SCIENCE *VERSUS* PSEUDOSCIENCE − CAN WE TELL THE DIFFERENCE?

foredrag på temamøte om vitenskap og pseudovitenskap*
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The claims that science, as a collective enterprise, makes for itself are both modest and highly ambitious. They are modest in the sense that science does not profess to have attained the final and unalterable truth, but only approximations of it. But at the same time science makes the ambitious claim that it possesses both the currently best available approximation of the truth and the best methods to test and challenge, improve or replace that approximation in order to arrive at something better.

This capacity for self-improvement, even radical self-improvement, is in my view, more than anything else, the major underlying strength of science, and the "secret" of its success. Science represents the triumph of criticism and creativity over dogmatism and deference. In this presentation I will begin by clarifying what I mean by science (Section 1) and how we can distinguish it from pseudoscience (Section 2). I will then turn to a theme introduced by Edzard Ernst, namely clinical trials, and clarify why we have strong reasons to rely on them − even stronger than the reasons we have to rely on other scientific investigations (Sections 3−4). Finally, I will introduce the notion of science denialism and discuss its characteristics and how it differs from other types of pseudoscience (Section 5).

1 What is science?

The English word "science" is primarily used about the natural sciences and other fields of research that are considered to be similar to them. Hence, political economy and sociology are counted as sciences, whereas studies of literature and history are usually not. The corresponding German word, "Wissenschaft", has a much broader meaning and encompasses all the academic specialties, including the humanities. The same applies to the corresponding words in several other Germanic

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languages including, if I am correctly informed, the Norwegian "vitenskap". "Wissenschaft", "vitenskap" and their cognates in related languages have the advantage over the English "science" of more adequately delimiting the types of systematic knowledge that are at stake in the conflict between science and pseudoscience. The misrepresentations of history presented by Holocaust deniers and other pseudo-historians are very similar in nature to the misrepresentations of natural science promoted by creationists and homeopaths.

More importantly, the natural and social sciences and the humanities are all parts of one and the same human endeavour, namely systematic and critical investigations aimed at acquiring the best possible understanding of the workings of nature, man, and human society. The disciplines that form this *community of knowledge disciplines* are increasingly interdependent (Hansson 2007). Since the second half of the 20th century, integrative disciplines such as astrophysics, evolutionary biology, biochemistry, ecology, quantum chemistry, the neurosciences, and game theory have developed at dramatic speed and contributed to tying together previously unconnected disciplines. These increased interconnections have also linked the sciences and the humanities closer to each other, as can be seen for instance from how historical knowledge relies increasingly on advanced scientific analysis of archaeological findings, how the history of art uses more and more advanced physical and chemical methods, how linguistics employs methodology originally developed for the natural sciences[1], how methods from history are used to track down patterns of environmental pollution, and how historical and philosophical knowledge is used in the analysis of potential consequences of new technologies (Brey 2012).

The conflict between science and pseudoscience is best understood in terms of this extended sense of science. On one side of the conflict we find the community of knowledge disciplines that includes the natural and social sciences and the humanities. On the other side we find a wide variety of movements and doctrines, such as creationism, astrology, homeopathy, and Holocaust denialism that are all in conflict with results and methods that are generally accepted in the community of knowledge disciplines.

Another way to express this is that the demarcation problem has a deeper concern than that of demarcating the selection of human activities that we have for various reasons chosen to call "sciences". The ultimate issue is "how to determine which beliefs are epistemically warranted" (Fuller 1985, 331; Hansson 2013).

1. Methods and concepts from studies of biological evolution (such as the serial founder effect) have recently been successfully applied to throw light on the development of human societies and even on the development of languages tens of thousands of years before written evidence (Henrich 2004; Pagel et al. 2007; Lycett and von Cramon-Taubadel 2008; Atkinson 2011).

2 The demarcation issue

Many writers on pseudoscience have emphasized that pseudoscience is non-science posing as science. The foremost modern classic on the subject (Gardner 1957) bears the title *Fads and Fallacies in the Name of Science*. According to Brian Baigrie (1988, 438), "[w]hat is objectionable about these beliefs is that they masquerade as genuinely scientific ones". These and many other authors assume that to be pseudoscientific, an activity or a teaching has to satisfy the following two criteria:

(1) it is not scientific, and

(2) its major proponents try to create the impression that it is scientific (Hansson 1996).

The former of these two criteria has been at the focus of the discussion. The second also needs careful treatment, not least since many discussions of pseudoscience have been confused due to insufficient attention to it.

An immediate problem with the definition based on (1) and (2) is that it is too wide. There are phenomena that satisfy both criteria but are yet not commonly called pseudoscientific. One of the clearest examples of this is fraud in science. This is a practice that has a high degree of scientific pretence and yet does not comply with science, thus it satisfies both our criteria (1) and (2). Nevertheless, fraud in otherwise legitimate branches of science is seldom if ever called "pseudoscience". Another class of examples satisfying (1) and (2) that we do not usually see as pseudoscience is serious mistakes in science, committed due to human failure although the intent was to do good science. As I have discussed in some detail elsewhere (Hansson 1996, 2009, 2013), what is missing in cases of fraud and serious mistakes is a deviant doctrine. Isolated breaches of the requirements of science are usually not regarded as pseudoscientific. Pseudoscience, as it is commonly conceived, involves a sustained effort to promote teachings different from those that have scientific legitimacy at the time.

The example of fraud is particularly instructive. Fraud is not in general associated with a deviant or unorthodox doctrine. To the contrary, the fraudulent scientist is anxious to present results that are in conformity with the predictions of established scientific theories. Deviations from these would lead to a much higher risk of disclosure. This would give us reason to replace (2) by the following improved version:

(2') it is part of a non-scientific doctrine whose major proponents try to create the impression that it is scientific (Hansson 1996).

The term “pseudoscience” is often used in a wider sense than that which is captured in the definition constituted of (1) and (2’). Contrary to (2’), doctrines that conflict with science are sometimes called “pseudoscientific” in spite of not being advanced as scientific. Hence, Grove (1985, 219) included among the pseudoscientific doctrines those that “purport to offer alternative accounts to those of science or claim to explain what science cannot explain”. Lugg (1987, 227–228) maintained that “the clairvoyant’s predictions are pseudoscientific whether or not they are correct”, despite the fact that most clairvoyants do not profess to be practitioners of science. In this sense, pseudoscience is assumed to include not only doctrines contrary to science proclaimed to be scientific but doctrines contrary to science tout court, whether or not they are put forward in the name of science. To cover this wider sense of pseudoscience, (2’) can be modified as follows:

(2’’) it is part of a doctrine that conflicts with (good) science (Hansson 1996).

Common usage seems to vacillate between the definitions (1)+(2’) and (1)+(2’’). Personally I believe that the latter definition is the most useful one.

Irrespective of which of these definitions we choose, it should be interpreted as time-relative. It was not pseudoscientific in the 1950s to describe the proton as a fundamental particle, i.e. one that cannot be divided into composite parts. Today, it would be pseudoscientific. Some authors have expressed a different opinion on this. For instance, after showing that creationism is in some respects similar to some doctrines from the early 18th century, Dolby said that “if such an activity was describable as science then, there is a cause for describing it as science now” (Dolby 1987, 207). As should be clear from what I have said at the very beginning of this presentation, this argument is based on a misconception of science. It is an essential feature of science that it develops continually through new investigations. A standpoint or theory cannot be scientific in itself, only in relation to this social process of improvement. This requires as a minimum that well-founded rejections of previous scientific standpoints are accepted. The demarcation of science cannot be timeless, for the simple reason that science itself is not timeless (Hansson 2013).

From this it also follows that the demarcation between science and pseudoscience requires knowledge of the current state of science. Therefore the demarcation issue cannot in practice be solved by philosophers of science alone. The demarcation is a collective responsibility for all members of the republic of science. We all have to contribute in our own fields of expertise.

3 Clinical trials

The capacity that science has for self-improvement can be illustrated by a comparison with homeopathy that has coexisted with medical science for more than two hundred years. What progress has homeopathy made since it was created in 1796? I would say none. Let me explain why.

Admittedly, some new homeopathic remedies have been introduced. One of them is called “Berlin wall” (Dam 2006a; Dam 2006b). It is made from a piece of the Berlin Wall, diluted until there is not a single molecule left (Figure 1.). This drug is taken against claustrophobia and a few other mental afflictions. Notably, it is based on exactly the same principles as the first homeopathic drugs that were introduced by Samuel Hahnemann (1755–1843), the inventor of homeopathy. A person developing a new homeopathic drug today uses the same principles and methods as Hahnemann.

Compare this to a team of scientists developing a conventional pharmaceutical drug. They make use of an enormous database and they employ completely new ways to understand the human body that have been developed in the last two centuries in biochemistry, physiology, genetics, and a host of other disciplines. In contrast, homeopaths do not even make use of the very basic insight that all matter, including the human body, consists of molecules that are composed of atoms bonded to each other. If they had accepted that notion, they would presumably not have used dilutions in which no single molecule of the supposedly active substance is left. The reason for this anomaly is of course a combination of their inability to learn new things and the fact that molecules were unknown in Hahnemann’s days.

There is also an even more important lesson that scientists have learnt but homeopaths have not: the methodological insight that treatments have to be tested in treat- ment experiments, usually called clinical trials. In modern medical science, such experiments are the gold standard for judging what treatments should be used in the clinic (Hansson 2014). The most fundamental difference between scientific and non-scientific medicine (the latter is often euphemistically

Figure 1. A homeopathic drug. The text reads: Ainworths Homoeopathic Pharmacy 36 New Cavendish Street, London W1G 8UF BERLIN WALL 200C

called "alternative" medicine) is precisely this: Scientific medicine submits its treatments – both new and old ones – to clinical trials. This protects patients against the limitations of scientific knowledge and also against the wishful thinking of both scientists and physicians. A new drug may have a seemingly perfect biological mechanism that works wonderfully in experiments on isolated cells and non-human laboratory animals, but a clinical trial can nevertheless reveal that the effect is weak or non-existent in patients, or that it has unacceptable side-effects.

Currently, clinical trials are putting an end to a long tradition of choosing psychiatric treatments according to ideologies. Some psychiatrists followed a conviction that in principle all psychiatric diseases should be treated with pharmaceutical or other physiological treatments, whereas others were equally convinced that only psychological treatments (psychotherapy) should be used. Clinical trials showed that both ideologies were wrong. When treatments are chosen according to proven efficiency, both pharmaceutical and psychotherapeutic treatments will be used, in both cases against specific conditions for which a specific type of treatment has been shown to be efficient. We now see how specific science-based treatments replace ideologically chosen psychiatric panaceas, to the patients' great advantage.

Without clinical trials, conventional medicine would still be using a large number of inefficient and/or potentially dangerous treatments that have, thanks to this methodology, now been replaced by better ones. But there is not one single variant of non-scientific ("alternative") medicine that subjects its treatments to well-conducted clinical trials and throws out the treatments that turn out not to work. It cannot be too much emphasized that this is where we should draw the line between scientific and unscientific medicine. Wherever you see a physician who refuses to give up a diagnostic or therapeutic method that has been proven substandard in clinical trials, you see a person who has *de facto* joined the camp of homeopaths, anti-vaccinationists, and aids denialists. And wherever you see an "alternative" practitioner willing to submit her or his treatment methods to clinical trials, and give up any methods that do not stand the test, you see a person whom we should most heartily welcome to science.

4 Action-guiding experiments

It has often been pointed out that many scientific observations depend to a high degree on theory: We have theoretical reasons for choosing what to observe, and our interpretations of observations depend largely on the theoretical framework that we employ. For instance, there would not have been much reason to read off scales beside mercury pillars if we did not believe that there is an objective temperature to be measured in this way. However, the theory-dependence of scientific observations differs widely between different observations (and their interpretations). This is particularly important in the context of clinical trials since clinical trials belong to a category of observations that have a remarkably low theory-dependence. To see this we need to have a close look at the specific class of experiments that clinical trials belong to.

By an experiment (in the modern sense of the word) is meant a procedure in which some object of study is subjected to interventions (manipulations) that aim at obtaining a predictable outcome or at least predictable aspects of the outcome. We can distinguish between two types of experiments, namely directly action-guiding respectively epistemic experiments (Hansson 2014). An experiment is directly action-guiding if and only if it satisfies two criteria:

(a) The outcome looked for should be some desired goal of human action, and

(b) The interventions studied should be potential candidates for being used in a non-experimental setting in order to achieve that goal.

Both these criteria are obviously satisfied by clinical trials. For instance, in a clinical trial of an analgesic the outcome looked for is efficient pain reduction with minimal negative side effects, and the experimental intervention is a treatment that might be administered for that purpose in a clinical, non-experimental setting. Other examples of directly action-guiding experiments include agricultural field trials, many technological tests such as tests of the longevity of light bulbs, and social experiments trying out the effects of different methods of social work. The other major type of experiments are the epistemic experiments that aim at providing us with information about the workings of the world we live in.

The epistemological justification of directly action-guiding experiments is very strong. We can summarize the notion of a directly action-guiding experiment in the form of the following simple recipe:

> *Recipe for directly action-guiding experiments:*
>
> If you want to know if you can achieve *Y* by doing *X*, do *X* and see if *Y* occurs.

This recipe is in a sense self-vindicating. In order to find out whether you can achieve *Y* by doing *X*, what better method can there be than to do *X* and see if *Y* occurs? In particular, we have no problem in justifying the use of an intervention or manipulation (the *X* of the recipe). We want to know the effects of such an intervention, and then it is much better to actually perform it than to passively observe the workings of nature. This is a simple and indisputable argument that applies to directly action-guiding experiments but not to epistemic experiments. This justification also explains why directly action-guiding experiments should be repeatable. Since the purpose of the experiment is action-guiding, we need to establish a connection between an intervention-type and a desired outcome. In order to be practically useful such a connection has to appear regularly; it is not sufficient that something happened once.

Someone might counter this by asking: "Can this be true? Can directly action-guiding experiments really be that strongly justified? Have we not learned that all experiments are theory-laden?" Well, indeed we have, but the common arguments showing the theory-ladenness of experiments refer to epistemic experiments, not to directly action-guiding ones. This should be no surprise since the theory of science has had an almost exclusive focus on investigations performed with epistemic rather than action-guiding purposes.

Obviously, the strong justification of clinical trials (and other directly action-guiding experiments) does not mean that we should rely unconditionally on them regardless of how they have been performed. They are the superior method for finding out the effects of treatments, but like all other methods they can be misapplied or misinterpreted. A whole series of safeguards, such as control groups, blinding, and randomization, have been developed in order to ensure the reliability of the information obtained from clinical trials. Critical examinations of how clinical trials are conducted and interpreted are essential parts of clinical science.

However, there is also another type of criticism that does not seem to fill a constructive purpose, namely general criticism against the use of clinical trials to determine the effects of medical treatments. Interestingly, such criticism does not seem to have emerged in the other areas where directly action-guiding experiments have a similarly strong standing. I have not been able to find any examples of farmers or agricultural scientists opposing the use of field trials to determine the agricultural properties of crops or farming methods. Neither have I found traces of any resistance against the use of directly action-guiding experiments in technological or engineering contexts. The opposition against clinical trials is in most cases strongly connected with adherence to treatments such as homeopathy. Clinical trials of homeopathic remedies show no positive treatment effect, or at least no effect over and above that of placebo. Proponents of homeopathy tend to see this as a proof that clinical trials are no good. It is of course much more plausibly interpreted as proof that homeopathy is no good.

It is an essential but often neglected part of public education on health to explain why and how clinical trials are performed and how they can be interpreted. We have to explain the relative theory-independence and the exceptionally strong epistemological foundations of clinical trials. The recipe is simple:

> If you want to know if treatment *X* has the desired medical effects, try *X* on patients for whom it is intended, and compare them to patients receiving other treatments. Do this in a way that is fair in the sense of giving equal chances to the different treatments, and make sure that you are not fooled by your own biases or those of anyone else.

This is a simple recipe. As patients we should require that our doctors offer us the treatments that have been most efficient in studies following this recipe. This may indeed be a matter of life and death.

5 Promotors and denialists

The doctrinal deviation of pseudoscience can take two major forms. We can distinguish between *science denialists* and *pseudotheory promotors*. Science denialists are driven by their enmity towards some specific scientific account or theory. Some typical examples are:

holocaust denialism
relativity theory denialism
aids denialism
vaccination denialism
tobacco disease denialism
climate change denialism

Pseudotheory promotors are driven by their aspirations to advance a theory of their own. This implies the rejection of some parts of science, but the rejection of scientific theories is not a primary goal for them, only a means to promote their own theory. Some examples are:

astrology
homeopathy
iridology
scientology

transcendental meditation
ancient astronaut theories

The two categories are by no means mutually exclusive. Most pseudoscientific teachings seem to belong primarily to either of the two, but often the practice of one leads into the other. For instance, scientology is predominantly a case of theory promotion, but as part of the promotion of their own alleged solutions to psychiatric problems scientologists have engaged in vitriolic attacks on virtually all forms of psychiatry, including science-based psychiatric treatment that (contrary to scientological practices) have well-documented beneficial effects. Another particularly interesting example is creationism. It had its first origins in theory promotion, namely the promotion of a fundamentalist interpretation of the Book of Genesis. This led to evolution denialism that developed further into the promotion of pseudoscientific theories (creationism and its skeletal version "intelligent design") that are constructed to support the fundamentalist interpretation of Genesis.

But in spite of such combinations it is useful to distinguish between the two forms of pseudoscience, science denialism and pseudotheory promotion. They have different characteristics, for instance pseudotheory promotion is much more often dominated by an individual founder or "entrepreneur" who started the movement and whose words are still taken to be the highest wisdom. Samuel Hahnemann in homeopathy, Rudolf Steiner in anthroposophy, L. Ron Hubbard in scientology, Maharishi Mahesh Yogi in Transcendental Meditation, and Erich von Däniken in ancient astronaut theory are some of the best known examples.

Science denialism has been less studied than the theory-promoting pseudosciences. I have found it particularly interesting to compare three recent, influential forms of science denialism, namely relativity theory denialism, evolution denialism, and climate science denialism. Relativity theory denialism had its heyday in the 1920s and 1930s. Evolution denialism and climate science denialism are currently two of the most influential pseudoscientific movements, in both cases largely through their strong standing in right-wing politics in the United States. The three have all been fairly well documented.[2] They have surprisingly many similarities that can be summarized as follows:

1. The enemy theory that they try to fight down is an established scientific theory that in some way threatens ingrained conceptions. Relativity theory is a chal-

2. On relativity theory denialism, see Beyerchen (1977) and Wazeck (2009), and for Scandinavian examples Silverbark (1999). On evolution denialism, see Ruse (2005) and Young and Edis (2004). On climate science denialism, see Mooney (2005) and Oreskes and Conway (2010).

lenge to common sense. Evolution theory is perceived as a threat to traditional religion. Climate science creates problems for certain views on politics and lifestyles.

2. The enemy theory is complex and not quite easy to understand. Both relativity theory (in particular general relativity) and climate science are based on mathematics that is inaccessible to the vast majority. Both evolution theory and climate science are built on a huge database, and it is quite difficult to gain an overview over how all these data combine to provide strong support for the respective theory.

3. The denialists deviate from common views in science on what is needed to justify assent to a scientific theory. The opponents of relativity theory claimed that a scientific theory has to be "anschaulich" (immediately graspable, easy to understand) but they did not pay much attention to exact predictions of observations and experiments. Creationists and so-called climate skepticists exhibit a remarkable lack of understanding of how a complex theory can be based on a large collection of evidence.

4. The leading denialists are usually private "researchers" without scientific research competence in the relevant area. All these three forms of science denialism are almost exclusively driven by amateurs. Only in rare cases have qualified researchers in the pertinent areas contributed to denialism. Of the three areas, relativity theory denialism has had the largest participation of qualified researchers (three Nobel Prize laureates).[3] Among the opponents of climate science and particular those of evolution theory the participation of competent scientists has been much smaller.

5. Science denialism is a predominantly male activity. Women are very few in all these three areas. Their absence is particularly remarkable in the case of evolution denialism. There is a comparatively strong presence of women in the legitimate biological sciences, but they are virtually absent from the activities of evolution denialism and creationism. I have no explanation why science denialism is such an exclusively male affair; but at any rate this speaks decisively against the common prejudice that logical and scientific thinking is somehow contrary to being a woman.

6. The science denialists fail to publish in established scientific journals. This applied also to the few enemies of relativity theory that were established researchers. Colleagues judged their writings on relativity as substandard, in spite of their previous important contributions to other parts of science. The situation is similar for the opponents of evolution theory and climate science.

7. The science denialists believe that there is a conspiracy behind their failure

3. The three were Philipp Lenard, Johannes Stark, and Charles Édouard Guillaume. On Lenard and Stark, see Beyerchen (1977) and Hentschel and Hentschel (1996). On Lenard and Guillaume, see Wazeck (2009).

to publish in respectable scientific journals. The opponents of relativity theory often claimed that the established physics journals and physics societies were under Jewish control. The other two groups of denialists have other conspiracy theories.

8. Partly in reaction to their failure to publish in scientific journals, the science denialists turn directly to the public. Numerous anti-relativity pamphlets were printed, and today we see a large number of Internet sites devoted to pseudoscientific criticism of evolution theory and climate science. (It is a serious problem for the public understanding of science that people who get their science published in the good journals are much less prone to write for the public than those whose manuscripts are always rejected by the scientific journals. From the viewpoint of science education one would have wished this to be the other way around.)

9. The science denialists try to create the impression that their support in science is much larger than it actually is. In all three areas petitions have been used for that purpose. The 1931 pamphlet *Hundert Autoren gegen Einstein* (A Hundred Authors Against Einstein) is a classic example, and so is the retort ascribed to Einstein: "If I were wrong, then one would have been enough to refute me."

10. Science denialism has strong political connections. A large part of the enemies of relativity theory were anti-Semites and Nazis. Evolution denialism is dominated by a Christian right wing that seeks confirmation of fundamentalist conceptions. Climate change denialism is dominated by a libertarian right that cannot accept the government interferences in business that climate science is taken to justify. These are three quite different political viewpoints, but in all three cases connections with political views have contributed to the uncompromising attitude and the inability to participate in rational discussions that characterize science denialism.

Finally: When arguing against pseudoscience I have often met colleagues who say something like: "Yes you are right. But what you do is meaningless. These people do not listen to arguments so you cannot make them change their minds." I willingly concede that chances are small for me or anyone else to persuade convinced pseudoscientists to become adherents of science. I would, for instance, be much surprised if someone managed to convince Prince Charles or other dedicated promotors of quackery that they should give up their irresponsible propaganda for inefficient and potentially dangerous treatments.[4] But there is a large number of people who do not know what to believe. Most of them will listen to

4. On the involvement of Prince Charles in quackery, see for instance Singh and Ernst (2008), Walker (2009), and Hawkes (2010).

good scientific arguments. It is our joint responsibility to make those arguments accessible to them.

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