FASTS Federation of Australian Scientific and Technological Societies

When is Science Valid?

A Short Guide on How Science Works and When to Believe It

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A short history of science
Science has evolved over thousands of years of human enquiry to provide a rational basis for understanding and predicting what happens in the world around us. We rely on science to enhance our standard of living, to keep us healthy, and to address the problems and challenges that we face.

Over the last five hundred years humanity has developed a new way of systematically testing ideas against physical evidence[1]. The modern world is a direct product of the growth of scientific knowledge sparked by that understanding.

Why do we rely on science?
Through scientific evaluation, we ensure that the knowledge we need is as reliable and as rigorously tested as we can make it. It is this process of scientific thought and examination that gives us confidence – confidence to fly apparently unsupported in an aircraft, to rely on mobile phones for instantaneous communication, and to feed our children a nutritious diet so they can grow into adulthood.

How does science ensure that knowledge is reliable?
Science takes ideas and constantly tests them. These tests are based on acquiring evidence, which is often (but not exclusively) provided by conducting experiments. When an idea fails the test of agreeing with new evidence, a new idea is needed that is itself then tested. And so the process goes on.

This is why our current understanding of the world around us is constantly improving and evolving. It doesn't mean that previous ideas are completely useless – after all, we don't need Einstein's theory of relativity (rather than Newton's mechanics) to drive a car. But science is always striving to improve on the ideas that currently exist by using evidence-based research.

How do we know that an idea has been tested properly?
Science tests ideas by putting the evidence out there for all to see. This is scientific publication by peer review.

When a research paper is submitted to a scientific journal, the editors and the expert referees that they select, rigorously scrutinise the paper to see if the evidence supports the claims. They may make suggestions on how to better substantiate the evidence and the claims. If the authors comply and meet the high standards of rigour and logic required, then the paper is accepted.

[1] This includes what is sometimes referred to as *scientific method.*

When an idea and its evidence are published in an internationally accessible journal, it is there for all scientists to judge whether the evidence stacks up.

More importantly, the process is designed to provide enough information on the experimental tests so that other scientists can reproduce the published results and validate (or otherwise) the initial idea. They may also take the idea further, and devise additional tests to see if the idea still stacks up.

Presenting previously peer-reviewed research in other formats is legitimate, but unreviewed material published in books or articles doesn't count. It's like writing on a billboard that the earth is flat. Only when the logic and evidence behind an idea is evaluated by other scientists in the field, is an idea considered peer-reviewed.

Does that mean those who publish in peer-reviewed journals are part of a self-defined, exclusive club?

No it doesn't. If anyone has a new idea that fulfils the criteria of rigour and logic based on sound evidence, then they can have that idea validated through publication in the scientific literature.

When is an idea accepted?

Like other fields of human endeavour, sometimes ideas in science take a while to catch on. We need only to look back into history to see that it took some time for people to grapple with the idea that the earth revolves around the sun.

In science, the test of any idea is not so much whether it is 'correct', but more so whether it is useful. For scientists, an idea is useful if it helps us make good sense of the world around us. However, if evidence contradicts an idea, or other ideas emerge that make better sense of the world, then science - ever pragmatic - will adopt the more useful idea.

For example, the concept that particles can behave as waves (and vice versa) as developed in quantum mechanics, was accepted as a more useful way to describe the microscopic world than classical mechanics. It subsequently led to important advances such as the transistor and the laser.

Of course, initially an idea may only be accepted by a small part of the scientific community – who might be regarded as the vanguard of a new wave of thinking. But unless eventually the *majority* of scientists in the field take on the idea, then it will wither and may eventually die.

On the other hand, if the idea becomes accepted by the majority of scientists in the field because it usefully describes the world we live in, then it becomes mainstream. The idea is then ready to be challenged by the next wave of evidence-based ideas.

To take a current example, let's consider the concept that recent climate change is mainly caused by increased greenhouse gas emissions produced by humans. This idea is now mainstream and accepted by the vast majority of the world's scientists. It has passed the test of expert examination, and the international deliberations of thousands of scientists support that view.

Of course there are some scientists who do not support the view of the mainstream majority on human-induced climate change, but they are in a tiny minority. Until that minority publishes their ideas - thereby confronting the mainstream view in the scientific literature so that the alternative views can be rigorously tested against the evidence - then the community will continue to adopt the concept of human-induced climate change.

This is because it is the explanation that best makes sense of all the scientific evidence, and is thus the most practical way to address the problems of the real world.

How do we know when an idea has been validated?
Here's a quick check list to establish whether a scientific idea has been validated:

- Has it been published in the peer-reviewed literature *in that field of science*?
- Have other scientists cited that publication as being valid (as opposed to citing it to show that it is wrong)?
- Have other scientists conducted additional tests that show the idea to be valid?
- Has the idea been built upon to create new understanding, i.e., has the idea become useful?

Is it useful to test ideas further by public debate in the media?
Ideas should always be tested, but an idea is only widely accepted when the majority of scientists vote with their feet on its usefulness.

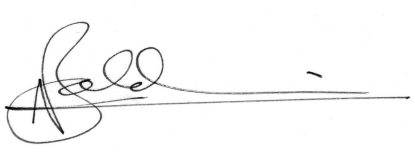
Does a media debate between two scientists contribute to this process? Not really.

The reason is twofold. First, a debate does not allow the full scrutiny required of evidence-based expert examination. Second, the majority view of expert scientists cannot be reflected by a debate. In a debate, one adversary is pitted against another. This does not tell us if the majority of the scientific community are sitting on one side or the other.

It's like having a debate between one person who believes that the earth is flat, and another person representing the rest of the population who believes the earth is round.

Summary

- Science works by systematically testing ideas against the evidence.
- Evidence-based ideas are examined by peer review and published for further scrutiny in the scientific literature so that additional tests can be applied.
- Scientific ideas are adopted when they usefully describe the world.
- When scientific ideas are widely accepted they become mainstream, and are applied until replaced by the widespread adoption of an alternative idea that makes better sense of the evidence.
- A scientific idea is validated when it is published in the peer-reviewed literature in the field, has stood up to further tests, and has been positively cited.



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