How not to defend science. A Decalogue for science defenders

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ABSTRACT

The public defence of science has never been more important than now. However, it is a difficult task with many pitfalls, and there are mechanisms that can make it counterproductive. This article offers advice for science defenders, summarized in ten commandments that warn against potentially ineffective or even backfiring practices in the defence of science: (1) Do not portray science as a unique type of knowledge. (2) Do not underestimate scientific uncertainty. (3) Do not describe science as infallible. (4) Do not deny the value–ladenness of science. (5) Do not associate with power. (6) Do not blame the victims of disinformation. (7) Do not aim at convincing the anti–scientific propagandists. (8) Do not contribute to the legitimization of pseudoscience. (9) Do not attack religion when it does not conflict with science. (10) Do not call yourself a "sceptic".

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It has never been more important than now to defend science. Science deniers have talked millions of parents into putting their children's health at serious risk by denying them vaccination against potentially deadly diseases. Promoters of creationism and other thoroughly refuted doctrines do their best to wipe out our understanding of the world we live in. Without that understanding, our chances are slim to prevent the serious threats to our natural environment that we are facing. And most seriously of all: Deniers of climate science try to make us continue greenhouse gas emissions at a rate that can make our planet uninhabitable for future generations. We need to defend science not only for its own sake as one of the foremost products of human culture, but also, and even more importantly, as a necessary means to avert these and other threats to the survival of our species.

But the defence of science is a delicate and most difficult task. The anti–scientific propagandists are often rhetorically skilled, and many of them are backed up by powerful economic interests. As defenders of science we need to be acutely aware of the many pitfalls of our undertaking. Much can be learned from the experience gathered by activists who have struggled against specific pseudosciences such as homeopathy, creationism and astrology, or delusive sects such as scientology, transcendental meditation, and anthroposophy (Hansson 2018a).

The general dos and don'ts apply. Defending rationality with irrational arguments is about as consistent as executing people because they are in favour of capital punishment. High standards of argumentation must always be upheld in the defence of science. The common fallacies such as ad hominem, the straw man fallacy etc. have no place here. But we also need to consider how the subject matter of science, and the social conditions under which it is discussed, should inform our argumentation and our choice of an argumentative strategy. The following "Decalogue" for science defenders aims at stimulating a more

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intense discussion on how we can improve our defence of science and make it more efficient.

§ 1. Do not portray science as a unique type of knowledge.

From a sociological point of view there can be no doubt that scientists form one of the elites of society.[1] Scientists are more educated and better paid than most of the workforce. They perform difficult tasks, which require many years of training, and parts of what they are doing cannot be understood without extensive explanation. They are also influential in many ways, not least through their role in education. It should be no surprise that science has often been defended in an elitist manner. Scientists are said to be in possession of means to knowledge, which others do not have. Allegedly, we should all put our trust in this privileged elite.

This, however, is a potentially counterproductive defence of science, since it fails to observe the important similarities between scientific knowledge and other forms of knowledge that most people are much more acquainted with. Furthermore, the claim that scientific knowledge is fundamentally different from all other forms of knowledge is based on a skewed comparison. If you compare a scientific paper or a discussion at a scientific seminar to casual everyday chatting, then the difference is large enough to justify the claim that they represent fundamentally different modes of reasoning. But that is not the relevant comparison. Instead we should compare scientific reasoning with the well–organized and precisely targeted forms of reasoning that take place outside of science.

In all human societies there are social situations and settings, more or less well demarcated, in which we aim at finding out how things really are. Such *fact–finding activities* are important parts of our everyday lives (Hansson 2018b). One example is the communication of instructions. If you tell someone how to find their way, how to make a particular dish, or how to prune an apple tree, then both of you will be involved in an attempt to get the facts right. Another example is our reasoning when searching for a lost object. Suppose that you and a friend are trying to find your lost keys. You will then put up explanatory hypotheses (“perhaps they are under the newspaper you put on the table”),

[1] For lack of better word I use the English ”science” in a wide sense that also includes academic disciplines such as history, musicology etc., which are covered by the standard meaning of the German “Wissenschaft” but not that of the English “science”. For an explanation why this wider category is the more adequate one, see Hansson (2013a)

check these hypotheses (in this case by lifting the paper), draw conclusions etc. A third example is how we search for faults in a malfunctioning device. For instance, if your bedlamp does not light, then you will probably put up a couple of explanatory hypotheses which you then proceed to test. Perhaps the light bulb has burnt out? That can be tested by replacing it with a bulb known to be functioning. Is the lamp cable no longer connected to the socket? That can be tested by identifying the plug and checking if it is properly inserted. Has the socket ceased to operate? That can be tested by inserting some electrical device that works when connected to another socket.

In these and many other everyday situations we reason in ways that are quite similar to how scientists reason when trying to solve a research problem. We do this because such rational thought patterns are efficient means of solving our everyday problems. Few people would resort to irrational practices in the situations just mentioned. I never heard of anyone who sat down with a pack of tarot cards to find out where (s)he put the keys, or chanted magical spells to make the bedlamp light again. Even strong believers in such practices only apply them to a small set of selected problems. Otherwise their lives would become unbearable. If you resort to tarot cards rather than look around systematically for your lost car keys, then chances are high that you won't find them in time to drive to the meeting of the Society of Soothsayers. And if you try to make the bedlamp light by reciting spells, you will not be able to read the *Handbook for Witches* in bed, as you had planned.

In addition to these fact–finding activities, which we all apply in our everyday lives, there are specialized and more well–defined *fact–finding practices*, which are usually bound to particular co–operative undertakings or to the tasks associated with professions and other groups of specialists. For instance, mechanics troubleshooting a malfunctioning engine or machine put up more elaborate hypotheses, and employ more complex hypothesis–testing methods, than those that we all employ when a lamp does not light or when a door gets stuck. Other examples of advanced fact–finding practises are those performed by police investigators trying to determine who committed a crime, and by investigative journalists trying to find out for instance whether rumours of corruption are correct. Such fact–finding practices can be found in all societies, including societies without a written language (Hansson 2018b). Traditional hunters who follow the tracks of prey continuously put up and test hypotheses about where the animal has gone, based on fresh observations and previous knowledge. They criticize and test each other's hypotheses, and in these discussions they take care to distinguish between observations and inferences (Blurton–Jones and Konner 1976; Liebenberg 1990; 2013). For the last ten thousand years or so, farmers have performed careful experiments to find out what seeds and cultivation methods yield the best harvest (Hansson 2019).

Science is a fact–finding practice, and therefore also part of a tradition that dates back to the distant prehistoric past. Of course, science differs from most other fact–finding practices in being highly specialized and having access to much larger resources. But the basic sources of knowledge are the same, namely observations and rational reasoning. And equally importantly, in order to be a successful fact–finder you need to apply the same investigative approaches in science as in the other fact–finding activities and practices: readiness to test your own hypotheses and to give them up if they turn out to be wrong, openness to new information, and willingness to identify and set aside your own biases as far as possible. As can be seen from these similarities, scientific knowledge is continuous with other types of knowledge. Far from being a unique and entirely different type of knowledge, it is an advanced, professionalized activity that extends and improves on the various fact–finding activities that are parts of our everyday lives, and have been so since long before recorded history.

Conclusion: Whatever you do, never endorse an elitist defence of science. It is counterproductive since it goes against the very nature of science. Instead, emphasize the close connections between science and the fact–finding activities which we engage in and rely on in our everyday lives.

§ 2. Do not underestimate scientific uncertainty

Science does not have answers to everything, not even in issues that clearly belong to its domain. This should be clearly recognized, since an honest defence of science must refer to what it can really do, not to some idealized version of science that has answers to all questions. Exaggerated claims of what science can do are sure to be disclosed sooner or later, and such disclosures can be severely damaging also to the other parts of your message.

There are many reasons why science cannot answer the questions we may want to ask. Most fundamentally, there are *questions that cannot be answered because they refer to what is, in a fundamental way, unknowable*. This applies, in particular, to questions about future developments in highly complex systems. For instance, we cannot predict the outcome of natural evolution. A major reason for this is that at least in the long run, all evolution is coevolution, which means that the different species reciprocally determine the conditions for each other's evolution. How each species evolves will be affected directly by the development of other species, such as its predators, its preys, its competitors for food, and then indirectly by the predators of its competitors, the preys of its prey, etc. Furthermore, the evolution of each of these species depends on a large number of random events affecting its members, such as mutations, genetic recombinations (through sexual reproduction or lateral gene transfer), and a wide variety of environmental occurrences with impact on survival and reproductive success. Some progress has been made in predicting short–term evolution driven by a strong and enduring selective force. For instance, in an increasingly arid climate, plants will evolve traits such as a deeper root system that make them more drought resistant. Pathogens encountering antibiotics in their hosts will develop resistance to those antibiotics. Detailed studies of evolutionary processes have led to improved predictions of such short–term evolution (de Visser et al 2018; Didelot et al 2016; Lässig, Mustonen and Walczak 2017; Wernegreen 2015). However, long–term evolution, which may involve various changes in the environment, new or substantially altered predators, etc., is beyond the reach of predictability, and we have reasons to believe that it will continue to be so.

The same applies to other highly complex systems, such as human societies. Again, some short–term developments are predictable with reasonable accuracy. For instance, the consumption of most types of goods decreases with increasing prices. However, long–term predictions of human societies are hampered by essentially the same problem as predictions of natural evolution: outcomes are determined by a large number of complex interactions between individual actions, many of which have a large component of randomness. The history of predictions of the development of human societies is largely a history of failures (Rejeski, Pauwels and Koo 2016).

Of course, this does not mean that all long–term predictions are impossible, either concerning nature, societies or individuals. Some causal factors are known to have such strong and ineludable effects that they form the ground for reasonably reliable predictions. Even if a random generator is completely unpredictable in the sense usually referred to, we can predict with high probability that it will stop producing outputs at all if we smash it with a sledgehammer. Something similar applies to complex biological and social systems. We know, for instance, that a large number of species will be lost if we turn large areas of rain forest into farmland (Barlow et al 2016), that access to clean water reduces the occurrence of severe infectious diseases (Prüss–Ustün et al. 2014), and that a person who takes cocaine regularly will develop an addiction. We certainly need to take such predictive knowledge on board. However, it is equally important to be aware that apart from forceful causal factors like those just mentioned, developments in complex systems are subject to so many influences that they are for all practical purposes unpredictable.

This unpredictability is a lesson that science has learned the hard way, namely from a long series of failures. The history of social science is replete with theorists who believed themselves to have found some grand pattern or design, which would enable them to predict what future societies would look like. But none of these attempted bypass routes around the inextricable complexity of human societies has been successful (Schulz 2016). And of course, the claims by soothsayers and others charlatans that they can bypass this complexity and predict the future "fate" of an individual are not only unfounded but also thoroughly confuted by scientific evidence (Kelly 1997; 1998).

In addition to these cases of plain unknowability there are also many *issues in which scientific knowledge may well be attainable, but has not yet been achieved.* The issue may not have been sufficiently investigated, the currently available methods of investigation may be inadequate, or the evidence as yet obtained may be contradictory or for other reasons inconclusive. In all these cases, the science defender has an important balance to uphold: On the one hand, scientific uncertainty should always be fully recognized. On the other hand, false or exaggerated claims of uncertainty should be refuted.

False claims of uncertainty are in fact quite common, since science denialists use them as a strategy to undermine legitimate science (Freudenburg, Gramling, and Davidson 2008; Hansson 2017a). Fabricated uncertainties have a long–standing tradition in the history of science denial. They were used in the 1920s and 1930s by deniers of relativity theory. At a time when relativity theory was already almost universally accepted in physics, they spread the myth that there was a huge debate among physicists about it (Wazeck 2009, pp. 268–269). Beginning in the 1950s, tobacco companies waged extensive campaigns for equally groundless claims that scientists had not been able to agree on whether or not cigarettes had any role in the causation of lung cancer. In actual fact, there was consensus that tobacco is the dominant cause of this deadly disease (Saloojee and Dagli 2000). The methods of "manufacturing uncertainty" developed by the tobacco industry have also been used with considerable success by promoters of other false claims, such as creationists, chemical companies denying the toxicity of their products, and climate science denialists (Dunlap and Jacques 2013; Oreskes and Conway 2010). Climate science denialists, in particular, have been proficient in securing equal space and time for themselves in mass media, claiming that their views on climate issues are equally valid as the consensus view of climate scientists (Boykoff and Boykoff 2004; Boykoff 2008, p. 1; McKewon 2012, p. 277; Koehler 2016).

Conclusion: As science defenders we just have to get it right about scientific uncertainty. It is a serious mistake not to affirm that science is uncertain when that is the case, and it is an equally serious mistake to allege scientific uncertainty or dissensus when there is none.

§ 3. Do not describe science as infallible

One of the most common arguments against science is that "scientists have been wrong before". The presumed inference is that since scientists have been wrong before, they should not be relied upon, and we had better go somewhere else than to science for answers to our questions (For examples of this argument, see Kramer 1988, p. 129 and Dreher 2007).

At first hand, this might seem like a reasonable argument. It is quite similar to sensible arguments like the following:

> Michael has lied before. Therefore he cannot be relied upon, and we had better go to someone else than him for answers to our questions.

However, there is an important difference. Lying is intentional, and therefore quite different from being mistaken. No one is infallible, and we are presumably all wrong now and then, even about subject matter that we know quite well. Rejecting science because scientists have on occasion been wrong is much like Anthony's reasoning in the following dialogue:

> Anthony: I saw a very unusual bird in Wales last summer. It was the size of a starling but it had an unusually long beak. It was a dwarf pelican.
>
> Bianca: What did you say, a dwarf pelican? I never heard of such a bird. Who told you that?
>
> Anthony: Eric did.
>
> Bianca: Well, I know that Eric has definite opinions on everything, but I didn't know he had much knowledge of birds. Have you asked Elena? She is a biologist and an avid birdwatcher. I believe she participated in a bird–ringing project in Wales a few years ago, so she if anyone should know.

Anthony: No, I don't trust her.

Bianca: Why?

Anthony: She once told me that a bird we saw at a distance was a female mallard. But it was in fact a gadwall.

Bianca: And did she admit the mistake?

Anthony: Yes, when the bird came close to us she told me that she had been wrong at first.

Bianca: So because of that you don't trust her.

Anthony: No, since she was wrong she can be wrong again. So now I ask Eric instead.

Bianca: And he has never confessed to be wrong about birds?

Anthony: No, never.

For science defenders, it is essential not to fall into the trap of accepting infallibility as an ideal for science. Instead, we have to explain why infallibility is a self–defeating ideal and why even the best available knowledge in empirical subject–matter is fallible.

To explain this it is useful to begin with everyday knowledge. What we believe ourselves to know about the people, places, and things around us is almost always *provisional knowledge*. By this is meant that we take something to be true because we currently have no reason to doubt it, but nevertheless, new information can make us change our minds. For instance, when I left home this morning I considered myself to know the shortest way to the local Metro station. However, it was perfectly possible that a few minutes later I would have found myself to be wrong since my passage was blocked for instance by a traffic accident, a criminal investigation, the shooting of a film, a hot air balloon that had just made an emergency landing, a sinkhole, a meteor downfall, or some other unexpected obstacle. If any of that happened, I would revise my previous conviction that I could reach the Metro by going the usual way. For such a revision to be possible, I will have to treat my conviction about the shortest way to the Metro as provisional knowledge, so that it can be revised if that becomes necessary.

Obviously, most of our everyday knowledge is provisional in this sense. The same applies to the knowledge we obtain in the various fact–finding activities and practices that were mentioned above in Section 1. For instance, if there is no reasonable doubt that the defendant committed the crime, then (s)he will be treated as guilty by the judicial system. However, it is an important constituent of the rule of law that a retrial will be arranged if new facts give reason to believe that the defendant was innocent (Oldfather 2009). Similarly, mass media publish corrections to articles if errors are discovered.

This also applies to the fact–finding practice that is at our focus here, namely science. Empirical knowledge in science is provisional in the same sense as our everyday empirical knowledge. Consequently, a scientific statement can never achieve the incontrovertible status that is often ascribed to religious dogmas. The highest status it can reach is that of something which we currently have no reason to doubt. This is basically the same criterion as in law: what we call scientific knowledge is that which we know "beyond reasonable doubt". Reasons to doubt it may come to light at some later point in time. When that happens, it will have to be reassessed, and may then have to give place to an improved account of its subject matter.

The capacity for self–improvement is a central part of what makes science successful. Contrary to various dogmatic disciplines, science is capable of questioning and reforming even its most foundational premises and ways of thinking. One of the best examples of this is the development of scientific pharmacology from the 1790s to today. The discipline has gone through several radical changes in its methodology, including the introduction of quantitative chemical analysis, the concept of an active ingredient, the importance of the administered dose of that component, and the use of blinded or double–blinded clinical trials to determine the effects of pharmacological treatments. But in the same period, homeopathy has remained essentially the same, thereby cementing its pseudoscientific character.

Conclusion: Never fall into the trap of espousing infallibility as an epistemic ideal for science. Instead, explain that ability to admit mistakes and learn something new is an essential part of what makes science successful.

§ 4. Do not deny the value–ladenness of science

One of the most important ideals of the scientific enterprise is that neither bias nor the values cherished by the investigator should affect the outcome of an investigation (Merton [1942] 1973). This ideal is by no means unique to science. Instead, it is a common feature of the various fact–finding practices of human societies. A judge who decides a case of suspected political corruption is expected to put aside her own political sympathies, and the same applies to a journalist investigating the case. Similarly, a car mechanic should not let her appraisal of what repairs are needed be influenced by which types of jobs she likes or dislikes to perform, etc. When science is said to (strive to) be "value–free", this signifies a similar endorsement of impartiality and a similar commitment to exclude irrelevant considerations.

This needs to be clarified, not least since critics of science often accuse scientists of not living up to its value–free ideal. When answering such criticism we need to make it clear what this ideal means. Bias, partiality and the like should not be defended, but other forms of value influence may be fully appropriate.

Most discussions on values in science focus on their impact on scientific standpoints, that is on which claims are considered to be (provisional) scientific knowledge. However, science can be influenced by values in many other ways. For instance, values have a large impact on the choice of issues to investigate. Study areas that produce practically useful knowledge tend to receive more funding than other areas. It is for value–based reasons that much more resources are devoted to studies of human diseases than to the diseases that affect the Goliath birdeater. For all that we know, the diseases of the latter species (the world's largest spider) may be as diverse and biologically interesting as the diseases suffered by humans, but much less is known about them.[2]

Another important avenue of value influence goes through research ethics, which is of course a value–based pursuit. Research ethics circumscribes what research goals are acceptable; for instance the development of new chemical warfare agents is ruled out. It also requires the informed consent of human research subjects, and it puts strict limits on the risks that they can be exposed to. The use of animals is also restricted. Furthermore, research ethics specifies how research should be reported, in terms of accuracy, transparency, and correct attribution. In sum, the demands of research ethics subsume the conduct of research under the values of the surrounding society.

But let us return to the impact of values on what claims scientists accept as (provisional) scientific knowledge. Such influence can involve many types of values, not only moral values. In particular, a major role is played by epistemic value, by which is meant "the value or disvalue which the different outcomes have from the point of view of pure scientific research rather than the practical advantages or disadvantages that might result from the application of an accepted hypothesis" (Hempel 1960). These are the values that reflect the usefulness of truth, simplicity, explanatory power, and other desiderata of

[2] However, knowledge about diseases of the Goliath is accumulating. It is kept as a pet, and both drugs and surgery have been applied in veterinary practice. (Pizzi 2009; Pellett, Bushell and Trim 2015)

scientific theories. Usually, the most important epistemic values are those that concern the effects on scientific research of mistakes in deciding what will be counted as (provisional) knowledge. If we treat a claim as scientific knowledge although the claim is in fact wrong, then this can seriously impair future research by setting it off in the wrong direction. The opposite mistake, that of keeping an issue open although it would have been right to close it, will lead to "unnecessary" investigations of the same issue, which is usually much less harmful than working under the wrong assumptions. Therefore, considerations of epistemic value usually contribute to keeping up high demands of evidence for accepting a claim as (provisional) scientific knowledge.

However, when scientific knowledge is needed for practical use, epistemic values are not the only values that have to be reckoned with. There are occasions when moral values induce us to take action based on a rather weak indication of a potential danger. For instance, suppose that bacteriologists tell us that our drinking water contains bacteria that may, for all they know, be of either of two types. One of these types is quite toxic, whereas the other is innocuous. Barring exceptional circumstances, the only morally defensible response to this information is to treat the water in the same way as if it were known with certainty to contain toxic bacteria. However, the evidence is much too uncertain for the claim that the bacteria are harmful to qualify as (provisional) scientific knowledge. Much stronger evidence would be needed to justify endorsement of that statement.

In cases like this (and there are many of them) we have a conflict between scientific and practical demands on the evaluation of an empirical claim. There are two major ways to resolve this problem. One of them is to lower our criteria of scientific knowledge, and then treat the claim that the bacteria are toxic as (provisional) scientific knowledge. The other solution is to make a distinction between our criteria of evidence for scientific knowledge and for practical action. In practice this means that we take action against a possible risk without considering ourselves to know whether it is real or not.

There are strong reasons to prefer the second solution to the first one. In particular, closing the issue would imply that no further investigations are needed to determine whether or not the bacteria are toxic. This would be unfortunate, not only for scientific but also for practical reasons. It could dissuade us from making investigations that would perhaps make it possible to declare "no danger", which could save us much trouble and resources.[3]

[3] For a much more detailed discussion of this problem, see Hansson (2017b).

Conclusion: We have strong reasons to (1) acknowledge that many types of values, including epistemic values and the moral values encoded in research ethics, have a considerable and quite appropriate role in science, (2) defend the more limited ideal of “value–freedom”, namely that scientific judgments should, as far as at all possible, be protected from the influence of biases, wishes and interests concerning what the outcome should be, and (3) promote a clear distinction between the criteria of evidence for scientific knowledge and those for practical action.

§ 5. Do not associate with power

One of the most common arguments against science is its association with powerful business interests. For instance, on the webpages of anti–vax campaigners, the Big Pharma Argument has a prominent role. It goes like this: The big pharmaceutical companies are irresponsible if not outright evil. They earn money by selling vaccines. Therefore, anyone advocating vaccination is furthering the interests of Big Pharma, and consequently such persons cannot be trusted. The use of vaccines furthers the interests of Big Pharma, which are contrary to the interests of common people, so surely the vaccines are bad for us.

This is a garbled argument that goes wrong in a very obvious way. Whether the pharmaceutical industry behaves irresponsibly is one issue, and the quality of their products is another, quite separate issue. Irresponsible business can be conducted either with good or bad products. It may in fact be easier to earn an unreasonable amount of money by selling a product that works than one that doesn’t. Even if you have good reasons to be highly critical of a company’s business practices, it does not follow without further arguments that their products are of inferior quality.

Similar arguments are common in other areas. For instance, the seed industry is dominated by a small number of multinational companies, some of which have a deeply problematic history of peddling poisonous pesticides. Nevertheless, the agricultural, environmental, and nutritional qualities of their seed brands is a separate issue. It will have to be determined on a case–by–case basis, for each individual product. For instance, the fact that GMO plants are predominantly sold by these companies does not imply that all such plants are bad for the environment. That has to be determined separately for each product. (The scientific consensus is that the answer will depend on the traits of the respective variety, rather than on the technology used to obtain those traits.)

For science defenders, it is essential not to accept any false links to companies or interests that one is not associated with (and of course, if you have any such connections they should be openly declared.) Most of us are critical of some aspects of the businesses in question. For instance, many of us are critical of major drug companies for the low priority they assign to diseases affecting poor people in developing countries. It is usually a good idea to articulate such criticism, in order to make it clear that you are not a megaphone of business interests.

In addition, it is worth pointing out that there are also business interests on the "other side". Some of the most prominent proponents of quackery and other forms of pseudoscience have been shown to have a considerable economic interest in the undertaking. For instance, such interests had a substantial role in promoting the now much decimated pseudoscience of HIV denial. This was a pseudoscientific doctrine that was peddled with the purpose of preventing AIDS patients from receiving life–saving antiretroviral therapy. It had its origin in the US and Europe, but had its most devastating effects in South Africa, where it is estimated to have killed about 340.000 people (Nattrass 2008). One of its most active propagandists was the German Matthias Rath, who also sold high–dose vitamin pills, which he groundlessly claimed to be efficient drugs against both AIDS and cancer. This ruthless and death–bringing act of quackery was finally stopped in 2008 due to the heroic struggle of AIDS activists in the Treatment Action Campaign (TAC). The TAC is a patient movement, with roots in the anti–apartheid movement, which has fought untiringly for AIDS prevention through education on safer sex, for free distribution of antiretroviral drugs, and against the various forms of death–bringing quackery that obtained official support under the Mbeke presidency (Kalichman 2009).

Another example is Andrew Wakefield, the author of an infamous fraudulent paper claiming that the common measles, mumps and rubella (MMR) vaccine gives rise to autism. It has been documented that the paper was part of a strategy to create a profitable business company that would sell diagnostic tests (Deer 2011). It should also be mentioned that homeopathic "remedies", which are demonstrably inefficient due to their lack of any active substance whatsoever (Ernst 2016), are sold and produced by large companies, including the French company Boiron which has a share of about 17 % of the global market (Transparancy Market Research 2018). In 2018, its turnover was 604 million euros. The Swiss company Weleda, which produces equally inefficient drugs of the anthroposophical variant, had a turnover of 401 million euros in 2017 (Weleda 2017). They can hardly be described as small–scale alternatives to big business. Furthermore, if it is dishonourable to earn too much money by selling drugs that work, it is arguably even more dishonourable to earn too much money by selling drugs that do not work.

Conclusion: Science defenders need to (1) clarify that our defence of science is a defence of science as a fact–finding practice, which is not to be confused with a defence of the practices of companies using scientific information in their business activities, (2) clearly distinguish between the moral standards of a company's business behaviour and the quality of its products, and (3) expose the unscrupulous businesses that sell inefficient drugs and other scam products.

§ 6. Do not blame the victims of disinformation

One of the most counterproductive ways to defend science is to lay out a conflict between, on the one hand, rational scientists and experts, and, on the other hand, a largely irrational general public. Such a message can alienate people and make them less willing to listen to scientific arguments. We should also realize that biases and fallacies affect us all. For instance, we all tend to be more tolerant of methodological deficiencies in studies whose conclusion we like than in studies we do not want to believe in. We probably also all have areas in which it is particularly difficult for us to think straight, due to wishful thinking or other forms of biases. Realizing this, and understanding that we are all prone to errors of reasoning, is an important part of the preparation for being an efficient defender of science.

This self–insight can hopefully also help us realize that confusions and mistaken beliefs do not show the person in question to be completely irrational. In most cases, pseudoscientific and irrational beliefs are rather small parts of otherwise quite rational habits of mind. Unless the person has strong personal interests or involvement in the pseudoscientific “patch” of her belief system, it is usually possible to find common grounds for a clear–minded discussion. The day before writing this I had a discussion with a neighbour to whom it was obvious that divination by tarot cards just could not work, but still believed that there might be “something in” astrology. After explaining to her by what means soothsayers convince their customers that a tarot reading reveals important truths, the parallel with astrology was more than obvious. Hopefully, I managed to sow some seeds of doubt on the predictive power of natal charts.

The vast majority of those who place some confidence in pseudoscientific claims do so because they have been misled and deceived. This applies in particular to those who endanger their own health, perhaps even their lives, by relying on various forms of quackery. Many practitioners of so–called alternative therapies are highly skilled salespersons. In particular if you are in a vulnerable situation, it is not easy to resist their enticing but false promises. Political decisions that legitimize various forms of quackery have not made it easier. For instance, the European labelling requirements for homeopathic preparations do not require disclosure of the product's true composition (which is required for regular pharmaceutical products). Instead, the label has to specify "the scientific name of the stock or stocks". This means that a substance of which not a single molecule is present in the preparation will be listed in a way that makes the consumer believe it to be an ingredient (it was used in the production, but nothing is left since it has been diluted away in a long series of homeopathic dilution steps; Hansson 2013c). With such legally supported disinformation, is not surprising that many patients resort to homeopathic preparations in the belief that they have some ingredient with a scientifically proven, positive medical effect (Holt and Gilbert 2009; Knapen 2018).

Conclusion: Do not blame the victims of deception. Save your criticism for the perpetrators of deception.

§ 7. Do not aim at convincing the anti–scientific propagandists

It is uncommon for active promoters of a pseudoscience to change their minds, and adopt a scientific view on the subject matter in question. True, there are a few exceptions. For instance, Edzard Ernst began his medical career as a practitioner of homeopathy. When he started to look for solid evidence of the efficacy of the drugs he was prescribing, he found that there was none. To the contrary, state of the art studies showed them to be inefficient. This insight led him to become a leading exposer of homeopathy and other medical humbugs (Ernst 2016, p. 4). And in November 1998 all five members of a local branch of the national Swedish UFO organization left that organization and instead formed a local branch of the Swedish organization of science defenders (Lindkvist 1999). But such journeys from advocacy of pseudoscience to advocacy of science are fairly uncommon. Only seldom do the successes of science defenders take the form of pseudoscientific propagandists turning over to science. Chances are much higher to dissuade those who are attracted to the pseudoscience but have not yet fully committed themselves to it.

Pseudoscientists often like to argue and debate, and it may therefore be tempting to engage in discussions with them in order to win them over. But in the vast majority of cases, this does not work since they are driven by motives and interests that make them impossible to convince. No matter what you say and what evidence you put forward, they will always find an argument for not changing their minds. For instance, no amount of evidence of anthropogenic global warming can convince a dedicated climate science denialist. Again and again, he will come up with some (increasingly far–fetched) reason to doubt the evidence (Dunlap 2014). Therefore, it is usually unproductive to spend time on trying to win over a committed pseudoscientist to science. That time can be spent much more usefully on reaching out to people who are genuinely uncertain and do not know what to believe, given the conflicting claims that they have been exposed to.

Conclusion: Do not waste time on discussing pseudoscience with those who have closed their minds to scientific evidence and inference in the issue at hand. Instead, communicate with those who are willing to seriously consider your arguments.

§ 8. Do not contribute to the legitimization of pseudoscience

In controversial issues mass media should normally give opportunity to proponents of different views to express, explain, and argue for their standpoints. This is how media in democratic societies deal with value–based policy conflicts. The same method is also appropriate in cases of genuine scientific controversies. However, scientific controversies in policy–relevant issues are much less common than what has often been claimed. Many of the "scientific controversies" presented in media do not represent differences of opinion among the scientists who are best equipped for having an opinion in the matter. Instead, they are controversies between, on the one hand, scientists who express the scientific consensus, and, on the other hand, proponents of ideas with little or no support in mainstream science.

A major reason why such false conflicts are common is that they often serve as efficient means to present unpopular policy standpoints in a more favourable light. For instance, suppose that a pesticide has recently been shown to have neurotoxic effects in children. Authorities plan to prohibit the substance, whereas the company that produces it opposes such legislation. How can the company convince decision–makers and the public that the pesticide should not be restricted? It would probably not be a good idea to present their true motive, namely company profits. A strategy that has proven much more successful is to proffer false allegations against the science. The company will then be engaged in a "scientific controversy" in which it is difficult for laypeople to have an opinion, instead of a policy discussion in which not many would side with the company. Wendy Wagner described this strategy as a "science charade" to which companies and other organizations resort "when faced with the alternative course of engaging in unwinnable debates over policy, such as the proper level of risk aversion for protection of public health or the appropriate social cost, expressed in dollars, of an additional cancer." (Wagner 1995, p. 1658)

Obviously, science defenders should not contribute to science charades or to other arrangements that create the illusion of a legitimate debate between two equally legitimate scientific opinions, when there is in fact a scientific consensus. It is also important to recognize that the common format of public debates, with equal time for each side, is monumentally unsuited for adjudicating issues of fact. In the same time that you need to explain why a single factual claim by the opponent is false, the opponent can make at least ten equally inaccurate statements. Academic seminars are much more suitable for that purpose, since rhetorical devices such as neglecting counter–arguments, shifting the subject, or bringing in multiple new topics are not accepted there.

The best answer to an invitation to debate with pseudoscientists may very well be: "I am available for an interview, but I do not debate with someone who claims that biological evolution has not taken place (or whatever the claim is). Such a debate would give the wrongful impression that his standpoint is equally worthy of consideration as the overwhelming consensus of scientists, which is the viewpoint I represent." There are usually good ways to present science to the public without lending legitimacy to pseudoscience (Cook 2016; Hansson 2018a).

For much the same reasons, it is important not to acquiesce to the pseudoscientists' agenda. For instance, the discussion on climate change should not be limited to the usually rather marginal issues that climate science denialists want to bring up, and the discussion on evolution should start out from the overwhelming scientific evidence and what we can learn from it. The public should of course have access to scientific responses to the claims of climate science denialists, creationists, and other pseudoscientists, but a too strong focus on their false claims may contribute to the misconception that these are the major issues in the scientific discussion. There are good reasons to give priority to topics that the pseudoscientists prefer not to discuss, such as the evidence that convinces climate scientists of the reality of anthropogenic climate change, and the remarkable explanatory power of evolution theory in all branches of biology.

Conclusion: Do not participate in science charades that give legitimacy to pseudoscience. Instead of accepting the pseudoscientists' agenda, put emphasis on what is important is science.

§ 9. Do not attack religion when it does not conflict with science

Pseudoscience can have many types of motivations, e.g. personal, political, and religious ones. In modern societies where science is perceived to have more authority than religion, there is a profusion of attempts to prove religious standpoints with science. Such endeavours can be found in all major religions, and they have given rise to multiple forms of pseudoscience. Pseudoscience purported to support religious beliefs can be divided into four main categories according to their religious purpose (Hansson 2013b):

§ 9.1. Alleged scientific proof of the literal veracity of scriptures or traditional dogmas

The most important example in this category is creationism, which attempts to replace evolution science by literalist interpretations of sacred texts (Matzke 2010). Creationism originated in Protestant Christianity, but has also spread to Judaism and Islam. Another example is scripture–confirming archaeology, which is devoted to the reinterpretation of excavation finds to suit for instance the biblical accounts of Middle East history or the version of American prehistory contained in the Book of Mormon (Biblical archaeology respectively Mormon archaeology; Davis 2004; Moshenska 2017). A third example is the pseudoscientific theories that have been developed in support of so–called sexual reorientation therapies (Grace 2008).

§ 9.2. Alleged scientific proof of the authenticity of venerated physical objects

Relics and other holy objects have an important role in many religions. One of the most famous examples is the shroud of Turin, a piece of cloth that is claimed by many Catholics to be the burial cloth of Jesus Christ. Carbon dating shows that it was made in the the 13^{th} or 14^{th} century. Outlandish claims about radioactive decay are therefore central components of the pseudoscientific literature on this relic (Nickell 2007).

§ 9.3. Alleged scientific proof of afterlife or the existence of non–human spiritual beings

The surge of spiritism in late 19^{th} century Northern America and Europe was accompanied by endeavours to authenticate séance room phenomena scientifically (Brandon 1983). Attempts have also been made to verify reincarnation with evidence from people alleged to have memories from previous lives, either spontaneously or after some intervention such as hypnosis (Edwards 1996). The "scientific" study of spiritism and reincarnation has not provided any tenable evidence of the purported phenomena.

§ 9.4. Alleged scientific proof of divine interference or the spiritual powers of humans

Miracles have a place in most major religions. The Roman Catholic Church beatifies and canonizes saints according to criteria that are based on the misconception that if there is no known explanation of a person's recovery from a serious disease, then that recovery must be due to supernatural forces (Woodward 1996). Minor alleged miracles, such as weeping and drinking statues and the liquefaction of congealed blood, have also given rise to considerable pseudoscientific advocacy, in spite of having plausible explanations such as pious fraud and natural phenomena (Nickell 1992). A related phenomenon is the claims of certain individuals to have superhuman, so–called psychic, abilities (Randi 1982). Contrary to miracles, these faculties are not ascribed to divinity but to humans who – less humbly – profess to have such powers themselves. None of these phenomena has been produced under controlled conditions that exclude sleight of hand or other natural explanations.

§ 9.5.

These and other religiously affiliated pseudosciences should of course be tackled in the same way as pseudosciences not affiliated with religion. Religion is not a protective belt against science–based criticism.

But it must also be emphasized that religious belief does not necessarily conflict with science. There are many believers whose beliefs do not contradict scientific knowledge or the use of scientific method. Around 89 per cent of the world's population is religious (Grim et al 2018, p. 13). Proponents of pseudoscience try to convince religious believers that their religion implies belief in various unfounded empirical claims. A strong connection between pseudoscience and religion is exactly what these pseudoscientists need. Therefore, a defence of science that confirms that supposed connection is bound to be counter–productive.

Conclusion: (1) Pseudosciences that are associated with religion are by no means immune to scientific criticism. They should be dealt with in the same way as if they had no connection with religion. (2) Criticism of these or other forms of pseudoscience should not be coupled to anti–religious messages. To the contrary, the possibility of combining religious belief and practice with support of science has to be emphasized.

§ 10. Do not call yourself a "sceptic"

The word "scepticism" has many meanings, but its original and central meaning refers to *philosophical scepticism*, which is about as old as the recorded history of philosophy (Vogt 2016). Scepticism is characterized by the consistent use of what is still one of the most powerful tools in the philosophical toolbox, namely radical doubt. By doubting what we do not usually doubt, by repeatedly asking questions like "Is it impossible that this might be wrong?" we can clarify the justificatory status of our knowledge and beliefs. Persistence is an essential component of this methodology. The philosophical sceptic does not give up, but continues to raise doubts as long as it at all possible to do so.

With the sceptical method of radical doubt, almost any belief can be put in question. Therefore this method is not useful for resolving scientific issues or for determining which empirical standpoints we should believe in. And that is certainly not its purpose. The reason why we philosophers still teach our students the method of radical doubt is not that they should apply it in their studies of science. Neither do we want to make them solipsists. The purpose is to provide them with valuable insights on the nature of human knowledge and belief.

When the modern movement of science defenders was formed in the 1970s, the term *scientific scepticism*, commonly abbreviated to just "scepticism", soon became the most common name of the movement (Loxton 2013). Since 1977, its flagship journal carries the title *Skeptical Inquirer*. In 1992, philosopher Paul Kurtz (1925–2012), who had a leading role in the movement, published his book *The New Skepticism*, in which he claimed a connection between the movement's ideals and classical philosophical scepticism (Kurtz 1992). However, as I noted in a review of that book, the connection is not very clear. Classical philosophical scepticism proclaimed that human knowledge is impossible, whereas Kurtz's scepticism is "guided by the conviction that human knowledge is attainable, viz. attainable by the means of scientific investigation." (Hansson 1994, p. 135)

Since then, a third form of "scepticism" has emerged, which we can call *pseudoscientific scepticism.* For instance, deniers of climate science call themselves "climate sceptics", a Danish anti–environmentalist author calls himself a "sceptical environmentalist", and the creationist Discovery Institute promotes what they call a "sceptical" view of evolution.

The use of the term "scepticism" in connection with pseudoscience is not entirely unfounded. There is a remarkable similarity between the argumentative behaviour of a philosophical sceptic and that of a pseudoscientist. As noted above, persistence is a fundamental characteristic of philosophical scepticism. A philosopher who develops sceptical argumentation will not bow to preponderant counterarguments, but will stick to her claims as long as it is at all logically possible to do so. Similarly, proponents of pseudoscience characteristically hold on to their views whatever evidence and arguments they are confronted with. If you point out that a homeopathic preparation is so dilute that it does not contain a single molecule of the supposedly active substance, then the homeopath will respond with a fanciful theory that ascribes "memory" to water molecules that have been close to the molecules in question. If you point out that homeopathic treatments have not been validated in clinical trials, then the homeopath will claim that contrary to the effects of other treatments, those of homeopathy cannot be seen in clinical trials. And so it goes on. Proponents of this and other pseudosciences tend to be just as persistent and inconvincible as philosophical sceptics (Hansson 2017c).

There is of course a difference. The philosophical sceptic who claims that (s)he does not know if you exist only poses as a non–believer in your existence; if (s)he treats you like air then that is surely for some other reason. In contrast, the climate science denialist and the homeopath can be expected to believe in what they are saying. They have in fact taken over the method of radical doubt from the philosophical sceptic. However, they use it selectively – they only apply it to scientific standpoints that they do not like. It is this selectivity, more than anything else, that in their hands turns this age–old philosophical tool into a tool of pseudoscience.

Currently, the term "scepticism" is used for at least three highly different viewpoints, namely philosophical scepticism, scientific scepticism, and pseudoscientific scepticism. This confusing situation is reason enough to carefully consider if "scientific scepticism" is really the preferable term for the defence of science. Another reason is that the term "scepticism" gives the impression that the movement has a special ideal or ideology that differs from science as such. That, however, is not the case. For instance, in debates on climate science the task of this movement has been to defend and promote the best climate science. It has most certainly not been to present some specific "sceptic" stance that differs in one way or other from the scientific consensus. Using the term "sceptic" tends to obscure the purpose of the undertaking.

Conclusion: Just say what you are doing. You are defending science. The additional terms "sceptic" and "scepticism" do not add anything to that, and they might make your message less clear. The risk of confusion will decrease if you consistently use the longer phrases "scientific sceptic" and "scientific scepticism", but it is even safer to stick to terms such as "science defender" and "defence of science".

§ 11. Conclusion

The public defence of science is no easy task. The enemies attack us from many positions, and some of them are remarkably resourceful. Therefore, we need a thought–through strategy, and we need to learn from previous experiences so that we repeat the successes, rather than the mistakes, of previous confrontations in this campaign.

This Decalogue has its focus on the don'ts, the pitfalls we should avoid. But of course, the most important commandment is a do, not a don't: Distortions and denials of science should not be left unrefuted. Go therefore and explain what science is and how we can use it to better our understanding of the world we live in!

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