Pseudoscience

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Pseudoscience is a claim, belief or practice presented as scientific, but which does not adhere to the scientific method.[1][2] A field, practice, or body of knowledge can reasonably be called pseudoscientific when it is presented as consistent with the norms of scientific research, but it demonstrably fails to meet these norms.[3]

Pseudoscience is often characterized by the following: contradictory, exaggerated or unprovable claims; over-reliance on confirmation rather than rigorous attempts at refutation; lack of openness to evaluation by other experts in the field; and absence of systematic practices when rationally developing theories. The term *pseudoscience* is often considered pejorative,[4] because it suggests something is being inaccurately or even deceptively portrayed as science. Accordingly, those labeled as practicing or advocating pseudoscience often dispute the characterization.[5]

Science is distinguishable from revelation, theology, or spirituality in that it offers insight into the physical world obtained by empirical research and testing.[6] Commonly held beliefs in popular science may not meet the criteria of science.[7]"Pop science" may blur the divide between science and pseudoscience among the general public, and may also involve science fiction.[7] Pseudoscientific beliefs are widespread, even among state school science teachers and newspaper reporters.[8]

The demarcation between science and pseudoscience has philosophical and scientific implications.[9] Differentiating science from pseudoscience has practical implications in the case of health care, expert testimony, environmental policies, and science education.[10] Distinguishing scientific facts and theories from pseudoscientific beliefs such as those found in astrology, alchemy, medical quackery, occult beliefs, and creation science combined with scientific concepts, is part of science education and scientific literacy.[11]

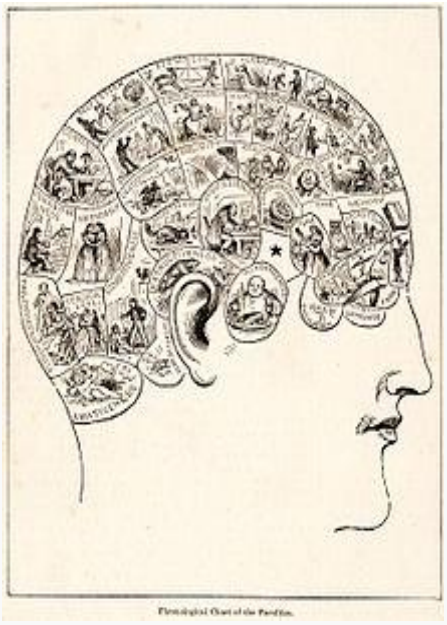
contents

- Etymology
- Overview
  - Scientific methodology
  - Falsifiability
  - Merton's norms
  - Refusal to acknowledge problems
  - Criticism of the term
- History
- Identifying pseudoscience
  - Pseudoscientific concepts
  - Use of vague, exaggerated or untestable claims
  - Over-reliance on confirmation rather than refutation
  - Lack of openness to testing by other experts
  - Absence of progress
  - Personalization of issues
  - Use of misleading language
- Demographics
- Explanations
  - Psychology
- Boundaries between science and pseudoscience
- Politics, health, and education
  - Political implications
  - Health and education implications
- References

Etymology

The word "pseudoscience" is derived from the Greek root *pseudo* meaning false[12][13] and the English word *science*. Although the term has been in use since at least the late 18th century (e.g. used in 1796 in reference to alchemy[14][15]) the concept of pseudoscience as distinct from real or proper science appears to have emerged in the mid-19th century. Among the first recorded uses of the word "pseudo-science" was in 1844 in the *Northern Journal of Medicine*, I 387: "That opposite kind of innovation which pronounces what has been recognized as a branch of science, to have been a pseudo-science, composed merely of so-called facts, connected together by misapprehensions under the disguise of principles". An earlier recorded use of the term was in 1843 by the French physiologist François Magendie.[16] During the 20th century, the word was used as a pejorative to describe explanations of phenomena which were claimed to be scientific, but which were not in fact supported by reliable experimental evidence. From time to time, though, the usage of the word occurred in a more formal, technical manner around a perceived threat to individual and institutional security in a social and cultural setting.[17]

Overview



A typical 19th century phrenology chart: In the 1820s, phrenologists claimed the mind was located in areas of the brain, and were attacked for doubting that mind came from the nonmaterial soul. Their idea of reading "bumps" in the skull to predict personality traits was later discredited.[18] Phrenology was first called a pseudoscience in 1843 and continues to be considered so.[16]

Scientific methodology

While the standards for determining whether a body of knowledge, methodology, or practice is scientific can vary from field to field, a number of basic principles are widely agreed upon by scientists. The basic notion is that all experimental results should be reproducible, and able to be verified by other individuals.[19] These principles aim to ensure experiments can be measurably reproduced under the same conditions, allowing further investigation to determine whether a hypothesis or theory related to given phenomena is both valid and reliable. Standards require the scientific method to be applied throughout, and bias will be controlled for or eliminated through randomization, fair sampling procedures, blinding of studies, and other methods. All gathered data, including the experimental or environmental conditions, are expected to be documented for scrutiny and made available for peer review, allowing further experiments or studies to be conducted to confirm or falsify results. Statistical quantification of significance, confidence, and error[20] are also important tools for the scientific method.

Falsifiability

In the mid-20th century, Karl Popper put forth the criterion of falsifiability to distinguish science from nonscience.[21]Falsifiability means a result can be disproved. For example, a statement such as "God exists" may be true or false, but no tests can be devised that could prove it either way; it simply lies outside the reach of science. Popper used astrology and psychoanalysis as examples of pseudoscience and Einstein's theory of relativity as an example of science. He subdivided nonscience into philosophical, mathematical, mythological, religious and metaphysical formulations on one hand, and pseudoscientific formulations on the other, though he did not provide clear criteria for the differences.[22]

Another example which shows the distinct need for a claim to be falsifiable was put forth in Carl Sagan's *The Demon-Haunted World* when he talks about an invisible dragon that he has in his garage. The point is made that there is no physical test to refute the claim of the presence of this dragon. No matter what test you think you can come up with, there is then a reason why this does not apply to the invisible dragon, so one can never prove that the initial claim is wrong. Sagan concludes; "Now, what's the difference between an invisible, incorporeal, floating dragon who spits heatless fire and no dragon at all?". He states that "your inability to invalidate my hypothesis is not at all the same thing

as proving it true",[23] once again explaining that even if such a claim were true, it would lie outside the realm of scientific inquiry.

Merton's norms

In 1942, Robert K. Merton identified a set of five "norms" which he characterized as what makes a real science. If any of the norms were violated, Merton considered the enterprise to be nonscience. These are not broadly accepted in the scientific community. His norms were:

- Originality: The tests and research done must present something new to the scientific community.
- Detachment: The scientists' reasons for practicing this science must be simply for the expansion of their knowledge. The scientists should not have personal reasons to expect certain results.
- Universality: No person should be able to more easily obtain the information of a test than another person. Social class, religion, ethnicity, or any other personal factors should not be factors in someone's ability to receive or perform a type of science.
- Skepticism: Scientific facts must not be based on faith. One should always question every case and argument and constantly check for errors or invalid claims.
- Public accessibility: Any scientific knowledge one obtains should be made available to everyone. The results of any research should be openly published and shared with the scientific community.[24]

The astrological signs of the zodiac.

Refusal to acknowledge problems

In 1978, Paul Thagard proposed that pseudoscience is primarily distinguishable from science when it is less progressive than alternative theories over a long period of time, and its proponents fail to acknowledge or address problems with the theory.[25] In 1983, Mario Bunge has suggested the categories of "belief fields" and "research fields" to help distinguish between pseudoscience and science, where the former is primarily personal and subjective and the latter involves a certain systematic approach.[26]

Criticism of the term

Philosophers of science such as Paul Feyerabend argued that a distinction between science and nonscience is neither possible nor desirable.[27][28] Among the issues which can make the distinction difficult is variable rates of evolution among the theories and methodologies of science in response to new data.[29] In addition, specific standards applicable to one field of science may not be applicable in other fields.

Larry Laudan has suggested pseudoscience has no scientific meaning and is mostly used to describe our emotions: "If we would stand up and be counted on the side of reason, we ought to drop terms like 'pseudo-science' and 'unscientific' from our vocabulary; they are just hollow phrases which do only emotive work for us".[30] Likewise, Richard McNally states, "The term 'pseudoscience' has become little more than an inflammatory buzzword for quickly dismissing one's opponents in media sound-bites" and "When therapeutic entrepreneurs make claims on behalf of their interventions, we should not waste our time trying to determine whether their interventions qualify as pseudoscientific. Rather, we should ask them: How do you know that your intervention works? What is your evidence?"[31]

History

The history of pseudoscience is the study of pseudoscientific theories over time. A pseudoscience is a set of ideas that presents itself as science, while it does not meet the criteria to properly be called such.[32] [33]

Distinguishing between proper science and pseudoscience is sometimes difficult. One proposal for demarcation between the two is the falsification criterion, most notably attributed to the philosopher Karl Popper. In the history of science and "history of pseudoscience" it can be especially hard to separate the two, because

some sciences developed from pseudosciences. An example of this is the science chemistry, which traces its origins to pseudoscientific alchemy.

The vast diversity in pseudosciences further complicates the history of science. Some modern pseudosciences, such as astrology and acupuncture, originated before the scientific era. Others developed as part of an ideology, such as Lysenkoism, or as a response to perceived threats to an ideology.

Despite failing to meet proper scientific standards, many pseudosciences survive. This is usually due to a persistent core of devotees who refuse to accept scientific criticism of their beliefs, or due to popular misconceptions. Sheer popularity is also a factor, as is attested by astrology, which remains popular despite being rejected by a large majority of scientists.[34][35][36][37]

Homeopathic preparation *Rhus toxicodendron*, derived from poison ivy.

Identifying pseudoscience

A field, practice, or body of knowledge might reasonably be called pseudoscientific when it is presented as consistent with the norms of scientific research, but it demonstrably fails to meet these norms.[3]

Karl Popper stated it is insufficient to distinguish science from pseudoscience, or from metaphysics, by the criterion of rigorous adherence to the empirical method, which is essentially inductive, based on observation or experimentation.[38] He proposed a method to distinguish between genuine empirical, nonempirical or even pseudoempirical methods. The latter case was exemplified by astrology, which appeals to observation and experimentation.

While it had astonishing empirical evidence based on observation, on horoscopes and biographies, it crucially failed to adhere to acceptable scientific standards.[38] Popper proposed falsifiability as an important criterion in distinguishing science from pseudoscience.

To demonstrate this point, Popper[38] gave two cases of human behavior and typical explanations from Freud and Adler's theories: "that of a man who pushes a child into the water with the intention of drowning it; and that of a man who sacrifices his life in an attempt to save the child."[38] From Freud's perspective, the first man would have suffered from psychological repression, probably originating from an Oedipus complex, whereas the second had attained sublimation. From Adler's perspective, the first and second man suffered from feelings of inferiority and had to prove himself which drove him to commit the crime or, in the second case, rescue the child. Popper was not able to find any counterexamples of human behavior in which the behavior could not be explained in the terms of Adler's or Freud's theory. Popper argued[38] it was that the observation always fitted or confirmed the theory which, rather than being its strength, was actually its weakness.

In contrast, Popper[38] gave the example of Einstein's gravitational theory, which predicted "light must be attracted by heavy bodies (such as the sun), precisely as material bodies were attracted."[38] Following from this, stars closer to the sun would appear to have moved a small distance away from the sun, and away from each other. This prediction was particularly striking to Popper because it involved considerable risk. The brightness of the sun prevented this effect from being observed under normal circumstances, so photographs had to be taken during an eclipse and compared to photographs taken at night. Popper states, "If observation shows that the predicted effect is definitely absent, then the theory is simply refuted."[38] Popper summed up his criterion for the scientific status of a theory as depending on its falsifiability, refutability, or testability.

Paul R. Thagard used astrology as a case study to distinguish science from pseudoscience and proposed principles and criteria to delineate them.[39] First, astrology has not progressed in that it has not been updated nor added any explanatory power since Ptolemy. Second, it has ignored outstanding problems such as the precession of equinoxes in astronomy. Third, alternative theories of personality and behavior have grown progressively to encompass explanations of phenomena which astrology statically attributes to heavenly forces. Fourth, astrologers have remained uninterested in furthering the theory to deal with outstanding problems or in critically evaluating the theory in relation to other theories. Thagard intended this criterion to be extended to areas other than astrology. He believed it would delineate as pseudoscientific such practices

as witchcraft and pyramidology, while leaving physics, chemistry and biology in the realm of science. Biorhythms, which like astrology relied uncritically on birth dates, did not meet the criterion of pseudoscience at the time because there were no alternative explanations for the same observations. The use of this criterion has the consequence that a theory can at one time be scientific and at a later time pseudoscientific.[39]

Science is also distinguishable from revelation, theology, or spirituality in that it offers insight into the physical world obtained by empirical research and testing.[6]For this reason, the teaching of creation science and intelligent design has been strongly condemned in position statements from scientific organisations.[40] The most notable disputes concern the evolution of living organisms, the idea of common descent, the geologic history of the Earth, the formation of the solar system, and the origin of the universe.[41] Systems of belief that derive from divine or inspired knowledge are not considered pseudoscience if they do not claim either to be scientific or to overturn well-established science. Moreover, some specific religious claims, such as the power of intercessory prayer to heal the sick, although they may be based on untestable beliefs, can be tested by the scientific method.

Some statements and commonly held beliefs in popular science may not meet the criteria of science. "Pop" science may blur the divide between science and pseudoscience among the general public, and may also involve science fiction.[7] Indeed, pop science is disseminated to, and can also easily emanate from, persons not accountable to scientific methodology and expert peer review.

If the claims of a given field can be experimentally tested and methodological standards are upheld, it is not "pseudoscience", however odd, astonishing, or counterintuitive. If claims made are inconsistent with existing experimental results or established theory, but the methodology is sound, caution should be used; science consists of testing hypotheses which may turn out to be false. In such a case, the work may be better described as ideas that are "not yet generally accepted". Protoscience is a term sometimes used to describe a hypothesis that has not yet been adequately tested by the scientific method, but which is otherwise consistent with existing science or which, where inconsistent, offers reasonable account of the inconsistency. It may also describe the transition from a body of practical knowledge into a scientific field.[42]

Pseudoscientific concepts

Examples of pseudoscience concepts, proposed as scientific when they are not scientific, include acupuncture, alchemy, ancient astronauts, applied kinesiology,astrology, Ayurvedic medicine, Vastu shastra, biorhythms, cellular memory, cold fusion,[43] craniometry, Scientology founder L. Ron Hubbard's engram theory,enneagrams, esoteric healing, eugenics according to Edwin Black,[44] extrasensory perception (ESP), facilitated communication, graphology, homeopathy, intelligent design, iridology, *kundalini*, Lysenkoism, metoposcopy, N-rays, naturopathy, orgone energy, paranormal plant perception, phrenology, physiognomy, polygraph, qi, New Age psychotherapies (e.g., rebirthing therapy), reflexology, remote viewing, neuro-linguistic programming (NLP), reiki, Rolfing, therapeutic touch, and the revised history of the solar system proposed by Immanuel Velikovsky.

Robert T. Carroll stated, in part, "Pseudoscientists claim to base their theories on empirical evidence, and they may even use some scientific methods, though often their understanding of a controlled experiment is inadequate. Many pseudoscientists relish being able to point out the consistency of their ideas with known facts or with predicted consequences, but they do not recognize that such consistency is not proof of anything. It is a necessary condition but not a sufficient condition that a good scientific theory be consistent with the facts."[45]

In 2006, the U.S. National Science Foundation (NSF) issued an executive summary of a paper on science and engineering which briefly discussed the prevalence of pseudoscience in modern times. It said, "belief in pseudoscience is widespread" and, referencing a Gallup Poll,[46] stated that belief in the 10 commonly believed examples of paranormal phenomena listed in the poll were "pseudoscientific beliefs".[47] The items were "extrasensory perception (ESP), that houses can be haunted, ghosts, telepathy, clairvoyance, astrology, that people can communicate mentally with someone who has died, witches, reincarnation, and channelling".[47]Such beliefs in pseudoscience reflect a lack of knowledge of how science works. The scientific community may aim to communicate information about science out of concern for the public's susceptibility to unproven claims.[47]

The following are some of the indicators of the possible presence of pseudoscience.

Use of vague, exaggerated or untestable claims

- Assertion of scientific claims that are vague rather than precise, and that lack specific measurements[48]
- Assertion of a claim with little or no explanatory power[38]
- Failure to make use of operational definitions (i.e. publicly accessible definitions of the variables, terms, or objects of interest so that persons other than the definer can independently measure or test them)[49] (See also: Reproducibility)
- Failure to make reasonable use of the principle of parsimony, i.e. failing to seek an explanation that requires the fewest possible additional assumptions when multiple viable explanations are possible (*see*: Occam's razor)[50]
- Use of obscurantist language, and use of apparently technical jargon in an effort to give claims the superficial trappings of science
- Lack of boundary conditions: Most well-supported scientific theories possess well-articulated limitations under which the predicted phenomena do and do not apply.[51]
- Lack of effective controls, such as placebo and double-blind, in experimental design
- Lack of understanding of basic and established principles of physics and engineering[52]

Over-reliance on confirmation rather than refutation

- Assertions that do not allow the logical possibility that they can be shown to be false by observation or physical experiment (*see also*: Falsifiability)[53]
- Assertion of claims that a theory predicts something that it has not been shown to predict.[54] Scientific claims that do not confer any predictive power are considered at best "conjectures", or at worst "pseudoscience" (e.g. *Ignoratio elenchi*)[55]
- Assertion that claims which have not been proven false must be true, and vice versa (*see*: Argument from ignorance)[56]
- Over-reliance on testimonial, anecdotal evidence, or personal experience: This evidence may be useful for the context of discovery (i.e. hypothesis generation), but should not be used in the context of justification (e.g. Statistical hypothesis testing).[57]
- Presentation of data that seems to support claims while suppressing or refusing to consider data that conflict with those claims.[58] This is an example

ofselection bias, a distortion of evidence or data that arises from the way that the data are collected. It is sometimes referred to as the selection effect.

- Promulgating to the status of facts excessive or untested claims that have been previously published elsewhere; an accumulation of such uncritical secondary reports, which do not otherwise contribute their own empirical investigation, is called the Woozle effect.[59]
- Reversed burden of proof: science places the burden of proof on those making a claim, not on the critic. "Pseudoscientific" arguments may neglect this principle and demand that skeptics demonstrate beyond a reasonable doubt that a claim (e.g. an assertion regarding the efficacy of a novel therapeutic technique) is false. It is essentially impossible to prove a universal negative, so this tactic incorrectly places the burden of proof on the skeptic rather than on the claimant.[60]
- Appeals to holism as opposed to reductionism: proponents of pseudoscientific claims, especially in organic medicine, alternative medicine, naturopathy and mental health, often resort to the "mantra of holism" to dismiss negative findings.[61]

Lack of openness to testing by other experts

- Evasion of peer review before publicizing results (called "science by press conference"):[62] Some proponents of ideas that contradict accepted scientific theories avoid subjecting their ideas to peer review, sometimes on the grounds that peer review is biased towards established paradigms, and sometimes on the grounds that assertions cannot be evaluated adequately using standard scientific methods. By remaining insulated from the peer review process, these proponents forgo the opportunity of corrective feedback from informed colleagues.[63]
- Some agencies, institutions, and publications that fund scientific research require authors to share data so others can evaluate a paper independently. Failure to provide adequate information for other researchers to reproduce the claims contributes to a lack of openness.[64]
- Appealing to the need for secrecy or proprietary knowledge when an independent review of data or methodology is requested[64]
- Substantive debate on the evidence by knowledgeable proponents of all view points is not encouraged.[65]

Absence of progress

- Failure to progress towards additional evidence of its claims.[66] Terence Hines has identified astrology as a subject that has changed very little in the past two millennia.[67] (see also: scientific progress)
- Lack of self-correction: scientific research programmes make mistakes, but they tend to eliminate these errors over time.[68] By contrast, ideas may be regarded as pseudoscientific because they have remained unaltered despite contradictory evidence. The work *Scientists Confront Velikovsky* (1976) Cornell University, also delves into these features in some detail, as does the work of Thomas Kuhn, e.g. *The Structure of Scientific Revolutions* (1962) which also discusses some of the items on the list of characteristics of pseudoscience.
- Statistical significance of supporting experimental results does not improve over time and are usually close to the cutoff for statistical significance. Normally, experimental techniques improve or the experiments are repeated, and this gives ever stronger evidence. If statistical significance does not improve, this typically shows the experiments have just been repeated until a success occurs due to chance variations.

Personalization of issues

- Tight social groups and authoritarian personality, suppression of dissent, and groupthink can enhance the adoption of beliefs that have no rational basis. In attempting to confirm their beliefs, the group tends to identify their critics as enemies.[69]
- Assertion of claims of a conspiracy on the part of the scientific community to suppress the results[70]
- Attacking the motives or character of anyone who questions the claims (see Ad hominem fallacy)[71]

Use of misleading language

- Creating scientific-sounding terms to add weight to claims and persuade nonexperts to believe statements that may be false or meaningless: For example, a long-standing hoax refers to water by the rarely used formal name

"dihydrogen monoxide" and describes it as the main constituent in most poisonous solutions to show how easily the general public can be misled.
- Using established terms in idiosyncratic ways, thereby demonstrating unfamiliarity with mainstream work in the discipline

Demographics

In his book *The Demon-Haunted World* Carl Sagan discusses the government of China and the Chinese Communist Party concern about Western pseudoscience developments and certain ancient Chinese practices in China. He sees pseudoscience occurring in the U.S. as part of a worldwide trend and suggests its causes, dangers, diagnosis and treatment may be universal.[72]

The National Science Foundation stated that pseudoscientific beliefs in the U.S. became more widespread during the 1990s, peaked near 2001, and declined slightly since with pseudoscientific beliefs remaining common. According to the NSF report, there is a lack of knowledge of pseudoscientific issues in society and pseudoscientific practices are commonly followed.[73] Surveys indicate about a third of all adult Americans consider astrology to be scientific.[74][75][76]

A large percentage of the United States population lacks scientific literacy, not adequately understanding scientific principles and methodology.[77][78][79][80] In the Journal of College Science Teaching, Art Hobson writes, "Pseudoscientific beliefs are surprisingly widespread in our culture even among public school science teachers and newspaper editors, and are closely related to scientific illiteracy."[8] However, a 10,000 student study in the same journal concluded there was no strong correlation between science knowledge and belief in pseudoscience.[81]

Explanations

In a report Singer and Benassi (1981) wrote that pseudoscientific beliefs have their origin from at least four sources.[82]

- Common cognitive errors from personal experience
- Erroneous sensationalistic mass media coverage
- Sociocultural factors
- Poor or erroneous science education

Another American study (Eve and Dunn, 1990) supported the findings of Singer and Benassi and found sufficient levels of pseudoscientific belief being promoted by high school life science and biology teachers.[83]

Psychology

The psychology of pseudoscience aims to explore and analyze pseudoscientific thinking by means of thorough clarification on making the distinction of what is considered scientific vs. pseudoscientific. The human proclivity for seeking confirmation rather than refutation (confirmation bias),[84] the tendency to hold comforting beliefs, and the tendency to overgeneralize have been proposed as reasons for the common adherence to pseudoscientific thinking. According to Beyerstein (1991), humans are prone to associations based on resemblances only, and often prone to misattribution in cause-effect thinking.[85]

Michael Shermer's theory of belief-dependent realism is driven by the belief that the brain is essentially a "belief engine," which scans data perceived by the senses and looks for patterns and meaning. There is also the tendency for the brain to create cognitive biases, as a result of inferences and assumptions made without logic and based on instinct — usually resulting in patterns in cognition. These tendencies of patternicity and agenticity are also driven "by a meta-bias called the bias blind spot, or the tendency to recognize the power of cognitive biases in other people but to be blind to their influence on our own beliefs."[86] Lindeman states that social motives (i.e., "to comprehend self and the world, to have a sense of control over outcomes, to belong, to find the world benevolent and to maintain one's self-esteem") are often "more easily" fulfilled by pseudoscience than by scientific information. Furthermore, pseudoscientific explanations are generally not analyzed rationally, but instead experientially. Operating within a different set of rules compared to rational thinking, experiential thinking regards an explanation as valid if the explanation is "personally functional, satisfying and sufficient", offering a description of the world that may be more personal than can be provided by science and reducing the amount of potential work involved in understanding complex events and outcomes.[87]

Some people believe the prevalence of pseudoscientific beliefs is due to widespread "scientific illiteracy".[88] The individuals lacking scientific literacy are more susceptible to wishful thinking, since they are likely to turn to immediate gratification powered by System 1, our default operating system which requires little to no effort. This system encourages one to accept the conclusions they believe, and reject the ones they don't. Further analysis of complex pseudoscientific phenomena require System 2, which follows rules, compares objects along multiple dimensions, and weighs options. These two systems have

several other differences which are further discussed in the dual-process theory. The scientific and secular systems of morality and meaning are generally unsatisfying to most people. Humans are, by nature, a forward-minded species pursuing greater avenues of happiness and satisfaction, but we are all too frequently willing to grasp at unrealistic promises of a better life.[89]

Psychology has much to discuss about pseudoscience thinking, as it is the illusory perceptions of causality and effectiveness of numerous individuals that needs to be illuminated. Research suggests that illusionary thinking happens in most people when exposed to certain circumstances such as reading a book, an advertisement or the testimony of others are the basis of pseudoscience beliefs. It is assumed that illusions are not unusual, and given the right conditions, illusions are able to occur systematically even in normal emotional situations. One of the things pseudoscience believers quibble most about is that academic science usually treats them as fools. Minimizing these illusions in the real world is not simple.[90] To this aim, designing evidence-based educational programs can be effective to help people identify and reduce their own illusions.[90]

Boundaries between science and pseudoscience

In the philosophy and history of science, Imre Lakatos stresses the social and political importance of the demarcation problem, the normative methodological problem of distinguishing between science and pseudoscience. His distinctive historical analysis of scientific methodology based on research programmes suggests: "scientists regard the successful theoretical prediction of stunning novel facts – such as the return of Halley's comet or the gravitational bending of light rays – as what demarcates good scientific theories from pseudo-scientific and degenerate theories, and in spite of all scientific theories being forever confronted by 'an ocean of counterexamples'".[9] Lakatos offers a "novel fallibilist analysis of the development of Newton's celestial dynamics, [his] favourite historical example of his methodology" and argues in light of this historical turn, that his account answers for certain inadequacies in those of Sir Karl Popper and Thomas Kuhn.[9]"Nonetheless, Lakatos did recognize the force of Kuhn's historical criticism of Popper – all important theories have been surrounded by an 'ocean of anomalies', which on a falsificationist view would require the rejection of the theory outright... Lakatos sought to reconcile the rationalism of Popperian falsificationism with what seemed to be its own refutation by history".[91]

> Many philosophers have tried to solve the problem of demarcation in the following terms: a statement constitutes knowledge if sufficiently many people believe it sufficiently strongly. But the history of thought shows us that many people were totally

> committed to absurd beliefs. If the strengths of beliefs were a hallmark of knowledge, we should have to rank some tales about demons, angels, devils, and of heaven and hell as knowledge. Scientists, on the other hand, are very sceptical even of their best theories. Newton's is the most powerful theory science has yet produced, but Newton himself never believed that bodies attract each other at a distance. So no degree of commitment to beliefs makes them knowledge. Indeed, the hallmark of scientific behaviour is a certain scepticism even towards one's most cherished theories. Blind commitment to a theory is not an intellectual virtue: it is an intellectual crime.
> Thus a statement may be pseudoscientific even if it is eminently 'plausible' and everybody believes in it, and it may be scientifically valuable even if it is unbelievable and nobody believes in it. A theory may even be of supreme scientific value even if no one understands it, let alone believes in it.[9]
>
> *— Imre Lakatos, Science and Pseudoscience*

The boundary lines between science and pseudoscience are disputed and difficult to determine analytically, even after more than a century of dialogue among philosophers of science and scientists in varied fields, and despite some basic agreements on the fundaments of scientific methodology.[3][92] The concept of pseudoscience rests on an understanding that scientific methodology has been misrepresented or misapplied with respect to a given theory, but many philosophers of science maintain that different kinds of methods are held as appropriate across different fields and different eras of human history. According to Lakatos, the typical descriptive unit of great scientific achievements is not an isolated hypothesis but "a powerful problem-solving machinery, which, with the help of sophisticated mathematical techniques, digests anomalies and even turns them into positive evidence."[9]

> To Popper, pseudoscience uses induction to generate theories, and only performs experiments to seek to verify them. To Popper, falsifiability is what determines the scientific status of a theory. Taking a historical approach, Kuhn observed that scientists did not follow Popper's rule, and might ignore falsifying data, unless overwhelming. To Kuhn, puzzle-solving within a paradigm is science. Lakatos attempted to resolve this debate, by suggesting history shows that science occurs in research programmes, competing according to how progressive they are. The leading idea of a programme could evolve, driven by its heuristic to make predictions that can be supported by evidence. Feyerabend claimed that Lakatos was selective in his examples, and the whole history of science shows there is no universal rule of scientific method, and imposing one on the scientific community impedes progress.[93]
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> *— David Newbold and Julia Roberts, "An analysis of the demarcation problem in science and its application to therapeutic touch theory" in International Journal of Nursing Practice, Vol. 13*

Laudan maintained that the demarcation between science and non-science was a pseudo-problem, preferring to focus on the more general distinction between reliable and unreliable knowledge.[94]

> [Feyerabend] regards Lakatos's view as being closet anarchism disguised as methodological rationalism. It should be noted that Feyerabend's claim was not that standard methodological rules should never be obeyed, but rather that sometimes progress is made by abandoning them. In the absence of a generally accepted rule, there is a need for alternative methods of persuasion. According to Feyerabend, Galileo employed stylistic and rhetorical techniques to convince his reader, while he also wrote in Italian rather than Latin and directed his arguments to those already temperamentally inclined to accept them.[91]
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> —*Alexander Bird, "The Historical Turn in the Philosophy of Science" in Routledge Companion to the Philosophy of Science*

Politics, health, and education

Political implications

The demarcation problem between science and pseudoscience brings up debate in the realms of science, philosophy and politics. Imre Lakatos, for instance, points out that the Communist Party of the Soviet Union at one point declared that Mendelian genetics was pseudoscientific and had its advocates, including well-established scientists such as Nikolai Vavilov, sent to a Gulag and that the "liberal Establishment of the West" denies freedom of speech to topics it regards as pseudoscience, particularly where they run up against social mores.[9]

It becomes pseudoscientific when science cannot be separated from ideology, scientists misrepresent scientific findings to promote or draw attention for publicity, when politicians, journalists and a nation's intellectual elite distort the facts of science for short-term political gain, when powerful individuals in the public conflate causation and cofactors (for example, in the causes of HIV/AIDS) through a mixture of clever wordplay, or when science is being used by the powerful to promote ignorance rather than tackle ignorance. These ideas reduce the authority, value, integrity and independence of science in society.[95]

Health and education implications

Distinguishing science from pseudoscience has practical implications in the case of health care, expert testimony, environmental policies, and science education. Treatments with a patina of scientific authority which have not actually been subjected to actual scientific testing may be ineffective, expensive, and dangerous to patients, and confuse health providers, insurers, government decision makers, and the public as to what treatments are appropriate. Claims advanced by pseudoscience may result in government officials and educators

making poor decisions in selecting curricula; for example, creation science may replace evolution in studies of biology.[10]

The extent to which students acquire a range of social and cognitive thinking skills related to the proper usage of science and technology determines whether they are scientifically literate. Education in the sciences encounters new dimensions with the changing landscape of science and technology, a fast-changing culture, and a knowledge-driven era. A reinvention of the school science curriculum is one that shapes students to contend with its changing influence on human welfare. Scientific literacy, which allows a person to distinguish science from pseudosciences such as astrology, is among the attributes that enable students to adapt to the changing world. Its characteristics are embedded in a curriculum where students are engaged in resolving problems, conducting investigations, or developing projects.[11]

Scientists do not want to get involved to counter pseudoscience for various reasons. For example, pseudoscientific beliefs are irrational and impossible to combat with rational arguments, and even agreeing to talk about pseudoscience indicates acceptance as a credible discipline. Pseudoscience harbors a continuous and an increasing threat to our society.[96] It is impossible to determine the irreversible harm that will happen in the long term. In a time when the public science literacy has declined and the danger of pseudoscience has increased, revising the conventional science course to address current science through the prism of pseudoscience could help improve science literacy and help society to eliminate misconceptions and assault growing trends (remote viewing, psychic readings, etc.) that may harm (financially or otherwise) trusting citizens.[96]

Pseudosciences such as homeopathy, even if generally benign, are magnets for charlatans. This poses a serious issue because it enables incompetent practitioners to administer health care. True-believing zealots may pose a more serious threat than typical con men because of their affection to homeopathy's ideology. Irrational health care is not harmless, and it is careless to create patient confidence in pseudomedicine.[97]

References

1. Definition:
   - "A pretended or spurious science; a collection of related beliefs about the world mistakenly regarded as being based on scientific method or as having the status that scientific truths now have," *Oxford English Dictionary*, second edition 1989.
   - "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 (Hansson 1996): (1) it is not scientific, and (2) its major proponents try to create the impression that it is scientific." Hansson 2008
   - '"claims presented so that they appear [to be] scientific even though they lack supporting evidence and plausibility"(p. 33). In contrast, science is "a set of methods designed to describe and interpret observed and inferred phenomena, past or present, and aimed at building a testable body of knowledge open to rejection or confirmation"(p. 17)' Shermer 1997, (this was the definition adopted by the National Science Foundation).
2. *"Wordnik, pseudoscience".*
3. Cover JA, Curd M (Eds, 1998) *Philosophy of Science: The Central Issues*, 1–82.
4. *Hill, Sharon (January 30, 2013). "The Trouble with Pseudoscience—It Can Be a Catastrophe". Skeptical Inquirer. Retrieved April 25, 2015.*
5. *Hansson, Sven Ove (2008). "Science and Pseudoscience Section 2: The "science" of pseudoscience". Stanford Encyclopedia of Philosophy.*
6. *Gould, Stephen Jay (1997). "Nonoverlapping magisteria". Natural History.*
7. *Pendle, George. "Popular Science Feature - When Science Fiction is Science Fact".*
8. *Art Hobson (2011). "Teaching Relevant Science for Scientific Literacy"(PDF). Journal of College Science Teaching.*
9. Imre Lakatos, Science and Pseudoscience, Science and Pseudoscience (transcript), Dept of Philosophy, Logic and Scientific Method, 1973.
10. *Hansson, Sven Ove (September 3, 2008). "Science and Pseudo-Science, Section 1: The purpose of demarcations". Stanford Encyclopedia of*

Philosophy. Stanford University. Retrieved April 16, 2011. From a practical point of view, the distinction is important for decision guidance in both private and public life. Since science is our most reliable source of knowledge in a wide variety of areas, we need to distinguish scientific knowledge from its look-alikes. Due to the high status of science in present-day society, attempts to exaggerate the scientific status of various claims, teachings, and products are common enough to make the demarcation issue pressing in many areas.

11. *Hurd PD (June 1998). "Scientific Literacy: New Minds for a Changing World".Science Education* **82** *(3): 407–416. doi:10.1002/(SICI)1098-237X(199806)82:3<407::AID-SCE6>3.0.CO;2-G.*
12. *"The Free Dictionary, "pseudo"". Farlex, Inc. 2015.*
13. *"Online Etymology Dictionary, pseudo". Douglas Harper. 2015.*
14. *"pseudoscience". Oxford English Dictionary (3rd ed.). Oxford University Press. September 2005.* (Subscription or UK public library membership required.)(subscription required)
15. Andrews & Henry 1796, p. 87.
16. *Magendie, F (1843). An Elementary Treatise on Human Physiology. John Revere (5th ed.). New York: Harper. p. 150.* Magendie refers to phrenology as "*a pseudo-science of the present day*" (note the hyphen).
17. *Still, A; Dryden, W (2004). "The Social Psychology of "Pseudoscience": A Brief History". J Theory Soc Behav* **34** *(3): 265–290. doi:10.1111/j.0021-8308.2004.00248.x.*
18. *Bowler, Peter J. (2003). Evolution: The History of an Idea (3rd ed.). University of California Press. p. 128. ISBN 0-520-23693-9.*
19. *e.g.* Gauch, Hugh G., Jr. (2003), Scientific Method in Practice, Cambridge University Press, ISBN 0-521-01708-4, 435 pages, 3–5 *ff*
20. Gauch (2003), 191 *ff*, especially Chapter 6, "Probability", and Chapter 7, "inductive Logic and Statistics"
21. Popper, KR (1959) "The Logic of Scientific Discovery". The German version is currently in print by Mohr Siebeck (ISBN 3-16-148410-X), the English one by Routledge publishers (ISBN 0-415-27844-9).
22. Karl R. Popper: Science: Conjectures and Refutations. *Conjectures and Refutations* (1963), p. 43–86;
23. Sagan, Carl. (1996). The Demon-Haunted World, p. 171. Ballantine Books, New York. ISBN 0345409469.
24. *Casti, John L. (1990). Paradigms lost : tackling the unanswered mysteries of modern science (1st ed.). New York: Avon Books. pp. 51–52. ISBN 0-380-71165-6.*

25. Paul R. Thagard "Why Astrology is a Pseudoscience" in PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association, Vol. 1978, Volume One: Contributed Papers (1978), pp. 223–234, The University of Chicago Press on behalf of the Philosophy of Science Association 223 ff.
26. Bunge M (1983) "Demarcating science from pseudoscience" Fundamenta Scientiae 3:369-388
27. Feyerabend, P. (1975) *Against Method: Outline of an Anarchistic Theory of Knowledge* ISBN 0-86091-646-4 Table of contents and final chapter.
28. *Gauch, H.G. (2003). Scientific Method in Practice. Cambridge University Press. p. 88. ISBN 9780521017084. LCCN 2002022271. A particularly radical reinterpretation of science comes from Paul Feyerabend, "the worst enemy of science"... Like Lakatos, Feyerabend was also a student under Popper. In an interview with Feyerabend in Science, [he says] "Equal weight... should be given to competing avenues of knowledge such as astrology, acupunture, and witchcraft..."*
29. *Thagard, PR (1978). Asquith, PD; Hacking, I, eds. Why astrology is a pseudoscience. PSA **1** (East Lansing: Philosophy of Science Association). p. 223.Thagard writes, at 227, 228: "We can now propose the following principle of demarcation: A theory or discipline which purports to be scientific is pseudoscientific if and only if: it has been less progressive than alternative theories over a long period of time, and faces many unsolved problems; but the community of practitioners makes little attempt to develop the theory towards solutions of the problems, shows no concern for attempts to evaluate the theory in relation to others, and is selective in considering confirmations and non confirmations.*
30. Laudan L (1996) "The demise of the demarcation problem" in Ruse, Michael, *But Is It Science?: The Philosophical Question in the Creation/Evolution Controversy*pp. 337–350.
31. McNally RJ (2003) Is the pseudoscience concept useful for clinical psychology?*The Scientific Review of Mental Health Practice*, vol. 2, no. 2 (Fall/Winter 2003)
32. *"Pseudoscientific". Oxford American Dictionary. Oxford English Dictionary.Pseudoscientific – pretending to be scientific, falsely represented as being scientific*
33. *"Pseudoscience". The Skeptic's Dictionary.*
34. *Humphrey Taylor. "The Religious and Other Beliefs of Americans 2003". Retrieved 2007-01-05.*

35. *"Chapter 7: Science and Technology: Public Attitudes and Understanding". National Science Foundation. Retrieved 2007-01-05. Public Attitudes*
36. *"Astrology". Encarta. Microsoft. 2008. Archived from the original on 2009-10-31. Retrieved 2007-08-28. Scientists have long rejected the principles of astrology, but millions of people continue to believe in or practice it.*
37. *Bufe, Chaz. "Astrology: Fraud or Superstition". See Sharp Press.*
38. Popper, Karl (1963) *Conjectures and Refutations*.
39. *Thagard, PR (1978). Why astrology is a pseudoscience.*
40. *"Scientific community statements". National Center for Science Education. Retrieved 21-05-2010.* Check date values in: |access-date= (help)
41. *"Royal Society statement on evolution, creationism and intelligent design"..*
42. Popper KR *op. cit.*
43. *Voss, David (May 1999). "'New Physics' Finds a Haven at the Patent Office".Science* ***284*** *(5418): 1252–1254. doi:10.1126/science.284.5418.1252.*
44. *Black, Edwin (2004). War Against the Weak. Thunder's Mouth Press. p. 370.ISBN 978-1-56858-321-1.*
45. *Robert T. Carroll (2011). "pseudoscience". From Abracadabra to Zombies. Robert T. Carroll, self-published.*
46. Gallup Poll: Belief in paranormal phenomena: 1990, 2001, and 2005. Gallup Polls, Gallup's original report.
47. *National Science Board (2006). "Chapter 7: Science and Technology: Public Attitudes and Understanding". Science and Engineering Indicators 2006. National Science Foundation. Belief in Pseudoscience (see Footnote 29). Retrieved 3 March2010.*
48. e.g. Gauch (2003) *op cit* at 211 *ff* (Probability, "Common Blunders")
49. *Churchland, Paul Montgomery (1999). Matter and Consciousness: A Contemporary Introduction to the Philosophy of Mind. MIT Press. p. 90. Most terms in theoretical physics, for example, do not enjoy at least some distinct connections with observables, but not of the simple sort that would permit operational definitions in terms of these observables. [..] If a restriction in favor of operational definitions were to be followed, therefore, most of theoretical physicswould have to be dismissed as meaningless pseudoscience!*
50. Gauch HG Jr. (2003) *op cit* 269 ff, "Parsimony and Efficiency"

51. Hines T (1988) *Pseudoscience and the Paranormal: A Critical Examination of the Evidence* Buffalo NY: Prometheus Books. ISBN 0-87975-419-2
52. Donald E. Simanek, What is science? What is pseudoscience?
53. Lakatos I (1970) "Falsification and the Methodology of Scientific Research Programmes." in Lakatos I, Musgrave A (eds) *Criticism and the Growth of Knowledge* pp 91-195; Popper KR (1959) *The Logic of Scientific Discovery*
54. e.g. Gauch (2003) *op cit* at 178 *ff* (Deductive Logic, "Fallacies"), and at 211 *ff*(Probability, "Common Blunders")
55. *Macmillan Encyclopedia of Philosophy* Vol 3, "Fallacies" 174 *ff*, esp. section on "Ignoratio elenchi"
56. *Macmillan Encyclopedia of Philosophy* Vol 3, "Fallacies" 174 'ff *esp. 177-178*
57. Bunge M (1983) Demarcating science from pseudoscience *Fundamenta Scientiae*3:369–388, 381
58. Thagard (1978)*op cit* at 227, 228
59. *Eileen Gambrill (1 May 2012). Critical Thinking in Clinical Practice: Improving the Quality of Judgments and Decisions (3rd ed.). John Wiley & Sons. p. 109.ISBN 978-0-470-90438-1.*
60. Lilienfeld SO (2004) *Science and Pseudoscience in Clinical Psychology* Guildford Press (2004) ISBN 1-59385-070-0
61. Ruscio J (2001) *Clear Thinking with Psychology: Separating Sense from Nonsense*, Pacific Grove, CA: Wadsworth.
62. *Gitanjali, B (2001). "Peer review -- process, perspectives and the path ahead"(PDF). Journal of postgraduate medicine* ***47*** *(3): 210–4. PMID 11832629.*; Lilienfeld (2004) *op cit* For an opposing perspective, e.g. Chapter 5 of Suppression Stories by Brian Martin (Wollongong: Fund for Intellectual Dissent, 1997), pp. 69-83.
63. Ruscio (2001) *op cit.*
64. Gauch (2003) *op cit* 124 ff"
65. Sagan, Carl (1994). "The Demon Haunted World", p. 210. Ballantine Books, New York. ISBN 0345409469
66. Lakatos I (1970) "Falsification and the Methodology of Scientific Research Programmes." in Lakatos I, Musgrave A (eds.) *Criticism and the Growth of Knowledge* 91–195; Thagard (1978) *op cit* writes: "We can now propose the following principle of demarcation: A theory or discipline which purports to be scientific is pseudoscientific if and only if: it has been less progressive than alternative theories over a long period of time, and

faces many unsolved problems; but the community of practitioners makes little attempt to develop the theory towards solutions of the problems, shows no concern for attempts to evaluate the theory in relation to others, and is selective in considering confirmations and disconfirmations."

67. Hines T, *Pseudoscience and the Paranormal: A Critical Examination of the Evidence*, Prometheus Books, Buffalo, NY, 1988. ISBN 0-87975-419-2. Thagard (1978) *op cit* 223 *ff*
68. Ruscio J (2001) *op cit.* p120
69. *Devilly, GJ (2005). "Power therapies and possible threats to the science of psychology and psychiatry". Australia and New Zealand Journal of Psychiatry* ***39****(6): 437–445. doi:10.1080/j.1440-1614.2005.01601.x.*
70. e.g. archivefreedom.org which claims that "The list of suppressed scientists even includes Nobel Laureates!"
71. Devilly (2005) *op cit.* e.g. Philosophy 103: Introduction to Logic Argumentum Ad Hominem.
72. *Sagan, Carl; Ann Druyan (1997). "The Most Precious Thing". The Demon-Haunted World: Science as a Candle in the Dark. Ballantine Books. ISBN 0-345-40946-9.*
73. National Science Board. 2006. *Science and Engineering Indicators 2006* Two volumes. Arlington, VA: National Science Foundation (volume 1, NSB-06-01; NSB 06-01A)
74. *National Science Board. "Science and Engineering Indicators 2006" (PDF)* ***2****: A7–14. Retrieved 2009-05-03.*
75. *FOX News (June 18, 2004). "Poll: More Believe In God Than Heaven". Fox News Channel. Retrieved Apr 26, 2009.*
76. *Taylor, Humphrey (February 26, 2003). "Harris Poll: The Religious and Other Beliefs of Americans 2003". Retrieved Apr 26, 2009.*
77. *"Public Knowledge About S&T". Retrieved August 28, 2013. Surveys conducted in the United States and Europe reveal that many citizens do not have a firm grasp of basic scientific facts and concepts, nor do they have an understanding of the scientific process. In addition, belief in pseudoscience (an indicator of scientific illiteracy) seems to be widespread among Americans and Europeans.*
78. *"AMERICAN ADULTS FLUNK BASIC SCIENCE". Retrieved August 28, 2013.A new national survey commissioned by the California Academy of Sciences and conducted by Harris Interactive® reveals that the U.S. public is unable to pass even a basic scientific literacy test.*

79. *"Science literacy: U.S. college courses really count". Retrieved August 28,2013.*
80. *"MSU prof: Lack of science knowledge hurting democratic process". RetrievedAugust 28, 2013. In a survey released earlier this year, Miller and colleagues found that about 28 percent of American adults qualified as scientifically literate, which is an increase of about 10 percent from the late 1980s and early 1990s.*
81. *Impey, Chris; et al. "A Twenty-Year Survey of Science Literacy Among College Undergraduates.". Journal of College Science Teaching.*
82. Barry Singer and Victor A. Benassi. "Occult Beliefs: Media Distortions, Social Uncertainty, and Deficiencies of Human Reasoning Seem to be at the Basis of Occult Beliefs." *American Scientist* , Vol. 69, No. 1 (January–February 1981), pp. 49–55.
83. Raymond A. Eve and Dana Dunn. "Psychic Powers, Astrology & Creationism in the Classroom? Evidence of Pseudoscientific Beliefs among High School Biology & Life Science Teachers". *The American Biology* Teacher , Vol. 52, No. 1 (Jan., 1990), pp. 10–21.
84. (Devilly 2005:439)
85. Beyerstein, B., and P. Hadaway. 1991. "On Avoiding Folly". *Journal of Drug Issues*. 20(4): 689–700.
86. *Shermer, Michael (July 2011). "Understanding The Believing Brain: Why Science Is the Only Way Out of Belief-Dependent Realism". Scientific American. Retrieved April 2014.*
87. *Lindeman M (December 1998). "Motivation, Cognition and Pseudoscience".Scandinavian Journal of Psychology* **39** *(4): 257–65. doi:10.1111/1467-9450.00085. PMID 9883101.*
88. *"What does Scientific Literacy look like in the 21st Century?". 10 October 2013. Retrieved 9 April 2014.*
89. *Shermer, Michael; Gould, Steven J. (2002). Why People Believe Weird Things: Pseudoscience, Superstition, and Other Confusions of Our Time. New York: Holt Paperbacks. ISBN 0-8050-7089-3.*
90. *Matute H, Yarritu I, Vadillo MA (2011). "Illusions of causality at the heart of pseudoscience". Br J Psychol* **102** *(3): 392–405.doi:10.1348/000712610X532210. PMID 21751996.*
91. *Bird, Alexander (2008). "The Historical Turn in the Philosophy of Science". In Psillos, Stathis; Curd, Martin. Routledge Companion to the Philosophy of Science (pdf). Abingdon: Routledge. pp. 9, 14.*
92. Gauch HG Jr (2003)*op cit* 3-7.

93. *Newbold D, Roberts J (2007). "An analysis of the demarcation problem in science and its application to therapeutic touch theory". Int J Nurs Pract **13** (6): 324–30.doi:10.1111/j.1440-172X.2007.00646.x. PMID 18021160.*
94. *Laudan, Larry (1983). "The Demise of the Demarcation Problem". In Cohen, R.S.; Laudan, L. Physics, Philosophy and Psychoanalysis: Essays in Honor of Adolf Grünbaum. Boston Studies in the Philosophy of Science **76**. Dordrecht: D. Reidel. pp. 111–127. ISBN 90-277-1533-5. Retrieved November 25, 2015.*
95. *Makgoba MW (May 2002). "Politics, the media and science in HIV/AIDS: the peril of pseudoscience". Vaccine (journal) **20** (15): 1899–904. doi:10.1016/S0264-410X(02)00063-4. PMID 11983241.*
96. *C.J. Efthimiou, R. Llewellyn (2006). "Is Pseudoscience the Solution to Science Literacy?". arXiv:physics/0608061 [physics.ed-ph].*
97. *The National Council Against Health Fraud (1994). "NCAHF Position Paper on Homeopathy".*

Bibliography

- *Andrews, James Pettit; Henry, Robert (1796). History of Great Britain, from the death of Henry VIII to the accession of James VI of Scotland to the Crown of England **II**. London: T. Cadell and W. Davies. p. 87. Retrieved 2010-10-11.*
- *Hansson, Sven Ove (2008). "Science and Pseudo-science".*
- *Shermer, Michael (1997). Why People Believe Weird Things: Pseudoscience, Superstition, and Other Confusions of Our Time. New York: W. H. Freeman and Company. ISBN 0-7167-3090-1.*

Further reading

- *Pigliucci, Massimo; Boudry, Maarten (2013). Philosophy of Pseudoscience: Reconsidering the Demarcation Problem. Chicago: University of Chicago Press.ISBN 9780226051963.*
- *Shermer, Michael (September 2011). "What Is Pseudoscience?: Distinguishing between science and pseudoscience is problematic". Scientific American: 92.*
- *Hansson, S.O (September 3, 2008). "Science and Pseudo-Science". Stanford Encyclopedia of Philosophy.*

- *Schadewald Robert J (2008). Worlds of Their Own – A Brief History of Misguided Ideas: Creationism, Flat-Earthism, Energy Scams, and the Velikovsky Affair. Xlibris.ISBN 978-1-4363-0435-1.*
- *Shermer, Michael; Gould, Steven J. (2002). Why People Believe Weird Things: Pseudoscience, Superstition, and Other Confusions of Our Time. New York: Holt Paperbacks. ISBN 0-8050-7089-3.*
- *Derksen AA (2001). "The seven strategies of the sophisticated pseudo-scientist: a look into Freud's rhetorical toolbox". J Gen Phil Sci 32 (2): 329–350.doi:10.1023/A:1013100717113.*
- *Wilson F (2000). The Logic and Methodology of Science and Pseudoscience. Canadian Scholars Press. ISBN 1-55130-175-X.*
- *Bauer Henry H (2000). Science or Pseudoscience: Magnetic Healing, Psychic Phenomena, and Other Heterodoxies. University of Illinois Press. ISBN 978-0-252-02601-0.*
- *Charpak, Georges; Broch, Henri; Translated from the French by Bart K. Holland (2004). Debunked: Esp, telekinesis, other pseudoscience. Johns Hopkins University Press. ISBN 0-8018-7867-5 Originally published 2002 by Odile Jacob as Devenez sorciers, devenez savants*
- *Cioffi, Frank (1998). Freud and the Question of Pseudoscience. Chicaco and La Salle, Illinois: Open Court, division of Carus. p. 314. ISBN 0-8126-9385-X.*
- *Hansson, Sven Ove (1996). "Defining pseudoscience". Philosophia naturalis 33: 169–176.*
- *Pratkanis, Anthony R (July–August 1995). "How to Sell a Pseudoscience". Skeptical Inquirer 19 (4): 19–25.*
- *Wolpert, Lewis (1994). The Unnatural Nature of Science. Harvard University Press.ISBN 0-674-92980-2 Paperback ISBN 0-6749-2981-0* First published 1992 by Faber & Faber, London.
- *Martin M (1994). "Pseudoscience, the paranormal, and science education". Science & Education 3 (4): 1573–901. Bibcode:1994Sc&Ed...3..357M.doi:10.1007/BF00488452.*
- *Derksen AA (1993). "The seven sins of pseudo-science". J Gen Phil Sci 24: 17–42.doi:10.1007/BF00769513.*
- *Gardner M (1990). Science – Good, Bad and Bogus. Prometheus Books. ISBN 0-87975-573-3.*

  Little, John (October 29, 1981). "Review and useful overview of Gardner's book".New Scientist 92 (1277): 320.

- *Gardner, Martin (1957). Fads and Fallacies in the Name of Science (2nd, revised & expanded ed.). Mineola, New York: Dover Publications. ISBN 0-*

486-20394-8. Originally published 1952 by G.P. Putnam's Sons, under the title *In the Name of Science*.

- *Gardner, Martin (2000). Did Adam and Eve Have Navels?: Debunking Pseudoscience. New York: W. W. Norton & Company.*