SCIENCE VS. PSEUDOSCIENCE: WHERE IS THE DIFFERENCE?

John Casti (in *Paradigms Lost*) provided an excellent summary of the characteristics of pseudo-science, which I briefly discuss here as a user-friendly guide for critical thinking. Philosopher Karl Popper proposed his criterion of falsification as a way to distinguish between science and pseudoscience. The idea is that science makes falsifiable predictions, while pseudoscience does not because one can always go back and modify the prediction a posteriori so that it fits the facts. Unfortunately for Popper, the demarcation problem is not so simple to resolve, mostly because science itself does not follow what I have termed above "naïve" falsificationism. A better way to think about this problem is as a continuum from "hard" sciences such as physics and chemistry (where experimental manipulation is possible) to "soft" ones like biology and geology (where the element of historicity becomes more heavy) to proto-scientific disciplines (most of the social sciences, for which often overarching theories are lacking or difficult to support empirically) to clear pseudosciences such as astrology and parapsychology (where not only the theory is unsound when compared to anything else we know about the functioning of the universe, but the empirical evidence clearly rejects the claims of the discipline's practitioners). Here is Casti's set of criteria for distinguishing between science and pseudoscience:

1. *Anachronistic thinking*. If an argument is based on the wisdom of the ancients (who, remember, knew much less about the world than any junior high school graduate should), or on the use of outmoded scientific terminology, there is good reason to be suspicious.

2. *Seeking mysteries*. While science's objective is to solve mysteries, pseudo-science tends to emphasize the existence and supposed unsolvability of mysteries. This is a rather sterile position, since if a mystery is by definition insoluble, then why wasting ones' time thinking about it?

3. *Appeals to myths*. This is the idea that ancient myths *must* be based on some kind of real events, which became distorted in the course of oral transmission from generation to generation. While this can certainly happen, just because some cultures share (usually superficially) similar myths, that does not imply that the underlying events are the same, or even ever happened. An alternative explanation is that human minds tend to work in a similar fashion, and therefore provide similar explanations for things they do not understand.

4. *Casual approach to evidence*. Evidence is the cornerstone that sets aside science from any other human intellectual endeavor, including (to a large extent) philosophy. Given its pivotal role, admissible evidence has to be solid and reliable. If we cite a "fact," we have to be reasonably sure that it indeed corresponds to a verifiable piece of evidence. Hearsay is not admissible.

5. *Irrefutable hypotheses*. Scientific progress can be made only if a hypothesis is at least potentially open to dismissal. If your hypothesis is not refutable (i.e., falsifiable) *no matter what the evidence*, then it is useless (of course, it may still be true, but there is no way to verify it).

6. *Spurious similarities*. A very insidious trap of human thinking is drawing parallels between concepts or phenomena that seem reasonable, and that require an in-depth analysis to be verified or discarded. For ex-

ample, one can draw mystical significance from the fact that one's car plate number is the same as one's civic address. But a moment of reflection would easily lead you to conclude that this is simply a coincidence. In other cases, however, the parallel may seem more compelling. In general, similarities can yield genuine insights into the matter under consideration, but they require a higher standard of verification than the one provided by a first intuition.

7. *Explanation by scenario*. It is pretty easy, if one has just a little bit of imagination, to explain something by telling a story, that is by imagining a reasonable scenario. Scientists are sometimes guilty of this practice (widespread, for example, among evolutionary psychologists). In fact, scenarios can be useful, because they may point the inquiry in the right direction. However, when scenarios remain just-so stories, not backed by data, they are not useful tools because many scenarios can be proposed to explain the same data, but presumably only one is actually correct.

8. *Research by literary interpretation*. This occurs when the proponent of a pseudoscientific position claims that statements by scientists are open to alternative, *equally valid* interpretations. This approach treats scientific literature as one might consider a novel or a painting: no one interpretation (not even the one espoused by the author!) is necessarily better than any other. In science, this is a far cry from the reality of things. Scientific statements are the more useful the more precise and unambiguous they are. Ideally, a scientific hypothesis or theory should have one and only one possible interpretation, and this is either correct or not.

9. *Refusal to revise*. One of the hallmarks of pseudoscience is the refusal to revise one's own positions in the face of new evidence. No matter how many studies are conducted on the ineffectiveness of astrology, astrologers will repeat the same arguments in support of their profession. Science is a process of a completely different nature, where the primary element is continuous revision and correction to accommodate new evidence.

10. *Shift the burden of proof on the other side*. The reader should be weary of statements such as "but it has not been disproved." First, there are simply not enough scientists and funding to verify or disprove every claim that has ever been made. That is not positive evidence for that claim, however, but simply of our ignorance (or disinterest) on the matter. Second, when one proposes an alternative to a very well established theory, the burden of proof is logically and squarely on the side of the newcomer. When Copernicus suggested that the Earth rotates around the Sun, and not vice versa, people did not just believe him because nobody had proven him wrong (on the contrary, most people did *not* even consider his arguments!). Other astronomers demanded evidence, and it took more than a century for the theory to be accepted.

11. *A theory is legitimate simply because it's new, alternative, or daring*. This is the "Galileo" effect. Proponents of new theories are fond of recalling the many examples of scientists who had been derided, ignored, or worse persecuted because of their radical theories, which then proved to be correct. What this line of reasoning ignores, of course, is the fact that for every Galileo who eventually succeeded there were thousands of crackpots who did not. For every example of a daring, new scientific theory which ends up being accepted, there are many, many examples of wrong theories, forever rejected and confined to the limbo of pseudoscientific history. Novelty per se is no evidence.

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