On Science, Part 2 [1]

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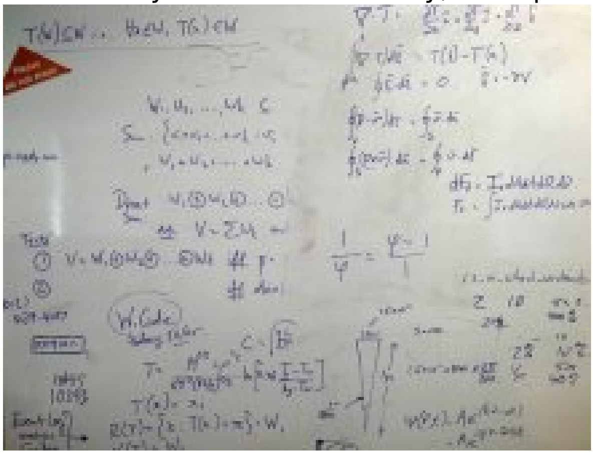

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Science is a truly noble ideal: it is a way to interrogate (physical) reality with rigour to arrive at a probable truth. Just as with other ideals, though, it falls short of being really ideal, because the agents of it are human being, who will always be fallible.

In this second part of my series on science [2], I am going to look at problems in contemporary science and research.

We have built a modern day cult around The Scientist. "*Science confirms x!*" or "*Researchers discover y!*", exclaim our news outlets and glossy magazines. The man in the white lab coat is regarded with the same reverence as the priests of the old religions.

To understand how science looks and works today, we need to humanise these people, and the work that they do.

Immovable Scientists

One of the core traits of a scientist is that they are willing to change their mind if the evidence is contrary to their beliefs. Let us imagine that I have built a new kind of battery. My calculations show that it will be more efficient and cost effective than existing batteries. It is based on some new chemical process that I have developed. I now need to actually physically test this battery and see how it compares to existing batteries. If my battery has horrible performance and is dangerous to use, I need to admit that I may have made a mistake in my assumptions when coming up with my new chemical process, or that there is something that I misunderstood.

If science is a dependable and unmovable rock, then human pride is the unstoppable force that collides with it. Things are not always so ideal. People want to defend their pride and their reputation, and want to justify the time and energy that they have invested[1].

And it is not just young and immature scientists who are prone to this. One famous example is of Fred Hoyle. In the mid-twentieth century, he was a leading proponent of the scientific theory of the origin of the universe called the Steady State model. This model said that the universe simply had always existed, and there were many nuances to it to explain phenomenon which now makes "common sense" in the current Big Bang theory. But in Hoyle's time, the scientific world was not yet convinced of the Big Bang theory, and it had problems. The Big Bang theory was eventually confirmed in 1964 by an experiment which detected what is named *cosmic microwave background* (CMB). Big Bang won because it *predicted* CMB before it was discovered. Steady State lost, because it could not account for CMB. The scientific world switched to Big Bang, but Hoyle and others tried for years afterwards to keep their theory afloat and to adjust it to accommodate for CMB. It should be noted that this was not merely a cerebral battle, but emotions and human pride were factors as well. Hoyle died at the beginning of the new millennium never having accepted the Big Bang theory.

That is certainly not to say that scientists do not change their views: it certainly does happen [3].

Another very famous scientist who was influenced by his prejudice, was Albert Einstein. His mathematics showed him that the universe was expanding. This contrasted his belief that the universe was static. To "remedy" this conclusion, he introduced the so-called "cosmological constant", which would correct the mathematics to indicate a static universe. Eventually Einstein accepted the evidence that the universe was expanding, abandoned the cosmological constant, and called it his "biggest blunder". Even giants can stumble over their preconceptions.

Science is Big and Complex

An apocryphal anecdote claims that Carl Friedrich Gauss, who died in 1855, was the last person to be knowledgeable in all the then-existing fields of mathematics. Even at that time mathematics was a huge field, but Gauss was incredibly intelligent, and since then science has ballooned. It is almost unfathomable to think how much science has advanced since then, and at what pace it is going now.

The effect of this has been a flood of information. It is impossible for anyone to know everything. Instead, scientists these days are typically focussed on narrow or at least specialised fields. When a link between fields is discovered, it is often serendipitous and by a fluke.

The "size" of science is not a problem in and of itself: rather, the problem is the limits of human understanding and ability. It is easy to worship at the altar of science if you never spend your time on anything else. When the field of science was small, people studied all facets of human knowledge: literature, philosophy and theology. Today this is impractical, and we need to wonder what gets lost in the process.

The sheer volume of publications which appear each year also leads to another problem: we are forced to rely on other people. We depend on other people reading dense and complex papers, summarising it succinctly and accurately, and then sharing that information with us. Sometimes this process is more trustworthy (such as when sharing with a research colleague) and other times it is less reliable and more imaginative (such as when popular news outlets try to report on scientific findings *and* try to make it sound interesting). And even if someone *could* read all of the publications that were relevant to them, that person would still not be able to verify all the reported results for themselves2. It is no longer optional: the modern scientist needs to rely on faith [4]; that is, that what others tell them are trustworthy. This might not seem like a problem, but actually it flies in the face of the inherent scepticism that science engenders. Taking this together with the narrow fields of focus of a scientist, which I just discussed, and we end up with things like "The Myth of the Climate Change 97%" [5].

In recent years, one of the most disturbing revelations have been the negligence of the review process of papers before they get published. Computer programs can generate computer science [6] and mathematics [7] papers. These papers look and read, on the face of it, like legitimate papers. They don't actually make sense, but a careless and embarrassed reviewer might think this is because the subject matter is beyond their level of knowledge on the subject. And papers generated this way (which really is just nonsensical rubbish) do get published [8] in scientific journals.

Mistakes get Made

Science is done by humans. Human beings are fallible. Ergo, mistakes are inevitable. It recently came to light [9] that a software "bug" affected "approximately one-fifth" of genome studies. Now this is just one example, and the affects are likely not as significant as one might fear. But there are countless examples of mistakes being made during the conduct of scientific study: some more humours, others more serious.

To mitigate this, science implements the peer-review process. All scientific papers need to be subjected to critical evaluation by other experts in your field. Unfortunately, it has also come to light that the peer-review process is not infallible and it is now well understood that papers can get published with mistakes in them [10], even in prestigious journals.

"Wrong science" is supposed to be further rooted out by the *repeatability* aspect of science. Once something is published, it is up to others to try and reproduce and verify the findings. That, again, is part of the rigour and "hostility" of science to ideas and reported findings. This may readily happen in new and exciting fields of study. But in other fields, one needs to wonder if anyone even bothers. After all, you certainly won't win a Nobel Prize for confirming someone else's findings.

While most mistakes may be harmless, and despite what was said in the previous section, it is at this time appropriate to remember that it was a single (now discredited [11]) study that fuelled the current anti-vaccine movement.

Money Talks

This is the big one. All of the problems mentioned until now can, in most cases, be dismissed as rare fringe cases. But money is the big one.

While I was busy doing my master's degree, I lived with another post graduate computer scientist who was busy doing a study in the field of computational biology. Would would discuss our work with each other, and one of our in-jokes came from his field: whenever you write a new paper, you begin with something like "Every year, millions of people die from AIDS...". The point is that the paper will discuss something which is remotely relevant to AIDS research (but likely also all kinds of other biological research). This is meant to pique people's interest, and to eventually dip into the pockets that fund AIDS research.

What we were joking about, was the "marketing" of scientific papers.

Whether we realise it or not, scientists do science as a career (the same goes for other academic disciplines). Gone are the days where scientists were supported by patrons who would support them to do their research as they please and have debaucherous orgies [12] in between. At stake now are degrees, research funds, tenure, professorships; universities may evaluate someone based on how many research papers they publish in a year. This puts pressure on academics, including scientists. Suddenly they are working against the clock and competing against other people. And these kinds of conditions can only fuel the problems already listed above. It can also add other problems, such as blatant dishonesty. For example, when private organisations fund research, they usually "expect" a certain conclusion to be reached as the outcome. Think, for example, of what agenda the tobacco industry or fizzy cool drink industry [13] could have. But even the individual scientist can be corrupt [14].

It is also not just junior researchers in a small departments of lesser renown universities who have to "market" their research. Whenever we read about some big new discovery made by NASA, that is likely PR work to try and keep the public interested and excited, and therefore the government funding it. The significance of these discoveries are often overstated [15], but the various kinds of news outlets report it in such a tantalising manner that one cannot help but get caught up in the excitement.

Money is such a powerful force in science that I cannot overstate it. It can even influence the direction of scientific research: directing it in one direction and cordoning off others. Imagine, for a moment, the scenario where you believe you have a plausible theory that could discredit the notion of man made climate change. Needless to say, this would cause quite an upset in the scientific world. This is such a controversial field, that the dare would be to find any "neutral" institute that would be willing to entertain your ideas and fund them. And this is not in the spirit of science. If man made climate change is real, then the scientific process itself will defeat your theory. And it should be allowed to do so[3]. But, as there is only so much money to go around, I postulate that you would be left out in the cold (no pun intended) for your efforts to get your theory off the ground.

There is no consensus in science

A large part of science is about interpretation4. One thing which our postmodern culture understands very, very well, is subjectivity and value of individual interpretation. In science it is not always so that the data unambiguously point towards a specific conclusion.

Very few things in science are (or, rather, should be) universally accepted. Remember, science is about *interrogating* and questioning ideas and theories. If people stop doing that, science loses momentum, and can even get stuck. Some of the most revolutionary discoveries upset the *status quo* when they were made. And while one can interrogate an idea that one truly believes in, it is merely human that the most vigorous efforts on this part come from true critics of an idea.

So, while it may seem strange to outsiders, scientists *should* disagree. And the honest scientist will sincerely listen to their opponents. This may seem like a stumbling block to progress, but this openness to criticism is a hallmark of science.

Where there is scientific consensus, one should tread lightly, especially in a young field.

Conclusion

Despite what may seem like a scathing critique of science, the above criticisms are about the *human* element of science. "Pure" science, like I said at the beginning, really is a noble enterprise. And in the following article [16], I shall be discussing why, despite all that was mentioned in this article, you cannot ignore or discount what science reveals.

Postscript

While I was busy preparing this series of articles, I noticed this link [17] posted by one of the faculty members from my former computer science department. It nicely reflects what I have written here, and provides some validation that I am not being overly biased. This article [18] is also very good. Lastly, at least scientists can laugh [19] at themselves [20].

- 1. Thankfully in science, even "dead ends" are valuable, as it eliminates an avenue of investigation on which other people in the future may have spent time. However, this kind of science is not glamorous and won't make you a celebrity.
- 2. Indeed, not even the reviewers of scientific papers do this.
- 3. And of course, on the off chance that you do manage to disprove man made climate change, you might very well become the most hated Nobel Prize winner in history.
- 4. Unless you are Edwin Hubble, who reported raw data and left it up to other astronomers to draw conclusions from that data.

Categories:

- Terminology & Concepts [21]

Tags:

- science [22]
- scientific method [23]
- money [24]
- human limitations [25]
- albert einstein [26]

- einstein [27]
- edwin hubble [28]
- hubble [29]
- fred hoyle [30]
- hoyle [31]
- carl gauss [32]
- gauss [33]
- pride [34]

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