Feynman's Basics of Science

Jakub Mańczak

2025-12-03

In his speech given to commemorate year commencement at Caltech, later entitled "Cargo Cult Science", as well as in his recorded lecture on the scientific method given 10 years prior, Feynman broke down the basics of how science is made, what drives it forward, who or what halts it and what the correct procedures for doing science are. And these are the kinds of speeches or articles that explain it so effortlessly it may as well all go over your head, as you find yourself agreeing, but not necessarily synthesizing what was said and what lessons there are to learn.

But there are lessons in there for sure, as in 10 minutes of speech (1964) and 4 pages of writing (1974), Feynman mixes critique of inductionism, falsification based views on science, and plenty of short stories and anecdotes about how science comes to be.

What is science?

Let's define science as those laws of nature's behavior which are sufficiently supported by evidence; those which drive forward the understanding of mankind or are reliably useful in practical ways - I believe this might be one of the more common definitions. Feynman describes the process of coming up with, or finding such usable, probably-true laws explicitly, at the very start of his lecture (1964). This process is as follows:

1. Try to guess it; come up with some idea that explains things further than is explained now.
2. Compute the consequences of that guess; how your idea interacts with current knowledge.
3. Compare the implications of its consequences with the tests and data that you have available, or can make available by testing and experimenting. Try to disprove it.

And if and only if these implications of its consequences match what's found in observed fact, not producing one contradiction along the way, you may proceed in calling it a finding, a rule, or a law, as Feynman puts it. But you must not call it proven, as there may come experiments that bring about new facts and observations which clash with your ruling - and if whilst riding a wave of applause you crowned yourself Supreme Scientist, you shall be stripped of that newfound title along with your dignity and reputation.

Popper's falsifiability

This aligns very nicely with Popper's hypothetico-deductive model of falsifiability; it's exactly that model, in fact, though retold in different terms (Popper, 1959). In Popper's terms, a conjecture or hypothesis is formed, born of bold ideas or stemming somehow from your experience. Predictions are formed that are refutable by observation. This quality lets you call them scientific, as when you test it and try to disprove it, it can fail, and be discarded or adjusted depending on the severity of its expectations' misalignment with reality. And if it doesn't, it's tentatively, temporarily accepted.

They only diverge when it comes to framing science: here we see not logic nor criticism, but honesty and discipline. Feynman has some ideas about what makes science good and bad.

Good science and bad (cargo cult) science

Good science is science that adheres to principles; the hubris mentioned two paragraphs above, exaggerated as it may be, is the opposite of what scientists should strive for (Feynman, 1974). To avoid such cruel fate you must always try to break your theories in all the ways you can think of - and only when you've exhausted all the ways to attack it should you consider it a candidate for sharing with the world. Perhaps more importantly, you should document those attempts along with your eventual findings, so that all those aiming to reproduce your findings know what was tried, what wasn't, what worked and what didn't. Those aiming to build upon your findings should naturally try to reproduce them first, and will naturally benefit too.

Feynman clearly states:

> The idea is to try to give *all* of the information to help others to judge the value of your contribution; not just the information that leads to judgement in one particular direction or another.

It's a shame that doesn't always happen - as illustrated by the example of Mr. Young's rat running study uncovering the precise way science with rats is to be conducted, and being subsequently ignored or forgotten about. But ignorance is not the only path resulting in a bad quality of science. So can overzealousness manifesting in a heightened desire to publish something good, something revolutionary, where you might conceal parts of your process or describe it in a way that misrepresents what it means for science at large.

What scientists do at the behest of publishers, and on their own

It is very often this desire to do good that results in bad being done.

First, scientists fool themselves. When results are expected to fall into a range that is unknown to be wrong, those without a strong sense of scientific integrity might knowingly or unknowingly correct their findings, such that they're closer to the status quo. This is illustrated via Millikan's electron charge measurement skewing results (Feynman, 1974).

With the desire to publish new findings, comes the lack of desire to publish - or even do! - anything less substantial. This has applications in marketing or politics, where omission of potentially harmful observations is a dirty, but common play. It also works in the lab - where experiments basing off of previous work are unfairly deprived of a baseline reproduction of that work, for it is considered a waste of time. Those wanting lab equipment and grant money to be spent only on discoveries and new findings ironically end up hurting those same discoveries, by not letting the experiments performed be controlled in a way that improves their probabilities. It's a vicious cycle that can only be stopped by a widespread understanding of the intricacies of science among the populace - such that time, equipment and money spent on reproductions can never be misconstrued as wasted.

It's science done wrong, to whatever degree. It's exactly what halts science. Feynman calls missteps like that Cargo Cult Science - inspired by an apparent phenomena in the south Pacific, where indigenous peoples that saw planes land on runways and bring useful supplies would imitate the environment in which planes had appeared, hoping to bring about wealth.

The fault in Inductionism

It was imitation without understanding of the mechanisms that powered the phenomenon, and a kind of failure of naive inductionism; where the natives saw a cause in a set-up of runways, radios and towers, and an effect in goods arriving, was a far more complex set of relationships, or even a complete reversal of cause and effect - the infrastructure only being there to allow the planes to land, which was arranged ahead of time.

Had the belief that planes would arrive when they built the runways been phrased differently, perhaps it would not have become such a known stereotype. Perhaps if there was an upper bound, that the runways have to be modeled up to some accuracy, and they were, the planes would come. And when they inevitably wouldn't, while some would argue to up the accuracy, others would propose different ideas - such that it was not the runway, but something else entirely that made the planes land.

If imitation without understanding of the causes leads to failure, inferring scientific laws from observations alone will never be sufficient. This is where inductionism shows its limit, and why it needed to be enriched with further ideas; with pursuit of a closer approximation of truth, with conjectures falsifiable by design, and with a more rational science.

Summary

Feynman's views on science through the lens of these two publications seem to be that within the framework of falsifiability, science is more of a moral exercise grounded in intellectual honesty than a strictly defined procedure. While there are definitely elements of rigor in the requirements for a sense of scientificity, the process need not be complicated.

He does not recommend a completely lax attitude however; He identifies certain looming dangers that can only be fought with heightening integrity in the minds of the scientists, regulators and policy-makers, and the general populace. Pressures to publish, to impress, to conform can only be quelled if the pursuit of tentative truth is above all else.

Ultimately, science only progresses when people are honest with each other. I sure hope they will be, forevermore.

Bibliography

Feynman, R. P. (1964). *On Scientific Method*.

Feynman, R. P. (1974). Cargo Cult Science. *Engineering and Science*, *37*(7).

Popper, K. (1959). *The Logic of Scientific Discovery*. Hutchinson.