science & philosophy, by Massimo

What is science and why should we care? — Part II

March 27, 2014February 8, 2015 essay politics, pseudoscience, religion, science, war

(https://scientiasalon.files.wordpress.com/2014/03/homeopathy-medication.jpg)by Alan Sokal

Let me now pass to a second set of adversaries of the scientific worldview, namely the advocates of pseudoscience. This is of course an enormous area, so let me focus on one socially important aspect of it, namely so-called "complementary and alternative therapies" in health and medicine. And within this, I'd like to look in a bit of detail at one of the most widely used "alternative" therapies, namely homeopathy — which is an interesting case because its advocates sometimes claim that there is evidence from meta-analyses of clinical trials that homeopathy works.

Now, one basic principle in all of science is GIGO: garbage in, garbage out. This principle is particularly important in statistical meta-analysis: because if you have a bunch of methodologically poor studies, each with small sample size, and then subject them to meta-analysis, what can happen is that the systematic biases in each study — if they mostly point in the same direction — can reach statistical significance when the studies are pooled. And this possibility is particularly relevant here, because meta-analyses of homeopathy invariably find an inverse correlation between the methodological quality of the study and the observed effectiveness of homeopathy: that is, the sloppiest studies find the strongest evidence in favor of homeopathy. [12] When one restricts attention only to methodologically sound studies — those that include adequate randomization and double-blinding, predefined outcome measures, and clear accounting for drop-outs — the meta-analyses find no statistically significant effect (whether positive or negative) of homeopathy compared to placebo.

But the lack of convincing statistical evidence for the efficacy of homeopathy is not, in fact, the main reason why I and other scientists are skeptical (to put it mildly) about homeopathy; and it's worth taking a few moments to explain this main reason, because it provides some important insights into the nature of science.

Most people — perhaps even most users of homeopathic remedies — do not clearly understand what homeopathy is. They probably think of it as a species of herbal medicine. Of course plants contain a wide variety of substances, some of which can be biologically active (with either beneficial or harmful

consequences, as Socrates learned). But homeopathic remedies, by contrast, are pure water and starch: the alleged "active ingredient" is so highly diluted that in most cases not a single molecule remains in the final product.

And so, the fundamental reason for rejecting homeopathy is that there is no plausible mechanism by which homeopathy could possibly work, unless one rejects everything that we have learned over the last 200 years about physics and chemistry: namely, that matter is made of atoms, and that the properties of matter — including its chemical and biological effects — depend on its atomic structure. There is simply no way that an absent "ingredient" could have a therapeutic effect. High-quality clinical trials find no difference between homeopathy and placebo because homeopathic remedies are placebos.

Now, advocates of homeopathy sometimes respond to this argument by asserting that the curative effect of homeopathic remedies arises from a "memory" of the vanished active ingredient that is somehow retained by the water in which it was dissolved (and then by the starch when the water is evaporated!). But the difficulty, once again, is not simply the lack of any reliable experimental evidence for such a "memory of water." Rather, the problem is that the existence of such a phenomenon would contradict well-tested science, in this case the statistical mechanics of fluids. The molecules of any liquid are constantly being bumped by other molecules — what physicists call thermal fluctuations — so that they quickly lose any "memory" of their past configuration. (Here when I say "quickly," I'm talking picoseconds, not months.)

In short, all the millions of experiments confirming modern physics and chemistry also constitute powerful evidence against homeopathy. For this reason, the flaw in the justification of homeopathy is not merely the lack of statistical evidence showing the efficacy of homeopathic remedies over placebo at the 95% or 99% confidence level. Even a clinical trial at the 99.99% confidence level would not begin to compete with all the evidence in favor of modern physics and chemistry. Extraordinary claims require extraordinary evidence. (And in the unlikely event that such convincing evidence is ever forthcoming, the person who provides it will assuredly win a triple Nobel Prize in physics, chemistry and biology — beating out Marie Curie, who won only two.)

Despite the utter scientific implausibility of homeopathy, homeopathic products can be marketed in the United States without having to meet the safety and efficacy requirements that are demanded of all other drugs (because they got a special dispensation in the Food, Drug, and Cosmetic Act of 1938). Indeed, U.S. government regulations require each homeopathic remedy that is marketed over-the-counter (OTC) to state, on the label, at least one medical condition that the product is intended to treat — but without requiring any evidence that the product is actually efficacious in treating that condition! [13] The laws in other Western countries are equally scandalous, if not more so.

Fortunately, it seems that this particular pseudoscience has thus far made only modest inroads in the United States — by contrast with its wide penetration in France and Germany, where homeopathic products are packaged like real medicines and sold side-by-side with them in virtually every pharmacy. But other and more dangerous pseudosciences are endemic in the United States: prominent among these is the denial of biological evolution.

It is essential to begin our analysis by distinguishing clearly between three very different issues: namely, the fact of the evolution of biological species; the general mechanisms of that evolution; and the precise details of those mechanisms. Of course, one of the favorite tactics of deniers of evolution is to confuse these three aspects.

Among biologists, and indeed among the general educated public, the fact that biological species have evolved is established beyond any reasonable doubt. Most species that existed at various times in the past no longer exist; and conversely, most species that exist today did not exist for most of the Earth's past. In particular, modern *Homo sapiens* did not exist 1,000,000 years ago; and conversely, other species of hominids, such as *Homo erectus*, existed then and are now extinct. The fossil record is unequivocal on this point, and this has been well understood since at least the late 19th century.

A more subtle issue concerns the mechanisms of biological evolution; and here our modern scientific understanding took a longer time to develop. Though the basic idea — descent with modification, combined with natural selection — was set forth with eminent clarity by Darwin already in his 1859 book, the precise mechanisms underlying Darwinian evolution did not become fully elucidated until the development of genetics and molecular biology in the first half of the twentieth century. Nowadays we have a good understanding of the overall process: errors in copying DNA during reproduction cause mutations; some of these mutations either increase or decrease the organism's success at survival and reproduction; natural selection acts to increase the frequency in the gene pool of those mutations that increase the organism's reproductive success; as a result, over time, species develop adaptations to ecological niches; old species die out and new species arise. This general picture is nowadays established beyond any reasonable doubt, not only by paleontology but also by laboratory experiments.

Of course, when it comes to the precise details of evolutionary theory, there is still lively debate among specialists (just as there is in any active scientific field): for instance, concerning the quantitative importance of group selection or of genetic drift. But these debates in no way cast doubt on either the fact of evolution or on its general mechanisms. Indeed, as the celebrated geneticist Theodosius Dobzhansky pointed out in a 1973 essay, "nothing in biology makes sense except in the light of evolution". [14]

Everything that I have just said is of course common knowledge to anyone who has taken a half-decent course in high-school biology. The trouble is, fewer and fewer people — at least in the United States — nowadays have the good fortune to be exposed to a half-decent course in high-school biology. And the cause of that scientific illiteracy is (need I say it?) politics: more precisely, politics combined with religion. Some people reject evolution because they find it incompatible with their religious beliefs. And in countries where such people are numerous or politically powerful or both, politicians kowtow to them and suppress the teaching of evolution in the public schools — with the result that the younger generation is denied the opportunity to evaluate the scientific evidence for themselves, and the scientific ignorance of the populace is faithfully reproduced in future generations.

The results of a fascinating cross-cultural survey, carried out in 2005 in 32 European countries along with the United States and Japan is particularly enlightening in this respect. [15] Respondents were read the statement, "Human beings, as we know them, developed from earlier species of animals," and were asked whether they considered it to be true, false, or were not sure. Of all 34 countries, the United States holds 33rd place for belief in evolution (with roughly equal numbers responding "true" and "false"). Only Turkey — where the secular heritage is under increasing assault from the elected Islamist government and its supporters — shows less belief in evolution than the United States. (Please note that this question concerns merely the fact of evolution, not its mechanisms.)

Of course, not all religious people reject evolution. Fundamentalist Christians do reject evolution, as do many Muslims and orthodox Jews; but Catholics and liberal Protestants have come (over time and perhaps grudgingly) to accept evolution, as have some Muslims and most Jews. Therefore, from a purely tactical point of view, non-fundamentalist religious people are the allies of scientists in their struggle to defend the honest teaching of science.

And so, if I were tactically minded, I would stress — as most scientists do — that science and religion need not come into conflict. I might even go on to argue, following Stephen Jay Gould, that science and religion should be understood as "nonoverlapping magisteria": science dealing with questions of fact, religion dealing with questions of ethics and meaning. But I can't in good conscience proceed in this way, for the simple reason that I don't think the arguments stand up to careful logical examination. Why do I say that? For the details, I have to refer you to a 75-page chapter in my book [16]; but let me at least try to sketch now the main reasons why I think that science and religion are fundamentally incompatible ways of looking at the world.

When analyzing religion, a few distinctions are perhaps in order. For starters, religious doctrines typically have two components: a factual part, consisting of a set of claims about the universe and its history; and an ethical part, consisting of a set of prescriptions about how to live. In addition, all religions make, at least implicitly, epistemological claims concerning the methods by which humans can obtain reasonably reliable knowledge of factual or ethical matters. These three aspects of each religion obviously need to be evaluated separately. Furthermore, when discussing any set of ideas, it is important to distinguish between the intrinsic merit of those ideas, the objective role they play in the world, and the subjective reasons for which various people defend or attack them.

Alas, much discussion of religion fails to make these elementary distinctions: for instance, confusing the intrinsic merit of an idea with the good or bad effects that it may have in the world. Here I want to address only the most fundamental issue, namely, the intrinsic merit of the various religions' factual doctrines. And within that, I want to focus on the epistemological question — or to put it in less fancy language, the relationship between belief and evidence. After all, those who believe in their religion's factual doctrines presumably do so for what they consider to be good reasons. So it's sensible to ask: What are these alleged good reasons?

Each religion makes scores of purportedly factual assertions about everything from the creation of the universe to the afterlife. But on what grounds can believers presume to know that these assertions are true? The reasons they give are various, but the ultimate justification for most religious people's beliefs is a simple one: we believe what we believe because our holy scriptures say so. But how, then, do we know that our holy scriptures are factually accurate? Because the scriptures themselves say so. Theologians specialize in weaving elaborate webs of verbiage to avoid saying anything quite so bluntly, but this gem of circular reasoning really is the epistemological bottom line on which all "faith" is grounded. In the words of Pope John Paul II: "By the authority of his absolute transcendence, God who makes himself known is also the source of the credibility of what he reveals." [17] It goes without saying that this begs the question of whether the texts at issue really were authored or inspired by God, and on what grounds one knows this. "Faith" is not in fact a rejection of reason, but simply a lazy acceptance of bad reasons. "Faith" is the pseudo-justification that some people trot out when they want to make claims without the necessary evidence.

But of course we never apply these lax standards of evidence to the claims made in the other fellow's holy scriptures: when it comes to religions other than one's own, religious people are as rational as everyone else. Only our own religion, whatever it may be, seems to merit some special dispensation from the general standards of evidence.

And here, it seems to me, is the crux of the conflict between religion and science. Not the religious rejection of specific scientific theories (be it heliocentrism in the 17th century or evolutionary biology today); over time most religions do find some way to make peace with well-established science. Rather, the scientific

worldview and the religious worldview come into conflict over a far more fundamental question: namely, what constitutes evidence.

Science relies on publicly reproducible sense experience (that is, experiments and observations) combined with rational reflection on those empirical observations. Religious people acknowledge the validity of that method, but then claim to be in the possession of additional methods for obtaining reliable knowledge of factual matters — methods that go beyond the mere assessment of empirical evidence — such as intuition, revelation, or the reliance on sacred texts. But the trouble is this: What good reason do we have to believe that such methods work, in the sense of steering us systematically (even if not invariably) towards true beliefs rather than towards false ones? At least in the domains where we have been able to test these methods — astronomy, geology and history, for instance — they have not proven terribly reliable. Why should we expect them to work any better when we apply them to problems that are even more difficult, such as the fundamental nature of the universe?

Last but not least, these non-empirical methods suffer from an insuperable logical problem: What should we do when different people's intuitions or revelations conflict? How can we know which of the many purportedly sacred texts — whose assertions frequently contradict one another — are in fact sacred?

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