 # Opinion Page

Science and Pseudoscience: Reaffirming the Distinction[1]

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Twenty years ago, the philosopher/physicist Mario Bunge remarked:

> Given the intrinsic interest and the cultural importance of pseudoscience and anti-science, it is surprising that they should receive so little attention on the part of philosophers, particularly in our times of crisis of public confidence in science. (Bunge 2001, p.189)

When Bunge made his observation, there had been minimal philosophical discussion of pseudoscience.[2] Among the few who had taken up the issue was Imre Lakatos (1922-1974) who noted:

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[1] This paper is partly sourced from Matthews (2019 chap.13).
[2] For exceptions, see Bunge (1983, 1984, 1991a), Shermer (1997), Martin (1994), Hansson (1996), Grim (1982), Grove (1985), Derksen (1993), Butts (1993), Lugg (1987, 1992), Thagard (1978), and Lakatos (1978).

> … the problem of demarcation between science and pseudoscience is not a pseudo-problem of armchair philosophers: it has grave ethical and political implications. (Lakatos 1978, p.7)

A common stance was that pseudoscience was beneath philosophical attention, and its practitioners were unlikely to benefit from such attention even if it were proffered. Pseudoscience belonged in the sideshow alley of academic philosophy.

In the past 20-30 years, this dismissive attitude has passed. Pleasingly, there has been a growth of serious philosophical, historical, psychological, and sociological study of pseudoscience. And educators have become engaged with the issue. Disciplinary indifference to pseudoscience is a thing of the past.

Indifference is not an option as the entanglement of pseudoscience with science is such a marked feature of science denialism in climate change argument; in responses to the AIDS endemic and the on-going Covid pandemic; and in debate about what research and treatments should or should not be covered in hugely expensive national health schemes. In some countries, the expression 'pseudoscience' has become part of national political discourse. The HPS community can rightly be expected to make a contribution to these debates. Remaining mute is irresponsible.

Making a contribution is part of the social responsibility of the relevant disciplines, and more generally, the university. And it has been made. There is now a substantial literature of papers, books, anthologies, and handbooks on the philosophical issues underpinning the pseudoscience debates.[3]

Indigenous Science

Widespread calls for the inclusion of indigenous science and traditional cultural knowledges in school and university science curricula have meant that educators need to address the demarcation subject.[4] Many countries dealing with the problem of science illiteracy among university graduates have moved to making completion of at least one science course compulsory. But what constitutes a course in science?

Until the early 1990s, the University of Auckland required completion of one science course for all prospective teachers. In 1993 the Anthropology Department's Mātauranga Māori (Māori Knowledge) subject was accepted as an alternative to first year physics, chemistry, biology etc. courses (Matthews 2021, chap.7). The same argument, and outcome, was repeated in many countries.

There are tens of thousands of Indigenous Sciences or Traditional Ecological Knowledges (TEK) rooted in different cultures, traditions, and places. These might be widely shared across regions or be localised to clans, tribes, or kinship groups. Allegiance can vary from millions to hundreds; and the beliefs can be more or less systematic or structured, more or less codified by tradition, books, or institutions.

All stable communities develop and pass on techniques, technologies and local knowledge relating to health, medicine, agriculture, fishing, animal husbandry, cooking, construction, the lunar cycle, planets, stars, navigation, child raising, social organisation, governance, language, Creation stories, spirits, devils, gods and much else. These are all the components of civilization; without such local and transmissible knowledge, societies would not survive.

Many point out that TEKs are not just bodies of knowledge, they are melded with ways of life, polity, worldviews, and ethics. Hence their preference for labelling the package as Indigenous Ways of Knowing, Being and Doing (IKBD). Such authors maintain:

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[3] See Pigliucci & Boudry (2013), Boudry & Pigliucci (2017), Hansson (2021), Kaufman & Kaufman (2018), McIntyre (2019), Lilienfeld (2018), Blancke, Boudry & Pigliucci (2017), Reisch (1998), Resnick (2000), Thurs & Numbers (2013), and Shermer (2002).

[4] Matthews (2022a), Parke & Hikuroa (2023), Corballis, Rata & Nola (2019).

> Discussions of IKBD and science must take social, cultural, ethical and political contexts into account' (Parke & Hikuroa 2023, p.2).

So, changing beliefs about nature, changing the understanding of science, is not just changing components of a body of knowledge, it has consequences for the 'package' in which beliefs about nature are embedded; that is, for culture and identity. Some routine cultural impacts of learning science are on the place and authority of women, the status of elders, the authority of sacred or foundational texts, and much else.

That science comes as part of a cultural-social-philosophical package is not a new understanding. Historians of science have long understood this. The Enlightenment understood science as part of a 'package'. The New Science was connected to, and had ramifications for, ways of life, religion, government powers, communication, freedom of expression, rights of assembly, ethics, and much else.

Specifically, the new science was not just a system of beliefs about the world and a methodology for ascertaining truths about the natural and social worlds, it was a belief system that was connected to liberal, democratic polity. The personal, scientific, religious and political trajectory of Joseph Priestley (1733-1804) well illustrates the traditional Enlightenment, and increasingly just plain modern, understanding of science as part of a 'package' (Matthews 2009).[5]

Importantly, the Enlightenment tradition gave priority to the epistemic component of the package; ascertaining the truth about nature and society was the goal, it carried most weight. For instance, the new scientific approach to biblical criticism, to the study of Revelation, had personal and cultural consequences for all religions based on divine, or semi-divine texts: Judaism, Christianity, Islam, Hinduism, Sikhism, Mormonism, Christian Science, etc.

Subsequent to the New Criticism, truth was the priority and adjustments in the package had to be made elsewhere when there were clashes between claims in sacred texts and scientific results. The history of the Galileo and Darwin 'Affairs'[6] are paradigmatic examples of the ultimate prioritising of truth over other components (politics, religion, commerce, tradition) in the science/culture package.

This does not mean 'truth at any cost'. Values, politics, economics, and other considerations, rightly bear upon directions and methodologies of research but, for genuine science, they cannot adjudge the truth or falsity of claims made. All universities have Ethics Committees that pass 'acceptability' judgement on all proposed research.

This option is less clearly available for IKBD interpreters. Indeed, Parke and Hikuroa are explicit: They assert that that epistemic questions cannot be abstracted from their 'social, cultural, ethical and political contexts' (Parke & Hikuroa 2023, p.2).

The Australian National University's (ANU) Indigenous Science and Knowledge major affirms:

> Indigenous knowledge systems consist of complex webs of social-cultural interaction, developed through relationships among communities and within their landscapes.

Whether such complex webs and knowledges are understood, treated, and funded as science is a central question with significant cultural, educational, economic, and philosophical consequences. Should the complex webs be better and more appropriately understood as protoscience, local knowledge, cultural lore, mythology, legend or, perhaps, pseudoscience?

The purpose of labelling something 'pseudoscience' only begins when the candidate system claims to be scientific. If the system makes no such claim, then the question does not arise. But the claim of scientificity is increasingly made for belief systems outside of customary science. A powerful advocate of Māori science maintains:

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[5] For informed elaboration of this matter, see Ferris (2010), Kitcher (2001) and Reisch (2017).
[6] On the first affair, see Finocchiaro (2007); on the second, see Ruse (2006).

> There is a need to struggle to assert the equal validity of Māori knowledge and frameworks and conversely to critically engage ideologies which reify Western knowledge (science) as being superior, more scientific, and therefore more legitimate. (Smith 1992, p.7)

While two others, in an article published in the journal of the Royal Society of New Zealand, are clear that:

> Although there will be opportunities to work together, that is not the goal of revitalising mātauranga. The goal is not partnership; it is tino rangatiratanga and instituting mātauranga as a primary and independent knowledge system. (Broughton & McBreen, 2015, p.86)

At face value, these claims reverse the onus of proof: If there is parity, why teach mainstream science to indigenous children? A question asked, and answered in the negative, by many (Montellano 1996).

The crucial issue involves the demand for inclusion of ethnosciences *in* science programmes, not as content in parallel social studies or anthropology programmes. The issue is raised when Indigenous knowledge (IKBD) is proposed as a substitute for 'normal' science courses where the latter are requirements for a degree.

Witness substantial educational and political debate about the status and curricular placement of Mātaurangi Māori in New Zealand, Aboriginal or First Nations science in Australia, Sámi worldviews and knowledge in Nordic countries, and Inuit knowledges in Canada. There is comparable debate and agitation about the curricular accommodation of the multiplicity of different First Nations knowledges in the USA, Asia, and Africa.

Are these bodies of knowledge sciences? Are they on epistemological par with science? Do they provide a comparable knowledge of nature as mainstream sciences? Are they sciences but of a different kind than 'mainstream' science? Are they protoscience? Or are they pseudoscience with no claim to space in a science curriculum or for science research funds? In New Zealand there has been an all-consuming national debate on the issue (Nola et al 2021, Dawkins 2021, Rata et al 2023). The author of an article in the South Australia Teachers' Association journal opines:

> How and why First Nations Australians applied heat-lithic treatment to siliceous rocks provides a cultural context to explore how First Nations Australians have long worked scientifically through making astute observations and use of trial and error in development of tool manufacturing processes. (Sambono 2021, p.9)

Does heating a rock, making astute observations, and using trial and error constitute science? Does it suffice for a culture having science as normally understood, funded and demanded in curricula? All of what Sambono relates, is better, and more simply, understood as technology. This does not carry the baggage or the add-on (philosophical, educational, or economic) claims pursuant to it being called science.

Joseph Needham (1900-1995) famously wrote in his 24-volume study of *Science and Civilisation in China* (Needham et al 1954-2004) that though pre-modern China had unmatched technologies, two-thousand years, or more, of recorded observations; and trial and error procedures across a multitude of domestic, commercial, and industrial practices including pottery, ceramics, iron making, canal building and much more — nevertheless premodern China (1644, end of Ming dynasty) had no science. It had advanced technology, but not science (Needham 1969, chap.1). For Needham, science was defined by:

> The application of mathematical hypotheses to Nature, the full understanding and use of the experimental method, the distinction between primary and secondary qualities, the geometrization of space, and the acceptance of the mechanical model of reality. Hypotheses of primitive or medieval type distinguish themselves quite clearly from those of modern type. Their intrinsic and essential vagueness always made them incapable of proof or disproof, and they were prone to combine in fanciful systems of gnostic correlation. (Needham 1969, p.15)

Needham is not explicit, but on balance one senses that 'The man who loved China', would say that on account of its intrinsic entanglement with imperial power, Confucian ideology, fanciful and gnostic

systems, and its inherent vagueness — that premodern (1644) Chinese science was not just poor science (something that could get better) but was pseudoscience (Jinn et al 1996).

One eminently sensible contribution to the indigenous science debate by Brazilian biologists, well trained in philosophy and who have long-worked with a traditional north-east coastal community is titled: 'Valuing indigenous knowledge: To call it "science" will not help' (El-Hani & de Ferreira Bandeira 2008).

Pseudoscience in Society

Jon D. Miller (University of Michigan), who for decades has published on science literacy and public understanding of science, correctly maintains:

> In addition to understanding basic scientific constructs, it is important for citizens to recognize pseudoscientific constructs that seek to be recognized as scientific. (Miller 2004, p.278)

YouGov's 2022 poll of 3,500 US adults found that a little more than one-quarter of Americans (27%) – including 37% of adults under 30 – say that they believe in astrology, or that the position of the stars and planets influences people's lives.

The Covid-19 pandemic precipitated a multi-million dollar tsunami of pseudoscientific, make-believe cures and treatments, some promoted by powerful Heads of State. But this was just the surfacing of an underlying social and economic malady: namely, the extent and depth of credulity and gullibility in society. This has been exploited by snake-oil merchants (and governments) for at least the past two centuries, and by sundry other merchants since the beginning of commerce.

In 2012, the US National Health Statistics Report stated that one third of US citizens spent $30 billion per year on alternative and complementary health medicines and therapies most of which are marketed as scientifically 'based' or 'proven'. A Google search for 'Magnet Healing' returned 16 million results in 0.6 seconds. In 2000, in the US, $300 million was spent on healing magnets and $1 billion spent globally. Whether healing magnets, or more generally alternative medicines, are scientific and reliable or not, are matters concerning the health of the population, the staffing of hospitals, and the cost of health insurance and government medical support. Should healing magnets be claimable on Australian government-funded Medicare (or its equivalent in other countries)? Should magnetic healers be salaried staff members of hospital?

In Hong Kong, Taiwan, and increasingly through the USA and some other countries, feng shui principles are, expensively, built into town planning decisions and construction projects. Such principles have always been deeply ingrained in Chinese law, building practice, and culture (Brown 2023). Feng shui principles are new to the West, but not to China (Matthews 2019).

In 2000, the Indian BJP government decreed that Hindu Astrology (Jyotisha) was a science on par with astronomy and consequently needed to be taught in university degree programmes. The decision was twice unsuccessfully appealed by scientists to the Indian Supreme Court. There are now astrology programmes, professorships and degrees throughout India (Nanda 1998, 2003).

In 2021, Narendra Modi blissfully ignored medical advice about the virus-borne Covid catastrophe ravaging India and gave his blessings to a 'super-spreader' event allowing millions of Hindus to descend in March/April 2021 upon the northern city of Haridwar to celebrate the Kumbh Mela festival (50 million had attended in 2019). There were 1,800 confirmed infections within four days. Science denialism had costs.

And not just India has embraced pseudoscience. The University of Wales (not New South Wales) offers an MA degree in Cultural Astrology premised on the supposed 'unfortunate' fact that the 'divorce between astrology and astronomy is (just) a feature of modern western thought'. The degree can be had for

the payment of UKP10,400. In 2003, the University of Lund established a professorship and chair in Parapsychology. Many other universities have comparable departments.

The Division of Perceptual Studies at the University of Virginia purports to have vindicated some reincarnation claims. Such claims are a core part of Hindu, Buddhist and Jain religions; they are a common feature of indigenous belief systems. The pertinent question is: Does the university's department claim to *scientifically* vindicate reincarnation? If so, then it becomes important whether the vindication is indeed scientific, poor science, or whether it is simply pseudoscientific. If no claim for scientificity is made, then the University of Virginia can say what it likes about reincarnation and bear the consequences.

There is no argument that physiotherapy is rightly claimable on Australian Medibank, or its equivalent in other countries that have 'socialised' the medical profession, as visiting US citizens are wont to say. But there should be argument whether hypnotherapy can be claimable. The issue is not that something works in this or that case, for this or that person. Hypnotherapy, magnets, drinking herb cocktails, chanting may or may not so work. The issue is whether the practice is based in scientific understanding of physiology and natural mechanisms, and so can be expected to be more generally efficacious. This is a foundational issue in Examining Holistic Medicine (Stalker & Glymour (1989), Gorski (2019), Hermes (2019).

The world-wide-web powers the full raft of alternative, holistic, and complementary sciences, therapies and pseudosciences. A December 2023 Google search for PSEUDOSCIENCE returned 17,300,000 results in 0.3 seconds. This is up from the same search in July 2023 that returned 6,400,000 results in half a second. As everybody realises, pseudoscience is on the rise. Myriad pseudoscience publications and communities are just one web-click away. Related baubles, 'scientifically proven' therapies, therapists and practitioners are as close as a credit-card transfer. The informative Wikipedia entry for Pseudoscience has 640 links and/or citations to different pseudosciences and related literature.

As with all personal, commercial, and government expenditures, it is important when appraising pseudoscience expenditure to look at the 'opportunity costs': What else could have been productively done with the money? Instead of healing magnets, snake oil, hypnotherapy, or an astrology degree — could a person have bought a good book, had a meal, have an overnight stay somewhere, or enrol in a decent science or philosophy degree? Instead of a new astrology appointment in an Indian astronomy department, could a radio astronomer have been appointed with more tangible benefit for Indian science and society.

The Nature of Science and Defining Science in Education

Debate about the nature of science (NOS) has been a part of science education since the late nineteenth century. Giants among the early contributors to the purpose of NOS in education, were Ernst Mach, Thomas Huxley, John Dewey, and Frederick Westaway. These pioneers were followed during and after the 1930s by Percy Nunn, Philipp Frank, Herbert Feigl, Walter Jung, Israel Scheffler, Gerald Holton, James Conant, Joseph Schwab, Michael Martin, Robert S. Cohen, Robert Ennis, and others (Matthews 2015, chaps. 1, 2, 5). For the past 20-30 years there has been a third wave of NOS debate and elaboration in education (Lederman 2007, Lederman, Bartos & Lederman 2014, McComas 2020, Matthews 2011).

These NOS debates are not settled. This in part because participants have been ambiguous about whether they are giving an account of NOS to satisfy historians and philosophers, or giving an account of NOS for science teachers to use in classrooms. These are two different projects as Norm Lederman (1952-2021) frequently pointed out. Another reason for the lack of closure is that, unfortunately, many of the participants have minimal HPS background and competence (Matthews 2015, chap.11, 2021, pp.276-277).

Peter Fensham, in his comprehensive study of the academic discipline of Science Education, remarked that lack of rigorous preparation for science education research is evidenced by the extent of shallow learning theory in the field, saying that:

> science educators borrow psychological theories of learning … for example Bruner, Gagne and Piaget. (Fensham 2004, p.105)

Damningly, he went on to say:

> The influence of these borrowings is better described as the lifting of slogan-like ideas from these theories. (ibid., p.105)

Even more slogan-like is the lifting of philosophical ideas by educators. Jay Lemke, a pioneering researcher on the effect of language in science learning, recognised this problem:

> Science education researchers are not often enough formally trained in the disciplines from which socio-cultural perspectives and research methods derive. Most of us are self-taught or have learned these matters second-hand from others who are also not fully trained. (Lemke 2001, p.303).

Consequently, in Education Schools, it is a case of the knowing-little leading the knowing-nothing. And the hiring, promotion, and tenure system is designed precisely to ensure this depressing outcome. Publishing a lot, the determiner of tenure, means understanding only a little. The two by-far, most cited researchers in the field - Wolf-Michael Roth (50,000 citations) and Kenneth Tobin (27,000 citations) - whose every piece is replete with philosophical claims, say in autobiographical statements that they have never studied philosophy or history of science. But this is no impediment to writing with confidence on such matters. For example, in a jointly-authored chapter they maintain:

> If, on the other hand, we begin with the ontological assumption of difference that exists in and for itself, that is, with the recognition that A↓A (e.g., because different ink drops attached to different paper particles at a different moment in time), then all sameness and identity is the result of work that not only sets two things, concepts, or processes equal but also deletes the inherent and unavoidable differences that do in fact exist. This assumption is an insidious part of the phallogocentric epistemology undergirding science as the method of decomposing unitary systems into sets of variables, which never can be more than external, one-sided expressions of a superordinate unit. (Roth & Tobin 2007, pp.99-100)

Foregoing HPS courses also means that opportunities to learn how to write clearly are missed.

None of this sad state of affairs is the fault of individuals, it is an endemic, systematic malady of the discipline. A malady affecting not just Schools of Education. Being a thoughtful scholar familiar with the literature, counts for little at tenure time. A common refrain of newly appointed staff is: ‘we are too busy with tenure tasks to read core historical literature’.

Whatever else science is, it is a systematic belief system that makes cognitive or truth-applicable (‘truth-apt’) claims about the world. That is, science generates propositions and hypotheses that can be true or false, probably true or probably false, warranted or unwarranted. Not all claims about the world are scientific claims. Some empirical claims can just be expression of feeling or verbalizing aesthetic responses to, for instance, a flower, a canyon, or sunset. Any genuine science must produce possible knowledge about the natural and social world; it must make truth-apt claims. Not all systematic belief systems making truth-apt claims are science, just some of them are.

The following is a useful beginning categorization:

Cognitive Belief Systems making Truth-applicable Claims						
SCIENCE			**NON-SCIENCE**			
Physical Science		**Social Science**	**Claims to be science**		**No claim to be science**	
Physics, chemistry, biology		*History, sociology, anthropology, economics*				
Mature and are or were adopted	**Mature and disputed**	**Mature and rejected**	**Ethno-sciences**	**Pseudo-science**	**Humanities**	**Arts**
Newtonianism Darwinism	*Punctuated equilibria*	*Phlogiston theory; caloric theory; Velikovsky*	Mātaurangi Māori, Verdic science, Islamic science	*Feng shu; Christian Science; tobacco industry research*	*Literature Poetry Theology, Philosophy*	*Music appreciation Art criticism*

Classification of Systemic Truth-Apt Cognitive Claims

Such classification is a beginning point. It does depend upon demarcation criteria at each horizontal level and between columns, but these need not be sharp, and they need not be timeless and essentialist. Demarcation criteria up and across can, and have, changed over time as scientific inquiry matures and takes new forms.[7]

In 1938 Robert Merton provided the beginning of a modern classification when he characterized science as: Communal, Universal, Disinterested, and Organized Skepticism [CUDOS] (Merton 1942/1973). Merton's characterization of good science has been remarkably robust, despite constant political and ideological attacks from *without* science, and then white anting from *within* science and the academy (Macfarlane 2023).

The basic vertical science/non-science bi-polar division is not all-or-nothing. Science contains non-empirical elements - mathematics, logic, ethics, and metaphysics, to name the obvious ones. Values are a part of science. Humanities contain scientific elements – historical research, biographical details, and sociological information, to name the obvious. Membership of a category is not cut and dried, it is a matter of family resemblance; there are clusters of criteria that mark out the categories, these can change over time, and the borders are to some extent porous.

In the above table, Cold Fusion research could reasonably be placed in the 'mature and rejected' category as it was originally a detailed scientific theory proposed by electrochemists Martin Fieischmann and Stanley Pons. But 30 years later it could be reasonably placed in the 'pseudoscience' category on account of proponents persisting with a uniformly rejected research programme.

Similarly, tobacco industry research showing that smoking is unrelated to lung cancer, was initially scientific, but over time became 'bad science' because its claims were consistently disproved. And now tobacco science is pseudoscience because it has lost all credibility and contact with the scientific

[7] For philosophical discussion on the 'demarcation problem' see at least: Bunge (2001, chap.8), Butts (1993), Hansson (2013, 2021), Mahner (2007, 2013), Nickles (2013), Pennock (2011), Pigliucci (2013), Fernandez-Beanato (2020) and Shermer (2013).

community.[8] To continue to pursue pro-tobacco research indicates a lack of scientificity; it is outside the scientific family or pale. The pro-tobacco 'research' becomes an ideological practice not a scientific one.[9]

The same pattern and trajectory can be seen in Trofim Lysenko's anti-Mendelian theory of the biological inheritance of acquired characteristics. It began in the USSR in the early 1930s as science, was soon enough shown to be bad science, and then became pseudoscience when it was persisted with solely because of external political and ideological pressures. By deference to politics, more specifically murderous Stalinism, Lysenkoism left the scientific family. Its practitioners became pseudoscientists. They had laboratories, took measurements, received state funding — but their research no longer amounted to science.[10]

And the trajectory of science-bad science-pseudoscience was repeated in Mao's disastrous control of Chinese science where Engels' *Dialectics of Nature* was installed as the guide for, and arbiter of, scientific correctness (Fang Lizhi 1992, 2016).[11]

The pattern is seen in the transition of Creation Science from initially a science, then to bad science, and finally to pseudoscience when proponents simply refused to acknowledge all the overwhelming post-Darwin evidence against the theory (Ruse 2013, Pennock & Ruse 2008). They buried their heads in the sand or went on to the Ark and closed the door. The same judgement, with more qualifications and nuance, could be made about Intelligent Design research which has the appearance of science (measurements, experiments, data collection, conferences, and so on) but ultimately is not science as it prematurely cuts off natural explanations for the purportedly designed elements of nature.

All pseudoscience contains some scientific terminology and content – concepts (such as energy, force, and field are in abundance), mathematics, instruments, recordings, meetings - in order to give the practice credibility. It is of the essence of pseudoscience to appear to be scientific; its 'authority' depends on mimicking science. Science has journals, so pseudosciences commence their own or 'take over' established journals; science has peer review, so pseudoscience has the same; science has numbers and statistics, so pseudoscience has tables, figures, correlations; science has experiments, so pseudoscientists conduct their own; science has meetings and conferences, so pseudoscience does the same, and so on (Shermer 2001). The social and philosophical task is to reliably separate the real from the mimic and the gimmick. The beginning of this task is first to distinguish science from non-science.

Demarcation of Science from Non-Science

Efforts to distinguish science from non-science, the original 'demarcation problem', have been pursued since at least David Hume's (1711-1776) time when in his *Inquiry* he advised that:

> When we entertain, therefore, any suspicion that a philosophical term is employed without any meaning or idea (as is but too frequent), we need but enquire, *from what impression is that supposed idea derived?* And if it be impossible to assign any, this will serve to confirm our suspicion. (Hume 1777/1902, p.22, emphasis in original)

Hume was enunciating his empiricism and using the grounding in sensation as a way of separating 'sensible' ideas from the wide class of others. Ernst Mach (1838-1916), the Austrian physicist-historian-philosopher-educator, took Hume's point seriously and, with recourse to his own philosophical phenomenalism, argued that a whole raft of central scientific concepts – mass, force, absolute space, absolute time, atom, molecule – were not scientific. This because they went beyond their sensory anchors,

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[8] On the scientific research of the tobacco industry see Brandt (2007) and Oreskes & Conway (2010).
[9] Despite this, in September 2023, the 76th Tobacco Science Research Conference was held. It is hard to keep a pseudoscience down; the more so when it is fabulously well funded.
[10] Pleasingly they were at least alive, and not shot or in gulags as were dissenters from the party position.On Lysenkoism, see at least: Joravsky (1970), Roll-Hansen (2005) and Soyfer (1994).
[11] On post-Mao Chinese science and its entanglement with philosophy, ideology, and the Chinese Communist Party, see Miller (1996).

or the observation statements that grounded them (Mach 1910/1992). He famously said that he would 'leave the Church of Physics' if belief in atoms was required for its membership (Blackmore 1989).[12]

Karl Popper (1902-1994) acknowledged the force of Mach's critique, but rather than accept the bulk of orthodox science as unscientific, he proposed in his 1934 *Logik der Forschung*[13] a new demarcation of science from non-science, namely Falsificationism or Testability. Rejecting the Humean/Machian/Positivist experiential confirmatory criterion, he proposed instead:

> But I shall certainly admit a system as empirical or scientific only if it is capable of being tested by experience. These considerations suggest that not the *verifiability* but the *falsifiability* of a system is to be taken as a criterion of demarcation. (Popper 1934/1959, p.40)

Popper addressed this foundational demarcation issue in a 1953 Cambridge lecture 'Science: Conjectures and Refutations' published in his 1963 anthology *Conjectures and Refutations: The Growth of Scientific Knowledge* (Popper 1963). He was adamant that his falsifiability criterion was not meant to separate meaningful from meaningless statements (Hume's project) but scientific from non-scientific statements or systems. There, dismissing the positivist link-to-experience (sensation) criterion as a demarcator of science, he says:

> But this criterion is too narrow (*and* too wide): it excludes from science practically everything that is, in fact, characteristic of it (while failing in effect to exclude astrology). No scientific theory can ever be deduced from observation statements, or be described as a truth-function of observation statements. (Popper 1963, p.40)

And proposed instead:

> One can sum up all this by saying that *the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability*. (Popper 1963, p.37, emphasis in original)

And later:

> A system is to be considered as scientific only if it makes assertions which may clash with observations; and a system is, in fact, tested by attempts to produce such clashes, that is to say by attempts to refute it. (Popper 1963, p.256)

Popper's original concern was to separate and defend good and revolutionary science, as manifest in Einstein's theory of general relativity that had spectacularly, and very publicly, been confirmed by Arthur Eddington's 1919 solar eclipse expedition, from popular belief-systems of the time that were also being enthusiastically embraced: Astrology, Psychoanalytic theory, Historical Materialism. For Popper, each of the latter was a pseudoscience, and his testability criterion was meant to separate them from the real thing.

But falsifiability did not work the way he envisaged. On the one hand, many supposed pseudosciences made claims about the world that could be, and were, falsified – creationist science and astrology, for instance. So, these should be just 'bad' science, not 'pseudo' science. On the other hand, many established sciences made claims that were falsified by empirical evidence, but this did not result in rejection of the theory. So, these should be pseudoscience.

Popper was correct in identifying the *growth* of knowledge as a hallmark of the scientific tradition; a static tradition is not scientific. In a 1961 Presidential Address to the British Society for the Philosophy of Science, he stated:

> My aim in this lecture is to stress the significance of one particular aspect of science – its need to grow, or, if you like, its need to progress. … I assert that continued growth is essential to the rational and empirical character of

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[12] Mach's seemingly antediluvian position can be defended by saying he forsook committed belief in the then current 'plum pudding' picture of the atom that had been advanced by J.J. Thompson. This is an issue for Machian scholarship.

[13] First English translation in 1959, *The Logic of Scientific Discovery* (Popper 1934/1959).

> scientific knowledge; that if science ceases to grow it must lose that character. It is the way of its growth that makes science rational and empirical; the way, that is, in which scientists discriminate between available theories and choose the better one or (in the absence of a satisfactory theory) the way they give reasons for rejecting all the available theories, thereby suggesting some of the conditions with which a satisfactory theory should comply. (Popper 1963, p.215)

Fifty years later, the German philosopher Paul Hoyningen-Huene concurred, writing:

> One of the most astonishing facts about science, especially about modern natural science, is its remarkable growth, both in scope and in precision. Science is a dynamic enterprise through and through. This feature probably best distinguishes science from all other knowledge systems, past and present. (Hoyningen-Huene 2008, p.176

A matter elaborated at length in his later book, *Systematicity* (Hoyningen-Huene 2013).

Consider the 2017 detection of gravity waves for which Barry Barish, Rainer Weiss and Kip Thorne were awarded the 2027 Nobel prize in physics. Since their initial postulation by Henri Poincaré (1854-1912) in 1905 these waves had something of the appearance, or feel, of feng shui's chi waves: they seemed mysterious, there was no obvious indicator for them, and seemingly their only warrant was speculation.

But this piece of metaphysics was different from routine pseudoscience metaphysics: it did not emerge from nowhere, or from textual analysis. Poincaré thought gravity waves had to be a consequence of Lorentz's electron theory; the latter required the former. In 1916 Einstein cemented gravity waves' place on the scientific agenda by showing that they were a requirement of his own General Theory of Relativity; 'ripples in the fabric of space-time' as they have been called. But it was a full century of theoretical and experimental refinement, and finally millions of dollars spent in the LIGO project, before the 'gravity wave' agenda item was approved.

The contrast of gravity wave science with pseudoscience speculation is dramatic. Consider feng shui as an exemplar of the latter. Harry Rolnick, a proponent of feng shui, writes:

> This flow that regulates our lives is an invisible energy known as ch'I (or *qi*). To partake in this energy, we can arrange our inner nature and our outer environment to allow it to flow like water or drift like the wind, and provide us with benefits rather than harm. We cannot control the wind, but we can however arrange our lives so this 'energy' benefits us. (Rolnick 2004, p.9)

Too easily, exponents of pseudoscience resort to a 'mysterium' defense as is well illustrated by the following claim of a feng shui advocate:

> Life is defined by *Qi* even though it is impossible to grasp, measure, quantify, see, or isolate. Immaterial yet essential, the material world is formed by it. (Beinfield & Korngold 1991, p.30)

The mysterium defense is ruled out of science. It might function as a short-term place holder, but it cannot be entrenched beyond that. Failure to find and measure chi in 3,000 years means it is not a scientific concept, yet it is the very heart of the whole feng shui enterprise. It might well have other purposes; and clearly it does so have, but chi and countless other such constructs should not, and need not, be recognized or treated and funded as science.

Despite incessant waving of the science banner, beating of the science drum, and liberal use of scientific terms; despite the significant number of science-trained practitioners; despite employment of instruments such as Meridian Energy Analysis Devices (MEAD) connected to computer monitors – feng shui is not a scientific practice. Further, it is not just poor science, it is pseudoscientific. 'Poor' science suggests it can get better, that if a few things (measurements, readings, data collection) are done more accurately, then feng shui can progress along to 'fair' or 'good' science. It cannot do this because it is fundamentally not science at all; it is outside the scientific pale.

In all of the 3,000+ years of chi-talk and appeals to mysterious energies, there simply has been nothing comparable to what occurred in the scientific proposing of, and search for, gravity waves. It was the continued and deep engagement with science that moved gravity waves from speculative metaphysics to tentative physics and then to being part of the accepted furniture of the world. There is no such movement in the feng shui tradition. Although there is a surfeit of international spread to the four corners, there is no intellectual depth. The same stories, texts, and mantras are endlessly repeated in countless different regions and languages.

A great deal of late twentieth-century philosophy of science has been taken up with problems occasioned by using Popper's testability as a demarcation criterion for science, and with efforts to find other more adequate criteria. Willard van Orman Quine, Thomas Kuhn, Imre Lakatos, Paul Feyerabend, Paul Thagard and Larry Laudan all contributed to this debate.[14] Lakatos thought that his 'methodology of scientific research programmes' did provide a warranted demarcation in the way that Popper's and Kuhn's had failed to do (Lakatos 1970).

The mushrooming, international, billion-dollar feng shui industry, and its related alternative or holistic medicine industry, is an example of the ethical, political, and cultural consequences of failing to identify pseudoscience; or saying that such identification is impossible (Matthews 2019). Being able to robustly identify feng shui as pseudoscience might put some brake on its spread and impact, it might redirect people's monies to effective treatments, in some jurisdictions it might enable conviction for false advertising, or even fraud. And beyond this, familiarity with such identification procedures can engage citizens in a better understanding of the nature of science.

Carl Hempel (1905-1997) offered a list of seven *desiderata* that identified good scientific theories, and which can serve in characterizing good scientific practice:

- A theory should yield precise, preferably quantitative, predictions.
- It should be accurate in the sense that testable consequences derivable from it should be in good agreement with the results of experimental tests.
- It should be consistent with currently accepted theories in its own and neighboring fields.
- It should have broad scope.
- It should predict phenomena that are novel in the sense of not having been known or taken into account when the theory was formulated.
- It should be simple.
- It should be fruitful. (Hempel 1983, pp.87-88; author formatting added)

This account employs a number of criteria to distinguish good theories from not-so-good or poor theories. Indeed, 'marks out of five' can be given to theories on the basis of how well they meet each criterion, with a maximum possible score of thirty-five. Then discussion can occur about 'cut-off' marks for separating good from poor theories or from proto theories. On this account, poor theories can be improved, they can raise their mark by attending to one or other deficiency. This account leaves aside the practice of science and the economic and political pressures on its conduct.

Hempel's *desiderata* are meant to separate good science from not-so-good or poor science. But there comes a point where poor marks indicate something is other than a poor or a protoscience, but it is rather a pseudoscience. Minimally, a zero on the third *desideratum* - consistency with currently accepted theory – is a strong indicator that something belongs to a pseudoscience, rather than being just part of a poor science.

This is, of course, a conservative criterion; it puts something that is entirely inconsistent with best established science in a domain, beyond the pale. There is an element of 'closed shop' here, but it can be justified. Over the span of about 400 years the Galilean-Newtonian Paradigm (GNP) has developed and matured into modern science with all its ontological, methodological, ethical and sociological dimensions. If something is inconsistent with all of these core characteristics, then it may be something, but it is not science; to claim that it is, amounts to it being a pseudoscience.

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[14] For an outline of the arguments and literature, see especially Ladyman (2002, chap.3) and Nickles (2013).

In appraising pseudoscience, it is important to note that good theories, as Hempel characterizes them, are the expected outcome and indicator of good science; but science as an organized, structured, historical-sociological entity, needs further characterization beyond what suffices for the identification of good theory. Extra ontological, methodological and sociological criteria are required; the more so in order to separate science as an historically situated, organized, knowledge-seeking activity, from pseudoscience. For a research group to be called a scientific group, or for it to be pursuing a scientific practice or inquiry, it needs have the following characteristics:[15]

- It should reliably produce a 'quota' of good scientific theories.
- It needs to seek new knowledge and to do research; not be ossified, stand still, and just repeat extant or textbook knowledge. Doing the latter makes it an educational group, not a scientific one.
- It should be constituted as a research community pursuing cognitive goals and committed to finding out new things about the natural and/or social worlds; not just a community sharing beliefs, inquiring into texts, or formulating legislative laws.
- Its members need be trained or certified in such cognitive inquiry; science can be advanced by lay-people, but if no or few members of the community are suitably trained, then the community falls short of being a scientific community.
- It should appeal only to ontologically stable entities in its explanations and theorizing. Reference to 'here today, gone tomorrow' entities - or entities that come in and out of existence depending on who is thinking about them, or for what culture they exist - diminish the scientific status of theories and communities that appeal to such entities.
- It needs be committed to at least pragmatic methodological naturalism as the basis for evidence collection and theory appraisal; appeals to political, ideological or religious authority is simply not allowed. Nor is deference to divine scripture or revelation permitted in justifying metaphysics or defending particular claims. Science simply does not allow such appeals to outside authority.

Most pseudosciences — including feng shui, astrology, phrenology, parapsychology, acupuncture, Mesmerism — fail both the scientific *theory* test and the scientific *organization* test. They lack scientificity.

Rejecting the Demarcation Project

Larry Laudan (1941-2022), in a much commented-upon paper, hoped to bring this discussion to an end with his claim that the demarcation quest was hopelessly and in-principle contentious:

> … it is probably fair to say that there is no demarcation line between science and nonscience, or between science and pseudo-science, which would win assent from a majority of philosophers. (Laudan 1983/1996, p.211)

And further that the efforts were misdirected because they:

> managed to conflate two quite distinct questions: What makes a belief well founded (or heuristically fertile)? And what makes a belief scientific? (Laudan 1983/1996, p.222)

He concluded his paper with the admonition:

> 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. (Laudan 1983/1996, p.222)

Laudan's paper is puzzling. He says that the term 'pseudoscience' is merely rhetorical and lacks specification. Yet two years earlier he published a detailed contribution to the 'Science Wars' (Brown 2001) critical of the Edinburgh Strong Programme, and its pretension to reduce philosophy of science to sociology of science, and rationality to politics by other means. The title of his earlier paper was: 'The Pseudo-Science of Science?' (Laudan 1983/1996). And Laudan there had recourse to a substantive view of pseudoscience

[15] See Bunge (1991a, 2001 chap.8) and Mahner (2013) where these points are elaborated.

that goes beyond just a banner headline. He rejects in its entirety David Bloor's, and the Strong Programme's, key work *Knowledge and Social Imagery* (Bloor 1976/1991), saying:

> … one must regard his [Bloor's] efforts at legitimation by assimilating himself to the scientist as rhetorical window dressing and nothing more than that. As for my calling his approach 'pseudo-scientific', the label comes to seem increasingly appropriate. A pseudo-scientist is, after all, one who claims himself to be a scientist but who is unable or unwilling to indicate what is scientific about his beliefs and his modus operandi. (Laudan 1981/1996, p.207)

Why two years later, 'pseudoscience' is relegated to mere rhetoric is not made clear.

Independently of Laudan, Roger Cooter, a historian, also argued that the label 'pseudoscience' has no epistemological value. For Cooter, it has only rhetorical value:

> … it would be preferable to have the term 'pseudoscience' replaced in our vocabularies with something like 'unorthodox science' or 'non-establishment science'. (Cooter 1982, p.138)

Another historian, in writing of the Velikovsky Dispute, makes the same claim:

> 'Pseudoscience' is an empty category, a term of abuse, and there is nothing that necessarily links those dubbed pseudoscientists besides their separate alienation from science at the hands of the establishment. (Gordin 2021, p.206)

Cooter argued for his case on social constructivist grounds, maintaining that all knowledge claims are the result of social negotiation in which truthfulness or falsity do not play a determining role; the rise and fall of theories reflect differences in social and cultural power. Truth tracks power. Attaching labels is a matter of ideological contention and the label's purpose is to either hide or serve social interests. So, the label 'pseudoscience' simply indicates 'sociopolitical deviance' (Cooter 1982, p.137). Earlier he had written that whenever the label 'pseudoscience' is used, it is in the service of 'conserving social interests' (Cooter 1980, p.237). This because:

> … since all knowledge of external nature is made by men and socially constructed, the identification and criticism of any particular body of knowledge as 'pseudoscientific' must count as a defence of some other body of knowledge. (Cooter 1980, p.259)

Cooter's papers are a contribution to social constructivist history[16] that was energized by the philosophical claims of the Edinburgh Strong Programme. The founders of this programme were Barry Barnes, David Bloor, Harry Collins, Bruno Latour, and Stephen Woolgar who all explicitly appealed to Thomas Kuhn's account of science in order to get their programme off the ground (Matthews 2004, 2022b).

The strong programme predictably energised constructivism, relativism, and multiculturalism in education. It gave succor to those arguing for the public funding of Alternative Medicine research and the establishment of Non-Traditional Medicine departments in universities (Hermes 2018). After all, if scientific theories are a 'front' for social forces, then all such fronts should be equally supported, with perhaps affirmative action for rejected theories and poorly supported programmes. The strong programme has been thoroughly criticized, including by Kuhn (Kuhn 1991/2000).[17]

Against Cooter, the later Laudan, and all other social constructivists who reject the use of 'pseudoscience' on account of its rhetorical function, it needs be recognized that labels can have both rhetorical *and* epistemological functions; to acknowledge a rhetorical function is not to say that the term has no epistemological import; to say that some analysis supports a particular social group, is not to say that the analysis is not correct, true, or constitutes knowledge. To say of a football team that it is 'excellent' is to

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[16] For scholarly and tightly argued refutation of this historicist programme, see Wootton's *The Invention of Science* (Wootton 2015). The book is reviewed at length in Matthews (2017).

[17] For critiques of the strong programme see, among many: Brown (2001), Bunge (1991b, 1992), Nola (1991, 2000) and Slezak (1994a, b).

support the team but at the same time, its use makes claims about the competence of the team. That part of the claim can be appraised in standard public ways; namely, do they win games?

The theory of global warming might support the renewable energy lobby, but that does not mean it makes no truth claims, or that its claims are false or compromised. Appraising of those claims can be detached from appraisal of the political claims; the two appraisals are orthogonal.

Laudan's philosophical argument against demarcation, and for the merely rhetorical function of 'pseudoscience', gained the assent of the majority of philosophers of science; not just the assent of the more general scholarly or educational constructivist community who could be expected to readily embrace it as Laudan was 'speaking their language'. Constructivists were very happy to hear prominent philosophers saying that 'everything is science; it is only politics, ideology, or culture that makes distinctions for their own purposes'.

This view, of course, was well received by Creationists and Intelligent Design advocates who were outraged at Judge Overton's ruling in the US 1981 *McLean vs. Arkansas* trial that Creationism was not scientific, and so had no place in US classrooms (Ruse 1988). Also happy with Laudan were proponents of multicultural science, specifically those wanting to recognise ethno-sciences not just as 'traditional' science or IKBD (as explained above), but as science proper and consequently warranting ethno sciences having a place in school and university science programmes, not just included to illustrate non-science or pseudoscience.

Reviving Demarcation

Although many philosophers concurred with Laudan's arguments on the problems of demarcation, not all did so. Robert Pennock was one among many defending demarcation in the Humean-Popper tradition:

> Because Laudan's and Quinn's discussions of demarcation, which can only be described as histrionic and ill-considered, and those of their careless imitators continue to muddy the waters to the detriment of both science and philosophy of science. (Pennock 2011, p.180)

Other philosophers felt the same way, and engaged in careful, informed and detailed refutation of Laudan's arguments.[18] His obituary for demarcation was premature. Mario Bunge provides both a broad and detailed account of the requirements for any cognitive field (that is, any inquiry generating putatively true or false propositions or theories) to be scientific (Bunge 2001 chap.8). His account subsumes the central theses brought forward by different contributors to the Laudan debate.

For Bunge, a mature science has ten features:

- A community (C) of appropriately trained inquirers with recognized public means of information exchange.
- A general outlook or philosophical background (G) that includes an ontology of discernible things, a realist epistemology, and an ethos supporting the free search for truth.
- Its domain of investigation (D) is real events and processes in the world, not texts and not ideas, though, of course, the latter are utilized.
- Its formal background (F) is a collection of current best logical and mathematical theories about D.
- Its specific background (B) is a collection of up-to-date and reasonably well confirmed data, hypotheses and theories from other fields relevant to F.
- Its problems or puzzles (P) consists of cognitive rather than practical matters concerning items and events in D, being usually a quest for laws.
- Its fund of knowledge (K) is a collection of up-to-date and testable (though not final) theories, hypotheses, and data compatible with B.

[18] See at least: Bunge (1991a, 2001, chap.8), Butts (1993), Derksen (1993), Ladyman (2013), Mahner (2007, 2013), Pennock (2011), Pigliucci (2013), Shermer (2013), most of the 23 contributions to Pigliucci & Boudry (2013), and the 15 contributors to Boudry & Pigliucci (2017).

- Its aims or goals (A) are the discovery of laws or confirmed hypotheses about elements of D.
- Its methods (M) consist exclusively of scrutable, checkable and justifiable procedures; there need not be commitment to a single method.
- It has a significant overlap (O) with other scientific fields of inquiry such that there are overlaps in the respective G, D, F, B, P, K, A, M sets. A mature science does not exist in cognitive isolation from other mature sciences; they learn from and feed off each other.[19]

Each of the ten features, or attributes, are definitive of science. The absence of any one suggests the field of endeavour is not a scientific one. The final feature (O) is especially important for Bunge. He regards both the natural and social worlds as ontologically systematic and emergent; everything existing thing is part of a system and is interrelated. Biological entities, cells and brains, are not just biological, they need be studied by chemistry and physics, and for the latter by psychology (Bunge 1979). If an intellectual endeavour is not learning from related sciences, it is probably pseudoscience, not science.

Pseudoscience as a Warranted Category

Different philosophical, sociological and political indicators or markers of pseudoscience have been advanced. Pseudoscience can be identified by working through each of Bunge's foregoing ten identifiers of mature science and taking their negation as a mark of pseudoscience.

Sven Hansson provided another such list whereby a corpus of belief and practice can be judged pseudoscientific in as much as:

- There is overdependence on authority figures.
- Unrepeatable experiments are too frequently adduced.
- Data selectivity, or cherry-picking of evidence is too common.
- There is an unwillingness to seriously test claims and predictions.
- Confirmation bias is endemic and disconfirmation is neither sought nor recognized.
- Some explanations are changed without systematic consideration. (Hansson 2009)

And additionally when:

- They make claims about events and mechanisms in the natural world.
- The claims cannot be epistemically warranted, yet effort is made to show their scientificity.
- They too easily resort to auxiliary hypotheses to insulate claims from empirical refutation. (Hansson 2009)

A further sociological characteristic can be added to Hansson's list:

- The practice makes scientific claims but refuses to engage with the scientific community by publishing in established research journals and presenting at research conferences.

The Bunge and Hansson lists provide a working template for judging putative pseudoscience.

Pseudosciences violate the fundamental principle that 'no science is an island sufficient to itself'. All genuine scientific endeavours, and disciplines, have contact with their neighbours. Without contact there is no science. More than contact, they need to accommodate adjacent sciences. This is what drives the cross-over or interdisciplinary sciences: biochemistry, electrochemistry, geophysics, paleoanthropology, physicalchemistry, and so on. Intellectual isolationism is a key marker of pseudoscience.

In the middle of the nineteenth century, a few years before publication of Darwin's *Origin* and in preparation for his appointment as the founding President of the Catholic University of Ireland, John Henry Cardinal Newman articulated this core philosophical, or more accurately, epistemological commitment. The growth of knowledge was a communitarian enterprise; the branches of knowledge, the disciplines, were interrelated; they had to attend to, learn from, and be reconciled with each other. Newman rejected the

[19] These defining features of science are elaborated in Bunge 2001, chap.8.

'Silo' view of knowledge and academic life; he did not want that entrenched in his new university (Matthews 2021, pps. 45-48). Contra to contemporary NOMA advocates, Newman wrote:

> I have said that all branches of knowledge are connected together, because the subject matter of knowledge is intimately united in itself, as being the acts and work of the Creator. Hence it is that the sciences, into which our knowledge may be said to be cast, have multiplied bearings one on another, and an internal sympathy, and admit, or rather demand, comparison and adjustment. They complete, correct, balance each other. (Newman 1852/1959, p.127)

Reiki Therapy

Consider, for example, Reiki therapy. The US Wellness Institute declaims:

> The Reiki practitioner is the conduit between the patient and the source of the universal life force energy; the energy flows through the practitioner's energy field and through her hands to the patient. . . . [She] places her hands in specific energy locations . . . [the] length of time determined by the flow of energy through her hands. . . . The patient experiences the energy as sensations such as heat, tingling, or pulsing where the practitioner has placed her hands. Sometimes, the sensations are felt moving through the body. HERE

This description abounds with scientific words, and careful procedures, but none of the extraordinary Reiki claims about mechanisms have ever found support in a laboratory. Indeed, they are inconsistent with science as they violate the fundamental conservation of energy principle. The violation is even more obvious when the busy, or fastidious, therapist uses 'at a distance' therapy where the patient is not touched, but the therapist's hands are merely moved over the putative energy center or zone.

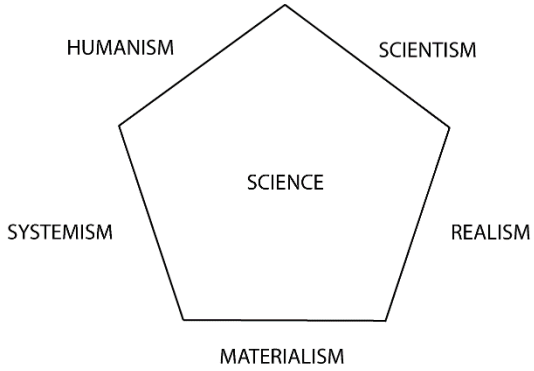
Not surprisingly, there are millions of web sites (13 million results in 0.3 seconds for REIKI SUPPLIES) selling Reiki Charkra pendants, stones, bracelets, rings and anything else that will separate a gullible citizen from their hard-earned dollars. For a fee, the Wellness Institute also offers instruction in Craniosacral Biodynamics, Polarity Therapy, NeuroEnergetic Therapy , Heart-Centered Hypnotherapy, and much more. People line up to transfer money to these operatives.

One commentator opines: 'Reiki is the hottest new Eastern healing practice making its way into the Western health industry' (Sacks 2014). A decent science education that attends to pseudoscience might well prepare students for the arrival of this 'hottest' newcomer. It might also prepare government and insurance bodies for the predictable demands to pay the cost of Reiki treatment from the public purse.

Cultural Ecology of Science and Pseudoscience

Science is not just the product of any thinking head, or even of a thoughtful and hard-working scientist. Science always occurs in a social-cultural-economic-technological context which has its own conceptual and philosophical characteristics. This is precisely the Enlightenment understanding of science mentioned at the beginning of this essay. It is the recognition underpinning the totality of Science-Technology-Society (STS) scholarship (Ziman 1968, 1980) and, more lately, Cultural Studies of Science research (Matthews 2023).

For Bunge, historical, sociological and philosophical studies of science show that for science to flourish, five important components are required in its social and intellectual environs. He calls this the 'conceptual ecology of science' and represents it as a pentagram (Bunge 2012, chap. 2).



Ecology for Scientific Progress (Bunge 2012, p.28)

Humanism/Commercialism. Scientists need to promote human welfare; not misery, business advancement or political advantage. The latter purposes more easily lead to corruption of science (witness Nazi Germany, Stalinist Russia or current 'big business' tobacco, oil and pharma science). But there are also less visible effects of commercialization on academic and industry research. These are effects that impact on directions of research, constriction of 'public knowledge' and access, the reward system in science and universities, communitarianism in science, and other considerations.[20] There can and should be applied science, but it ought be for human welfare and improvement.

Systemism/Compartmentalism. Competent well-informed scientists recognise that there are no isolated events, mechanisms, or problems in the world. Structures and events are parts of systematic causal wholes. John Donne famously wrote that 'no man is an island', so also no event, personal action or social movement is a causal island; and no science is an island. Consequently, good science generates cross-disciplinary research fields: geophysics, astrophysics, biochemistry, astrochemistry, social psychology, molecular biology, psycholinguists, economic history, political economy, and so on. Because they do not emerge from science, hybrids as astropsychology or creation science are just pseudolabels.

Materialism/Spiritualism. Scientists seek for causes and explanations in the kinds of things and mechanisms that are within the accepted ontology of science. A materialist ontology is informed by science, hence gravitational and electrical fields are material though not physical. *Methodological Naturalism* can satisfy this requirement, but evocation of *spiritualism, supernaturalism, occultism,* or *tradition-based* entities violates it.

To the degree that a society believes that the gods, spirits or the occult are responsible for earthquakes, then money for geophysical research will be limited; to the degree that societies are fatalistic, believing that 'everything happens for the better', then material steps for prevention, and remediation, of disaster will not be undertaken; where illness is seen as the consequence of spirit possession, then medical science does not develop; and so on.

Individuals can be spiritual without believing in or practising spiritualism; the latter involves belief in the intervention in worldly processes of spirits, supernatural entities, or the occult, and this impedes the growth of science. Modern science was created by Christian believers much of whose work was dependent on achievements of Islamic science. Religious scientists of all faiths contribute to the advance of modern science. But these contributions were dependent on adoption, explicitly or implicitly, of methodological naturalism in their science.

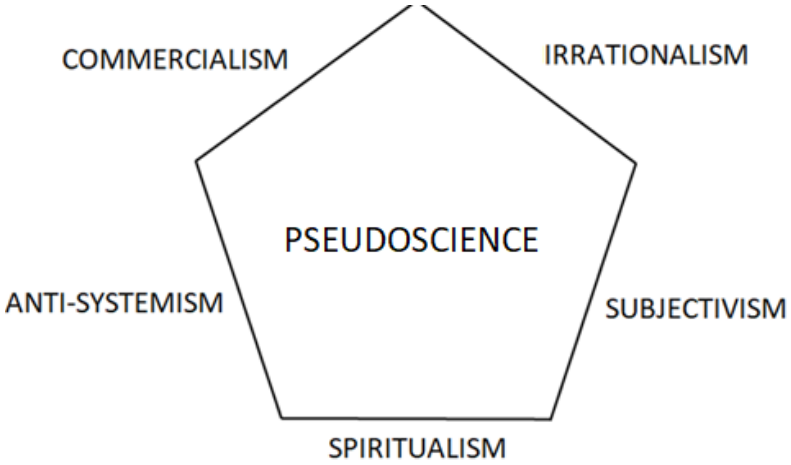
Realism/Subjectivism. Scientists recognise that there is an external world independent of human consciousness or experience; science attempts to provide knowledge of such a world; and these attempts are partially successful. Our concepts and theories are human creations, but the reality they conceptualise or explain is not a human creation. The external world judges the efforts of scientists to understand it; good theorising is not just what is acceptable to the prevailing of local or wider political power. Witness the ultimate collapse of Church-backed Ptolemaic astronomy, Nazi-backed German blood science, or Soviet

[20] On this, see contributions to Irzik (2013).

Communist Party-backed non-Mendelian genetics, or Maoist dialectical straight-jacketed cosmology during the ten 'abnormal' years of the Cultural Revolution (1966-76).

Scientism/Irrationalism. Scientists believe that science is rational, indeed it provides a model for social rationality; further, Enlightenment-influenced scientists believe that scientific methods are applicable outside the laboratory and are the only way in which knowledge of the world and society is attained. Without this commitment, social and cultural problems are addressed in wholly ineffective ways: praying for the end of Middle East conflict can be a comforting cultural engagement, but it can shed no light on the conflict, its history, or its remediation. Prayer might motivate such investigation, but equally it can, and often does, by-pass a naturalistic and scientific investigation.

For any society, to the degree that the first member of the above couples is maximised, then science can flourish. To the degree that the second member is elevated, then the society allows and promotes the growth of pseudoscience (Dawes 2001). So, we have:



Conceptual Ecology for Pseudoscience (Bunge 2012, p.33)

In societies and cultures where spiritualism, non-systematism, commercialism, irrationalism, and subjectivism (phenomenalism or instrumentalism) prevail, then science cannot thrive, but pseudoscience surely can and does.

The USA Example

Contemporary USA provides a case study for Bunge's claim about the supportive role of Commercialism, Irrationalism, Subjectivism, Spiritualism and Anti-systematism in the ecology of pseudoscience.

Despite all the money spent on education, study after study, report after report, catalogue the dismal US science literacy. A 2007 study deemed '216 million Americans are scientifically illiterate' (Duncan 2007). The National Science Board Science and Engineering Indicators (2014) document this dismal state of affairs. The Board's reports detail the progressive acceptance in the USA of astrology as a science. From one-third in 2010 to over one-half in 2014 (Kozak 2019).

In the US, spiritualism is pervasive. God and Gods are evoked everywhere, including on dollar bills; and for every purpose, including the killing of declared enemies, the prevention of natural disasters and the amelioration of their effects. Megachurches, attended by tens of thousands of joyful, clapping, singing congregants, are common; televangelism, with countless in-studio and at-home pay-for-a miracle

programmes appear 24/7 on TV and cable networks; bookshop aisles and websites are filled with paranormal, alternative, and esoteric literatures.[21]

At the present time in the USA, anti-systematism is routine: Life is compartmentalised; people live in cultural silos; a general or liberal education is progressively harder to get; specialisation is the academic norm; there are career, funding and disciplinary barriers to cross-disciplinary research. The much-embraced NOMA bandwagon launched by Stephen Jay Gould formalised the separation of science from other disciplines, specifically theology (Gould 1997). Supposedly, they cannot judge each other. But if theology makes claims about the world, then the claims can, and need be, judged by science.

Commercialisation and money-making is a preoccupation of dominant US groups; if this was not their preoccupation they would not be dominant. Commercialisation is captured in everyone's image of Wall Street, where excess, self-interest and pursuit of the bottom line is just normal business activity. It is equally captured in the Walmarting of hundreds of towns where whole downtown business and residential communities have been destroyed by the Walton family's pursuit of extra millions of dollars being spent in their own edge-of-town megastores.[22]

Powerful mining, agriculture, transport, tobacco, media, sporting and oil interests have always put commercial interest above community and environmental interest. Former president Trump rode US commercialisation all the way to the White House.

The malignance of commercialisation goes beyond the elevation of profit over social interest; this is at least objective, public and debatable. Worse, it is giving epistemological warrant to commercial interest. This is what was so depressing about the 'scientists for hire' and 'research for sale' realities in the tobacco and oil industries that was so well documented by Oreskes and Conway (2010).

Truth is bent or just invented for commercial interest. This mirrors the same degrading of truth for political, party, ideological, and religious interests that has been well documented by historians and sociologists. If truth claims about the world are not settled, ultimately, by reference to the world, then obviously the claims need to be settled by other considerations.

Irrationalism is now a respected and examined subject in US universities.[23] Whole faculties and colleges have been given over to promotion of irrationality. Universalism is everywhere rejected in favour of gender-, race-, religious-, political-, sexual-, economic-, and cultural- localism. Varyingly called Identity Politics. Supposedly, all truth is local, all rationality is local, all ethics are local. Anti-rationalism in the guise of postmodernism, is the Philosophy Department, Cultural Studies Department, and College of Education norm.

The tension, if not contradiction, between localism and rationalism is seldom explored; their consistency is assumed. But how local can rationality be before it becomes irrationality? And what features can be identified to define the local?

Husserl, Kuhn, Feyerabend, Heidegger, Derrida, Latour, Lyotard, Irigaray, Barnes, Collins, Pinch, Harding, von Glasersfeld, Giroux, and others are among the most read and most cited authors in sociology,

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[21] Kurt Andersen's *Fantasyland* (2017) provides extensive, if disheartening, documentation of the 500-year history of what counts as spiritualism in the USA. Parts of the Roman Catholic and Protestant traditions do their best to separate themselves from this spiritualism which they see as commercialized, corrupt, and theologically heretical. It might well be better deemed 'pseudospiritualism'.

[22] Apart from numerous books, the 2005 Robert Greenwald documentary, *The High Cost of Low Price*, well captures the Walmarted experience of the USA.

[23] David Stove provides a nice, informed and witty introduction to how irrationalism took root in contemporary philosophy of science (Stove 1982).

education, philosophy, and humanities programmes.[24] Senior figures in science education routinely advance outrageous and discredited positions, and are cheered and awarded for doing so.[25]

A steady diet of the above authors does have an effect on education, and most other things dependent on clear thinking. The enormity of the Sokal Hoax is testament to the diet's effect in academia (Sokal 2009). The hoax has been successfully repeated across many disciplines. Contrived nonsense has been peer-reviewed and passed off as disciplinary research.[26] That the former president of the United States can say that 'truth does not matter', and that his agents can say 'there are alternative realities' speaks to its down-stream effect in society and politics.[27]

Subjectivism and empiricism are deeply entrenched in US culture and academies. Epistemologically these are the claim that the test of truth is how things appear to the individual; individual experience, either sensation or ideational, is the epistemological bottom line. Hence the intellectual ground is prepared for when former president Trump says that no matter what his experts advise, he goes with his 'gut feelings'. Citizens nod their head on hearing this. In one book by a leading science educator, the personal pronoun occurs 96 times on one page, and it is not an autobiography. This level of narcissism and self-absorption flows easily from subjectivist and empiricist doctrine.

The empiricist doctrine is profoundly anti-scientific. The whole history of instrumentation in science is the history of making inter-subjective appraisals of temperature, heat, speed, duration, pressure, pulse rate, rain fall, voltage, wind speed, weight, and so on (Crump 2001). Objective, impersonal, non-subjective measurement is a precondition for science. Dispute about how hot a cup of water is, is settled not by comparing experiences, or taking a vote, it is settled by placing a thermometer in the cup.

At every step, progress in science has meant the overcoming of everyday experience. Galileo recognised this in his 1623 *The Assayer* essay where he makes his primary/secondary qualities distinction. This was the core message of Wolpert's book *The Unnatural Nature of Science* (Wolpert 1992). The book should have been more attended to by the 'learning by inquiry' movement in education. When a dash of Kant is added to empiricism, reality becomes the unknowable 'thing in itself'. With just the slightest extra intellectual nudge, even this disappears, and we are left with ontological idealism: there is no reality, just our experience.

Subjectivism was turbo-charged in the 1920s by the common, but mistaken, Copenhagen interpretation of quantum theory. Niels Bohr and Werner Heisenberg were among the first to bring the observer into measurement processes at the quantum level and thus to make physics subjective. Although rejected by Einstein, the Copenhagen Interpretation became for decades the norm in physics; it was advanced by von Neumann, Wigner and countless senior figures and textbook writers. In the Anglo-world it was popularised by two knighted physicists Sir James Jeans and Sir Arthur Eddington. Jeans, in a widely read and influential book, wrote:

> As the subject developed, it became clear that the phenomena of nature were determined by us and our experiences rather than by a mechanical universe outside us and independent of us. (Jeans 1948, p.294)

One can imagine the enthusiasm with which such claims were, and still are greeted. They gave a scientific green light for every imaginable brand of idealism, mysticism, obscurantism, and gender-, race-, class-, cultural-, localism. The philosopher David Mermin opined that quantum physics has taught us that 'the Moon is not there when nobody looks' (Mermin 1981, p.405). Copenhagen subjectivism, though in

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[24] On the inroads, if not capture, of universities by irrationalism see contributions to Gross, Levitt & Lewis (1996), Koertge (1998), Kurtz & Madigan (1994).

[25] The corpus of work in cultural studies in science education provide many examples of these inroads in science education (Matthews 2023).

[26] See Wikipedia tabulation **HERE**.

[27] A good and informed account of the attack on truth in both the academy and society is *Respecting Truth* by philosopher and social scientist Lee McIntyre (2019).

retreat among physicists and philosophers (Hobson 2019), is still being repeated at the highest levels in science education.

Consider the following:

> science as public knowledge is not so much a "discovery" as a carefully checked "construction" … and that scientists construct theoretical entities (magnetic fields, genes, electron orbitals …) which in turn take on a "reality" (Driver 1988, p.137).

And:

> …For constructivists, observations, objects, events, data, laws, and theory do not exist independently of observers. The lawful and certain nature of natural phenomena are properties of us, those who describe, not of nature, that is described. (Staver 1998, p.503)

Such idealist, anti-realist, subjectivist claims are made from the podium at international science education research conferences where they are met with generous clapping, if not standing ovations. Critical realist-informed comment is rarely heard, and less rarely published in education.

But beginning with Einstein there has always been substantial scientific and philosophical opposition to this scientific epistemological and ontological subjectivism. Susan Stebbing was among the first philosophers to voice criticism (Stebbing 1937/1958). At the core of Mario Bunge's philosophical project has been the rejection of subjectivism, phenomenalism, instrumentalism, and positivism in physics and, on the contrary, the defence of realism. As he writes in his autobiography:

> I believe that my main contribution to physics has been my book *Foundations of Physics* (1967), which had a strong philosophical motivation. This was my attempt to prove, not just state, that quantum and relativistic theories are realistic (observer-free) and that their subjectivist (observer-centered) interpretations are illegitimate philosophical grafts. (Bunge 2016, p.406)

He points out that none of the founders of quantum mechanics practised the subjectivism they preached:

> In fact, when calculating energy levels, transition probabilities, scattering cross-sections, and the like, all quantum physicists assume tacitly that no reference to the measurement device, much less to the observers' mind, occurs in their calculations. (Bunge 2006, p.68)

Many philosophers and physicists share Bunge's critical estimation of both epistemological and ontological subjectivism in physics.

The foregoing elaborations from the USA of the ecological pentagram for science and pseudoscience can be made for all societies and nations. And more detailed mechanisms can be described for the effects of each of the five cultural factors in the pentagram. The claim is that movement up or down of each of the five factors influences the growth of science or supports the proliferation of pseudoscience in communities and nations.There is a potential international research programme. The US biologist Michael Zimmerman correctly, if depressingly, observed:

> The problem is less that most Americans share no solid grasp of a body of scientific 'knowledge' (although many surely do not) than that they have a complete misunderstanding of the nature, processes, and purposes of science. Americans lack the critical capacity to distinguish real science from pseudoscience. … What we have is a public largely anxious to jump to supernatural and so-called alternative conclusions. (Zimmerman 1995, pp.14, 15)

Conclusion: Educational Responses

Pseudoscience beliefs in society, and in classrooms, present not so much a problem for teachers as an opportunity (Preece & Baxter 2000, Turgut 2011, Matthews 2018, Wilson 2018). Their considered, informed and appropriate examination in classrooms is a way for students to learn about the nature of

science and other important social processes. These might include the impact of marketing, the cultural determiners of gullibility, and so on.

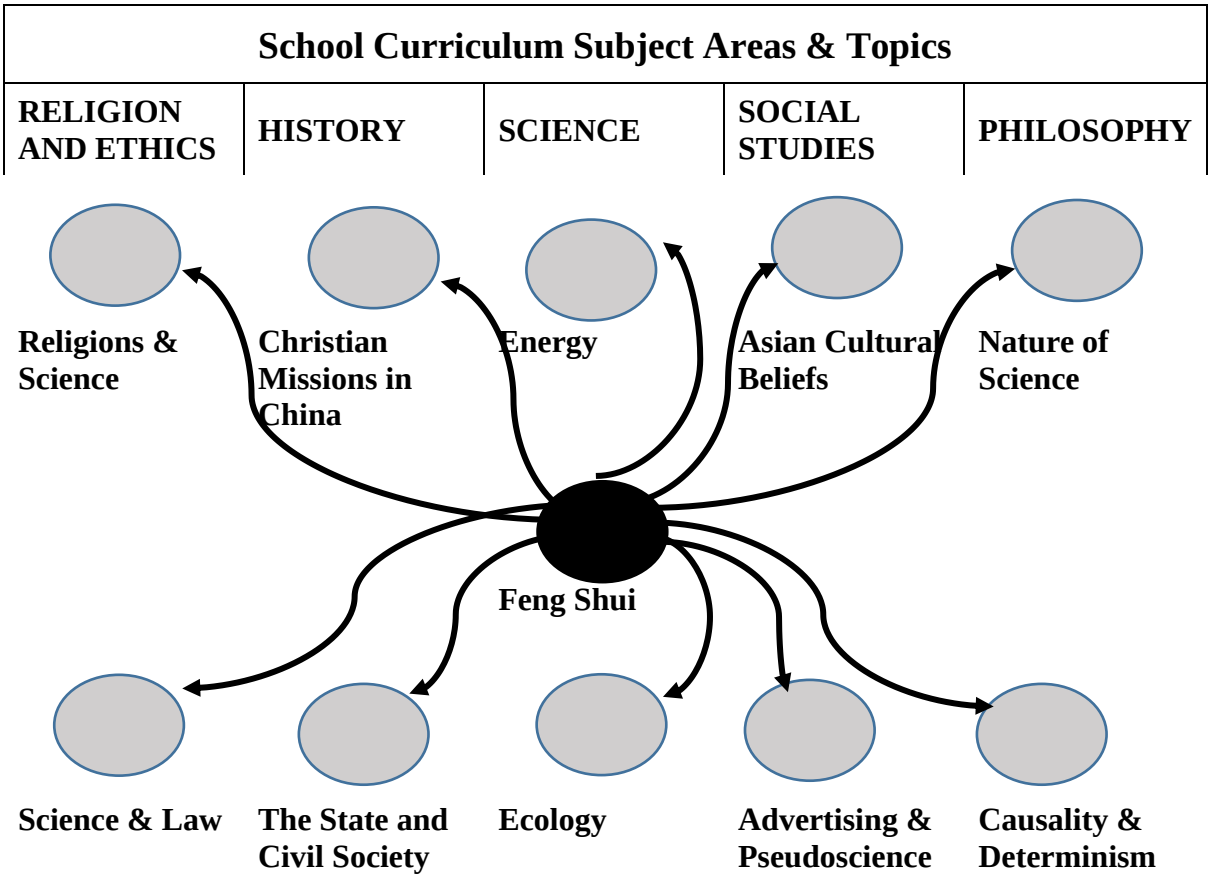
Students can volunteer possible or borderline pseudosciences. Some might be topical or newsworthy. Teachers or students can show how most of the proffered examples will violate all constitutive and procedural components of science. Pseudoscience ontology is evasive, ill-determined and unbound; its epistemology is empiricist and subjectivist. Such analysis can be science education's contribution to the cultural health of society.

Cultural health is inversely related to the degree that gullibility, credulity, superstition, and unwarranted beliefs prevail in the society. Where the latter are common, the former is uncommon. Chinese people need only think of the Cultural Revolution to have this truth driven home, while US citizens need only reflect on the first election, and possible re-election, of Donald Trump to receive the same lesson.

The quality of such learning will depend on the quality, sensitivity and informedness of the teaching. At all points of classroom examination of any pseudoscience, the issues should be problematized, questions asked, claims examined, and alternatives investigated. Little is gained by a didactic, catechism-like approach to the issues. This is the deadening catechism approach to religion so frequently taken by evangelists for religion in all religious traditions. The approach was shared by opponents of religion in Soviet and communist-states.

Over time, and by engagement with problematic aspects of any pseudoscience, the strengths and advantages of a scientific outlook should become apparent to students, along with appreciation of the methods and achievements in non-scientific intellectual and cultural domains.

Consider just the case of Feng Shui being examined as a pseudoscience in a school programme. The ideal liberal approach could look as follows:



Feng shui can with ease be linked to relevant topics across the broad liberal curriculum (Matthews 2018, 2019). The same template could be utilized with many putative pseudosciences so linking them with topics in other school subjects (Turgut 2011).

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