit pairs of quantum particles (electrons etc.) to become "entangled". Remember this is a model, not reality! One result of this entanglement could perhaps be that teleportation becomes achievable if one quantum system takes on the state of another quantum system with which it becomes entangled. (It should be said that most experts believe that objects would not be able to move between the systems…yet.)

So that's it. In making this story I have taken snippets that I barely understand from here, other snippets from there, and mixed them up with a whole lot of What If. In my opinion, in fiction this is allowed. Do I believe in magic? No, but I sure believe in there being more things in this heaven and this earth than are dreamed of in philosophy.

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