Tips for the SMART consumer of science

Science is for Everyone

It's not about having a degree or specializing in an area of study or some "expert" talking on an infotainment channel. The practice of science was built on a way of thinking about the world that relies on skepticism – skepticism *is* the heart of the Enlightenment. So we assume the truth is knowable by anyone – peasant or king. We don't need authorities to tell us what is true. If we know what to look for, we can see for ourselves.

Science is independent verification – a single study is not a scientific truth

A scientific truth is not expressed in a single study or single experiment any more than the Mona Lisa is expressed in a single brush-stroke. Everything that is discovered through science is based on repeating and verifying the results of others. The skepticism of science demands this verification. It is how we manage our own ignorance. All scientists swear an oath to submit their work to criticism and review, knowing that there is an independent truth out there to be discovered, even if they don't find it. It's not just because some scientists might try to skew the "truth" for their own ends, but simply because everyone makes mistakes. Experiments can be wrong. Scientists are human, and humans can be wrong. But a preponderance of multiple, independent verifications can be accepted as a scientific truth. Each verification should have its own reference.

Example: cigarette smoking and lung cancer

The causal link between cigarette smoking and lung cancer that we take for granted was not always so. Do not think the link was established in a single study in the 1950s, all subsequent work halted, and labels were affixed to cigarette packs forever more. Instead, the initial finding was controversial[1], and was only established through the independent confirmations of other researchers. This independent verification gave the Surgeon General the confidence to require warning labels.

[1] White, Colin, *Yale Journal of Biology and Medicine* (1990) **63**, 29

Example: dark energy

Dark energy is the accelerating recession of the distant galaxies, discovered in the late 1990s by two independent teams. The results were known to be revolutionary at the time – neither team believed it until they spoke to the other. But the Nobel Prize in physics was awarded for the discovery only in 2011. Why did they take so long if the magnitude of the initial discovery was evident? Because the results had to be confirmed. Now, the accelerating recession is verified by numerous research teams looking at several independent lines of evidence[2]. The discoverers knew their results would need independent confirmation, and they welcomed it.

[2] Frieman, J.A., et al., *Ann. Rev. Astron. Astrophys*. (2008) **46,** 385

Legitimate studies are in peer-reviewed journals

Scientific studies are published in scientific journals. The mainstream journals enforce a peer-review process before publication, in the spirit of skepticism. This filters any fatally-compromised methods and endeavors that are not worthy of further study. If you get into the business of reading the individual studies that make up the mosaic of the scientific consensus, then you will want to look for publications in peer-reviewed journals, such as *The Lancet* for medicine, or *Physical Review* for physics. New online journals have appeared in the age of the internet, giving science authors many more publishing platforms. Because peer review was and still is uncompensated, the level of peer review in some journals, paper and online, may be compromised – one must choose sources wisely. Newspaper editorial pages have no peer-review processes, and letters to the editor are generally understood to be opinions only, not scientific studies.

Don't reinvent the wheel – find the review article and start there

Every field of science will include review articles summarizing the state of the field and the general consensus on findings and their implications. This may be by a senior member of the research community, or some other disinterested expert who can be relied upon to give an objective overview of the various experiments and studies. Again, look for the review article in a reputable journal with peer-review processes, and make sure the author is not just promoting their own interpretation of data. The dark energy reference above is an example review article – the authors were not part of any of the experimental teams whose work they review.