SCIENCE AND MĀTAURANGA MĀORI

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Abstract

What is the relationship between Mātauranga Māori and science? We discuss how the former has grown with support through Government policies and university research funding sometimes in a way that makes it an alternative to science. In section 2 we examine a number of different conceptions of Mātauranga Māori, including moderate and more radical forms. Its advocates propose no agreed definition but offer a wide range of different characteristics which we attempt to evaluate. Section 3 investigates six different uses of the word 'know' which characterise both Mātauranga Māori and science and which highlight important differences between them. Section 4 investigates some of the claims made in four scientific papers which incorporate Mātauranga Māori elements. However the testing of hypotheses remains a central aspect of the methods of science with which Mātauranga Māori is not involved. Section 5 considers the legal rather than scientific claims that are often made concerning intellectual property rights. The final section considers the ways in which science has developed a reliable set of methods of investigation which are universally applicable to any hypothesis proposed by anyone and which has as an aim (amongst others) the discovery of truth. Mātauranga Māori may help itself to some of these attributes of science, but it cannot replace science as a way of testing hypotheses and pursing truth.

Keywords

Mātauranga Māori, science, knowledge, belief, hypothetico-deductivism, methods of science, testing.

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In some countries, there has been a move to incorporate indigenous knowledge into government science policies, typically justified as a reaction to the colonisation of native peoples. This includes New Zealand, where Māori knowledge (Mātauranga Māori) has been progressively added to policies for growth, industry, and science. Here, we examine the relations between Mātauranga Māori and science, and conclude that while Mātauranga Māori has much to offer in terms of culture and values, it also subverts those aspects of science—namely objectivity, universality, and dedication to progress—that can further advance the understanding of nature and help find solutions to the major problems afflicting the planet. At a time when acceptance and understanding of science are at a low ebb, indigenisation of science can only weaken its effectiveness, to the detriment of all, including indigenous cultures themselves.

1. The Politics of Mātauranga Māori

On the whole, science is one of the most successful human endeavours, underlying the extraordinary material and social progress over the past three centuries. Some of its main rivals include religious movements established in different parts of the world; but these have diminished in the face of the global advance of science. Also, science is not without its sceptics and critics who would weaken, and even reject, the claims and methods of science and its technological applications. The clamour of the anti-vaccers, the climate-change deniers, the footpath lichen eaters, and the 'alternative fact' claimants are impossible to ignore. In a recent article in the *New York Times* on the measles epidemic in the United States and the rise of anti-vaccination sentiment, a prominent expert on infectious diseases is quoted as saying: "Science has become just another voice in the room. It has lost its platform. Now, you simply declare your own truth."[2] If this is so, then science has lost its authority as a system of knowledge and as a way of getting it.

On a larger scale, there have been those who adopt competing worldviews, including those of religion, mysticism, or the many different, often incompatible, ethnic traditions to be found in the world. In this paper we consider one example of these, Mātauranga Māori, which is prominent in New Zealand and was formally introduced in the government's Vision Mātauranga policy in 2005. The stated aim of the policy is "to unlock the innovation potential of Māori knowledge, resources and people to assist New Zealanders to create a better future" (Ministry of Research, Science and Technology 2007: 2). It is to be achieved

by fostering connections between Māori, government, the science system and industry, and by providing support for the development of iwi-led research and development strategies. Vision Mātauranga is now deeply embedded in New Zealand's research institutions. The Ministry of Business, Innovation and Employment includes Mātauranga Māori among its investment priority areas, as do Crown Research Institutes.

It also has implications for basic research. Applicants for funding from the Marsden Fund of the Royal Society of New Zealand are asked, under the heading Vision Mātauranga, whether their research has relevance for Maori, or involves Maori. If so, they are expected to undertake appropriate consultation with Maori, and to indicate which of the four Vision Mātauranga themes can be associated with their research: Indigenous Innovation (economic sustainability), Taiao (environmental sustainability), Hauora/Oranga (health and social wellbeing), and Mātauranga (indigenous knowledge). Our universities have strategies to include Vision Mātauranga and their ethics committees and funding bodies monitor the research to ensure that it adheres to the strategy. It has become common for various university faculties, including science faculties, to urge lecturers to include Mātauranga Māori in lectures and research. Recent examples include an advertisement for a Mātauranga Māori lecturer in Zoology at the University of Otago, and the appointment of a teaching fellow to teach Mātauranga Māori at the University of Auckland. The Faculty of Education and Social Work at the University of Auckland includes among the priorities in its *Strategic Direction 2020-2028* to "Serve and advance mātauranga tangata whenua (knowledge), aspirations and tino rangatiratanga (self-determination)."

The case for incorporating Mātauranga Māori into New Zealand science gained special impetus late in 2019 with two publications in prominent New Zealand science journals. One was a supplement of the *Journal of the Royal Society of New Zealand* entitled "Ngā Ahua o te Ao Hurihuri - Rethinking our shared futures," and the other a special issue of the *New Zealand Science Review* entitled "Mātauranga and Science." The latter includes a proposal entitled "Towards building an indigenous science tertiary curriculum," with 16 authors, among whom 13 claim tribal affiliation, and might be considered a blueprint for the development of science faculties in our universities.

The move to include Mātauranga Māori in educational and research policy appears to have been acclaimed with near unanimity. There have nevertheless been pockets of dissent. In a review of Linda Tuhiwai Smith's (1999) book *Decolonising Methodologies*, often considered the founding document for Māori research initiatives, the late historian Peter

Munz (1999) is critical of the proposal for indigenous methodology, on the grounds that it is a "closed" system, in contrast to the "open" system normally practised in academia. Matthews (2015) warns of the danger of allowing science and education to be tied to institutional or political power, giving such examples as Thomism in the Roman Catholic Church, Marxism in the Soviet Union, and National Socialism in Hitler's Germany. He goes on to write that "the same situation pertains when custodians of traditional belief systems control what can be thought and taught in traditional indigenous cultures (*ibid.*, 361)." Critiques directed more specifically at the introduction of indigenous Māori systems into the education system are offered by Openshaw and Rata (2008) and (Rata 2012, 2017, 2019).

2. Various Accounts of Mātauranga Māori

Mātauranga Māori has a long history. The document on Vision Mātauranga (Ministry of Research, Science and Technology 2007) notes that Maori knowledge has accumulated in New Zealand over the past 600 years (though some must have come with the initial migration to New Zealand). It was oral-based until the encounters with Europeans in the 18th and 19th centuries. The document also says: 'Scientific knowledge has superseded traditional Māori knowledge in many ways, however, Mātauranga Māori contains suggestions and ideas that may yet make a contribution to RS&T [Research, Science and Technology].' (p. 16). Let us call the view expressed in the second half of the sentence the *moderate* claim on behalf of Mātauranga Māori, viz., it can propose "suggestions and ideas" for science to examine. Importantly, a presupposition is made in which the role of science remains fundamental even when testing "suggestions and ideas" from Mātauranga Māori. Examples of this will be given in sections 3 and 4. However in other literature we can detect a more radical view of Mātauranga Māori which obscures the more moderate form; it claims that Mātauranga Māori and science are at odds in ruling out, in various ways, the possibility of science testing "suggestions and ideas". We return to this important difference towards the end of this section.

This history has culminated in various contemporary accounts of Mātauranga Māori a few of which will be mentioned here. The on-line Maori Dictionary tells us it can be understood very broadly to include: "the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity and cultural practices" (Hikuroa, 2017: 5-6). An equally broad view is given when it includes "culture, values and world view" (*ibid.*, 5). It would be wrong to think of this as a definition of the

kinds of knowledge to be mentioned in the next section; rather it indicates the broad scope of the items which we can allegedly know.

Hikuroa (2017: 6) underlines a broad concept of Mātauranga Māori which is also advocated by several others: "the knowledge, comprehension or understanding of everything visible and invisible in the world". Again, this cannot be any kind of definition of 'knows'; rather it indicates the wide scope of what can be known. It is quite inclusive in that little seems to be left out in the disjunction of "visible or invisible". The invisible world contains much stuff including electrons, black holes, gravitational attraction, tectonic plates, Covid-19, and so on. But much of this invisible stuff has been found by science and not by Mātauranga Māori. Would the gods of traditional Māori belief, or the God of the colonizing Christian religion, be included in the invisible? As we will show later, it appears that Mātauranga Māori does indeed include such elements.

The Mātauranga Māori goal of pursuing the visible and invisible is a goal shared by science. For some this might be all they share. Hikuroa tells us that science differs from Mātauranga Māori, notably with respect to methods: "While there are many similarities between Mātauranga Māori and science, it is important that the tools of one are not used to analyse and understand the foundations of another" (*ibid*., 9). This alleged methodological difference takes us in the direction of the more radical view of Mātauranga Māori and away from the moderate view. In this context Hikuroa deplores the way Maori knowledge has been disregarded and neglected by the science community as "myth and legend, fantastic and implausible" (*ibid.*, 5).

We differ from Hikuroa in wishing to claim that Mātauranga Māori and science do share some "tools", e.g., principles of reasoning. We take the view that people in all human cultures share the capacity to form beliefs and to reason about them (we advanced this as a scientific hypothesis about human evolution). In particular, they have in common what we will call *proto-scientific methods* for judging their beliefs. This can be illustrated in the following way. A common "gold standard" of scientific investigation is the method of randomized clinical trials (with or without blinding) used in experiments from agriculture to medicine. We owe this standard to the reforms in statistical reasoning introduced by R. A. Fisher in the 1920s and subsequent work by people like Austin Bradford Hill. Before the 20th century people did conduct trials, but they were faulty in many crucial respects. For example, James Lind in 1747 conducted a trial on sailors which showed that citrus fruit would lessen the effects of scurvy on them while other remedies would not. By modern standards Lind's

controls were inadequate, and the sample size of two sailors who took citrus fruit was too small. It is important to note that in earlier centuries many believed that citrus fruit would cure scurvy. But these beliefs, though right, were not enough; what was needed was a proper scientific test of the claims about citrus fruit curing scurvy. There is a big difference between the common beliefs we humans happen to hold, and those beliefs we hold on the grounds of being established by testing.

Again, Bible scholars point to an account of a controlled experiment concerning what healthy food should be eaten in *Daniel* 1: 12-15. It was proposed that people be divided into two groups. One group eats only vegetables and drinks water for ten days while the other partakes for ten days of any food on the King's table. At the end of ten days it was judged that the first group looked healthier. Again, this is a proto-clinical trial; but it lacks good sample size, randomization, etc (can we suppose that consent was obtained?).

In the light of this we can say that, before the use of a properly developed methodology of clinical trials, humans in various cultures did use methods of science, but they were inadequate in various ways – hence they are *proto*-methods of reasoning. It would be up to historians of human forms of reasoning to adjudicate on any case whether or not it employed a proto-method. Of course, not all principles of method will have a proto-form, but many do.

Concerning whakapapa, Hikuroa cites a Māori dictionary which tells us that Mātauranga Māori incorporates "the body of knowledge originating from Māori ancestors, including Māori world view and perspectives, Maori creativity and cultural practices" (Hikuroa, 2017: 5-6). He then goes on to say of whakapapa that it is "a cognitive genealogical framework connecting creation of the universe to everything that exists within it via descent from ancestors." (*ibid*., p. 6) Then to expand the doctrine further, he appeals to aspects of traditional Māori religion: "In Māori cosmogony, because there is only one set of primal parents (Ranginui and Papatūānuku, from whom everything ultimately traces descent), all things are related" (*loc. cit*.). Concerning the place of traditional Māori religion, he is joined by Stewart who says: 'Māori knowledge includes 'the gods' or knowledge of spiritual realms, while science does not' (Stewart 2019: 66).

Clearly this account of Mātauranga Māori aligns it with Māori polytheistic religion. However, like monotheistic colonizing Christianity it, too, comes into conflict with science over the issue of the existence of god(s) and of creation; the difference is that there are many gods competing with the scientific account rather than just one. On the whole, science tends

to be neutral over the existence of god(s), though much scientific investigation into the existence of souls, ESP, contact with the dead, etc., has failed to detect these items. When it comes to the issue of whether the world was created or is eternal, there is an interesting debate going on which religions close off. (For a start, consult cosmologist Carroll: 2010 on the eternal existence of the universe rather than its creation.)

A more nuanced account of Māori creation stories can be found in Roberts *et al.* (2004) who in fact point out that the creation stories are not universally Māori but are more local and Iwi based (*ibid.*, 3). And interestingly, in these stories, creation can occur in three ways: either in Te Kore or the formless void; or by the two primal gods; or by the Supreme Io (which has overtones of a monotheistic Christian god). Mātauranga Māori may not be as monolithically Māori as many of its advocates claim. The account goes on to tell us "that to 'know' something is to be able to locate it within a whakapapa" (*ibid*., 4). And such a location would be in terms of external, and not internal, whakapapa relations. Though this would not be part of any definition of 'know' it would be a mark of when knowledge was achieved. Here is another way in which issues relating to whakapapa would not comport with science. Science might claim that we know something when, say, we can tell what its nature is (or essence or its internal relations as in chemical or atomic natures, for example, discussed in the next section) and not when we know what its external relations are.

A more recognisable form of whakapapa would be the recital from memory of one's ancestors back to the original canoe. This, if accurate, would not necessarily be in conflict with any science. However, the domain of allegedly related items can be markedly increased if one goes beyond the original canoe to include genealogical connections between humans and ecosystems and all flora and fauna – and in fact the whole created universe. Whether the world's items are so interconnected, i.e., holistically linked, is a matter for science to decide and not *a priori* pronouncement. Further, from a scientific stance one would not want to see Darwinian evolution displaced by such genealogical views. There is Darwin's tree of evolution with its relations of descent; but these kinds of relations might not sit happily with the envisaged genealogical relations of whakapapa. Some might argue that such connections might make us more respectful of nature and not destructive of it. However, there are other ways of establishing reasons for the care of the world in which we live which need not turn on as strong a tie as genealogical connections. This is an issue with which work on the environmental ethics of our relations with nature would deal.

Above, we cited Hikuroa who tells us that Mātauranga Māori incorporates "the body of knowledge originating from Māori ancestors". Does that mean that all later "knowledge"

must be consistent with earlier "knowledge" claims in some whakapapa lineage? Hikuroa wants to leave room for updating our "knowledge" as time goes by; in which case ancestral "knowledge" gets revised or dropped. But this might not be as easy as it sounds, given that there is strong emphasis in the whakapapa doctrine upon keeping ancestral "knowledge". On grounds of consistency of overall beliefs, something has to give here, but what is unclear.

Science does not adopt this stance. It does recognise the claims of past scientists (Galileo, Newton, Rutherford, Einstein) but readily modifies or dismisses earlier ideas based on new evidence and/or new theories. Thus, Newton corrected Galileo's free fall laws by getting us to incorporate changing gravitational attraction; and Einstein in turn corrected Newton's laws in many ways, for example, by getting us to acknowledge that mass can vary with velocity. Science is always oriented to progress and revision of ideas and hypotheses. Mātauranga Māori would add an unnecessary constraint in requiring that current viewpoints be consistent with earlier viewpoints and do not attempt to correct them.

Stewart (2019) also notes the antitheses between what she calls "Māori science" and "Western science," capitalising "Western" to highlight her view that it, too, is cultural, and not universal. But this perpetuates the fallacy of the misplaced adjective in that it is more accurate to speak not of "western science" but of "science in the West" (wherever that is) or "science amongst the Maori".

This now brings us to an important division between the advocates of Mātauranga Māori adumbrated earlier, viz., the moderates who leave open the possibility of Mātauranga Māori proposing "suggestions and ideas" for scientific testing versus the radicals who in various ways deny this. Three sets of authors will be cited to illustrate the radical stance. The first is Prof. Linda Smith who writes with other Waikato University colleagues: '…. some aspects of IK [Indigenous Knowledge] mātauranga are fundamentally incommensurate with other, established disciplines of knowledge and in particular with science' (Smith et al., 2016, p. 140). of: The crucial term here is 'incommensurate'. This dates from the 1960s philosophy of science of Thomas Kuhn and Paul Feyerabend in which, in various highly contested ways, pairs of scientific theories were alleged not to be comparable. This now dated doctrine is used by some to claim that Mātauranga Māori and science cannot be "comparable" with one another. Understood one way, this would rule out the possibility of scientifically testing the claims of Mātauranga Māori; that is, one is not capable of taking on the suggestions and ideas of the other.

We wish to reject this and argue that many of the propositions of science and Mātauranga Māori can sit happily together. In section 3 we will discuss how a claim of Mātauranga Māori, viz., *that tutu berries are poisonous*, can sit happily, as it obviously does, with a claim of science *that tutu poison has the chemical formula* $C_{15}H_{18}O_6$; moreover the latter provides part of the explanation of the former. And in section 4 we will discuss a paper which considers how hypotheses from Mātauranga Māori about agents which might combat Kauri dieback can be hypothetico-deductively tested. The claim about the incommensurability of Mātauranga Māori and science is clearly overstated. Perhaps one of the ways in which Smith *et al*. claim that incommensurability may arise is that science, unlike Mātauranga Māori, cannot have a role in '…. mediating the material and spiritual world, escorting a spirit on a physical and spiritual journey …' (*ibid*, p. 132). Talk of spirits takes us into realms of putative science which have no experimental basis in psychological investigations. Being sceptical about such existence claims is not a good ground for claiming some sort of lack of comparability.

The second author is Mason Durie who tells us: 'Indigenous knowledge cannot be verified by scientific criteria nor can science be adequately assessed according to the tenets of indigenous knowledge. Each is built on distinctive philosophies, methodologies and criteria' (Durie, 2004 p. 2). The claim 'indigenous knowledge cannot be verified by scientific criteria' 'clearly contradicts the moderate view of Mātauranga Māori. Moreover, this is false as the examples mentioned in the previous paragraph will show. Also in section 4 we discuss four experiments described in published papers in which different hypotheses taken from Mātauranga Māori can be scientifically tested, in particular hypotheses about agents for combatting Kauri dieback.

Durie goes on to speak of the distinctiveness of methodologies. But they cannot be distinctive in all respects as the use of common forms of inference across humanity show, e.g., induction and some rules of deduction. Moreover, we have argued that throughout human history all human cultures have used proto-scientific rules of method. It should be noted that Durie does not take the distinctiveness of science and indigenous knowledge to be so great that it undermines his attempt to bridge them *via* what he goes on to describe as 'An Interface Research Framework'. But there is no need to propose this since the problem which it is supposed to solve, viz., the alleged disparate character of indigenous knowledge and science, is not a real problem. Science can still do its job of testing claims from Mātauranga Māori without an otiose interface framework.

Finally in a publication of the *Royal Society NZ* in which MM and science are compared we are told: 'Mātauranga is its own system with its own organisation, and it is this system and organising that we want to prioritise' (Broughton and McBreen, 2015, p. 84). This clearly makes a claim for the independence of Mātauranga Māori from science even though it is quite unclear as to what kind of independence is being claimed.

Given the moderate versus radical stances, the burgeoning literature on Mātauranga Māori is not agreed about what role science can play. In addition, many of the radicals think that Mātauranga Māori is a "way of knowing" (as they say) that is quite distinct from science. In the light of this, one might well ask if they are really doing science or something else. When reading the literature on Mātauranga Māori the boundary is often obscured between: (i) the moderate view in which Mātauranga Māori merely makes suggestions and proposes ideas for science to investigate (while itself not being part of science); and (ii) the more radical view in which the procedures of Mātauranga Māori are alleged in some way to be incommensurate with, and so alternative to, science. We discuss (i) further in sections 3 and 4 but leave the obscurities of (ii) aside.

3. The Kinds of "Knowledge" in Māori Knowledge

The expression "Mātauranga Māori" is often translated into English simply as "Māori knowledge". Mātauranga is an abstract noun, as is the English 'knowledge'; these terms come from the verbs 'matatau' of Maori and 'know' of English. 'Mātauranga' is an omnibus, even ambiguous, expression and is as broad as the English term "knowledge", as will be seen. For the present, we will go along with this translation. But further alternatives might be "Māori beliefs" or "Māori belief systems" (as we suggest in section 4). In fact, some writers give us a broad range of epistemic terms as a translation of 'Mātauranga Māori': 'The term has many definitions that cover belief systems, epistemologies, values, and knowledge …' (Awatere and Harmsworth 2014: p 3). Surprisingly Mātauranga covers beliefs as well as the quite different knowledge. This might indicate that 'Mātauranga' does not always parallel the usage of the English 'knowledge'. In what follows in this section we will consider some of the kinds of knowledge that there are and then raise the question whether these kinds are universal in all languages or not.

Six kinds of knowledge. The following is a list of some of the different linguistic forms the verb 'know' takes in English (but which might have direct parallels in other languages). Knowers can be either some individual person or group (such as Māori, or more correctly Iwi

as the more primary source of knowledge); for convenience they will be denoted by 'X'. The grammatical objects of 'knows' will be propositions (statements or completed sentences) and will be denoted by 'p'; for example, that 2+2=4, that Matariki usually occurs in late May or early June, etc. In what follows we will use as a propositional illustration some remarks that can be made about tutu, the poisonous, native New Zealand plant. There are many linguistic forms the verb 'know' can take; we will consider just six of them.

(1) *Knows that p*. The letter 'p' following the verb can be replaced by a proposition; for this reason it is called *propositional* knowledge. For example: X *knows that* tutu is poisonous.

One might ask: how did the Maori know this? The question asks a very different matter concerning evidence for the claim that tutu is poisonous; it does not concern the linguistic structure of *know that* p which we are characterizing in talking about the different linguistic forms that 'know' can have. However, we will briefly comment on the evidential matter and then set it aside. There does not appear to be any direct, historical evidence about how the Maori came to know this. But it can be appropriately claimed that they made an *enumerative inductive* inference from individual cases of poisoning by tutu to the generalization: all tutu plants are poisonous. In much the same way from all the individual deaths that have occurred we infer 'humans are mortal'; from all the individual sips of water we take, we infer 'water quenches thirst', and so on. We can take this kind of inductive form of reasoning to be an inference or, more grandly, to be a proto-principle of scientific method which most people in all (we may well suppose) cultures have employed in their reasoning about the world. We take it that humans (and animals as well) have evolved at least to be "inductive machines".

(2) *Knows what* …. (definitional knowledge). For example, X *knows what is* tutu poison. Early scientific investigators isolated the poison and called it 'tutin'. So, we could say, uninformatively: X *knows what* is tutu poison, viz., tutin. However more information is provided when specifying the chemical formula for tutin: X *knows what* tutin is, viz., the chemical substance with formula $C_{15}H_{18}O_6$. This distinctive chemical was discovered in 1900 by Esterfield and Aston in the leaves and seeds of tutu. The structure of this molecule was discovered much later by Craven in 1963. In these two papers chemistry is the science employed, along with chemistry's standard modes of investigation at the time. There is no reference to Mātauranga Māori. *Knowing what* … in these cases is *knowing what* is the chemical nature of the substance tutin.

(3) *Know how* …. (explanatory knowledge). For example, we can say that X *knows how* tutin causes "poisoning". What is the "poisoning" and how does it act? It attacks the body's glycine receptor which helps control neurotransmission in the spinal cord and the brain stem. Tutin acts as an antagonist with the result that there is loss of control of motor neurons and of muscles. That tutin affected the nervous system was noted by its initial discoverers; but it was much later work which showed by what means tutin acted upon particular aspects of the human nervous system. Again, there is no Mātauranga Māori story to be told here; the explanation is entirely within the sciences of chemistry and physiology.

It is important to note the difference between (1) and (2), and the difference between (1) and (3). X might *know that* tutu poisons but not *know what* tutu poison is. In much the same way a person might *know that* aspirin relives headaches (on the whole) but not *know what* aspirin is. In a similar fashion X might *know that* tutu poisons but not *know how* it poisons (i.e., provide an explanation). In much the same way a person might know that aspirin relieves headaches but lack an explanation, i.e., not *know how* aspirin produces headache relief. Propositional knowledge is very different from explanatory knowledge, though the later can be expressed as the former.

(4) *Knows why* …. (another form of explanatory knowledge). Suppose we say: X *knows why* tutu causes poisoning. What can we say that X knows in the way of an explanation? It is not clear. But one suggestion is an evolutionary story in which some plants evolved certain kinds of ability to poison animals or insects that might eat them. So an explanation can be filled out from within Darwinian evolutionary theory. But perhaps no one *knows why* tutu acts in the way it does; it remains an open matter.

(5) *Knows* …., where the blank is filled by a direct object. This is a version of *knowledge by acquaintance*. Thus we may say: X *knows* (is acquainted with) Auckland (i.e., knows the way about) but X does not know Wellington (X gets lost); X *knows* (is acquainted with) the Prime Minister (is a friend, or can pick them out in a line-up); X *knows* kauri trees (i.e., can identify them). In the light of the last example, we can say that X *knows* tutu in the sense that X can recognise a tutu plant when X sees one in the bush.

Note that in English the same word ‘know’ is used in all the above contexts. However, to the consternation of English speakers in contexts of knowledge by acquaintance the French will use ‘connaître’ here in contrast to ‘savoir’; and the Germans will use the verb ‘kennen’ as opposed to ‘wissen’; and so on for many other European languages. Is it an advantage, or a disadvantage, of English that it uses the same word for these different linguistic structures whereas many other languages will use different words to mark the different structures? This raises an interesting point about how in different languages different words pick out similar epistemic concepts - a point to be addressed shortly.

(6) *Know how to* …. Here the verb ‘know’ denotes a skill or an ability. Thus we say: X *knows how to* speak Te Reo; X *knows how to* play the violin; X *knows how to* do multiplication; and so on. In particular we can say: Maori (and subsequently early settlers) *knew how to* make a non-intoxicating drink from the juice of tutu berries - once the seeds had been strained out (Fitchett and Malcolm 1909: 336). Fitchett and Malcolm largely report on the toxic effects of tutin on a variety of animals, including humans (in 1869 one Government analyst, W. S. Skey, even tried the poison on himself). This highlights the interesting point that Maori *know-how* in this case involves *know that*; hence the separation of the seeds from the berry juice. That is, we can say that Maori *knew that* tutu berry seeds were poisonous; also, they *knew that* the juice was not poisonous.

What bearing does all this have on Mātauranga Māori, or as we will say here, Maori knowledge? In English an abstract noun, ‘knowledge’ is used. But in analysing what is going on here, it is better to avoid the abstraction and consider the various concrete verb forms as has been done above. What emerges from this is a more fine-textured and informative approach to the way in which epistemic terms get employed in Maori and English. What it shows is how both Mātauranga Māori and science can be intertwined when they are involved in the same investigations; but as has been done above, they can be separated out.

As far as knowledge content is concerned, the conclusion we can draw from the above is that, at best Mātauranga Māori is only employed in three kinds of “knowledge”, viz., *know that* …, *know how to* …, and *know* … (by direct acquaintance). Mātauranga Māori is not part of any further story to be told about knowledge of chemical substances, *know what* …, or the two kinds of explanatory knowledge, viz., *know why* … and *know how* …. Rather it is scientific theories and scientific practices which gives us these kinds of knowledge.

It might now be asked: how is *knowledge* to be defined? The answer is: one ought not attempt to do so. In the light of the above six different uses of the word 'know' there would be at least six different definitional accounts to give of the verb 'know'. It is left to the reader to consult books on epistemology (e.g., Nagel 2014, chapter 4) for how one might define, or analyse, some of these six forms, especially the first propositional form of *knows that* in the context 'X knows that p'. However, there is little appropriate research work in Mātauranga Māori available on *knowledge* or *knows* to this end. We will not attempt such definitions here and leave the task of defining the various uses of the word 'know' to philosophical works in epistemology.

A research programme in linguistics and epistemology. Linguists and philosophers have wanted to know if all languages have the same, or different, linguistic devices using what we might call epistemic terms such as 'knows', 'knowledge', 'knows that', 'belief', 'understanding', and so on. As an example, investigators ask whether the concept of 'X knows that p' involve the truth of p. Philosophers have always assumed that it does; but this is not obvious as it is not always reflected in the ordinary use of 'knows that'. Linguists have, again, wanted to know the frequency with which a factive *knows that* occurs in any sample of languages. An answer is both important for the study of linguistics and whether, as philosophers have assumed, there is a universal concept of *know that* which always involves truth.

Over the last twenty years or so there has developed a research project looking into such matters. Some of this interesting work has been collected in Stich *et al.* 2018. Much attention has been devoted to the use of English expressions such as 'know' to express epistemic concepts. So, what happens in other languages when their epistemic counterpart words are considered? In the Stich *et al.* collection, aptly named *Epistemology for the Rest of the World,* a host of other languages are also explored, such as Sanskrit, Japanese, Chinese (modern and ancient) Hindi, native American languages, some Australian aboriginal languages, and so on. Alas Polynesian languages, including Māori, are not discussed; it remains to extend this research project to Māori. So, no answer can yet be properly given to whether or not, say, the six various uses of the English verb 'know' have exact counterparts in Māori. Or whether there is a factive Māori counterpart to *knows that*. We have already noted some variation between English and French or German in the case of knowledge by acquaintance. There is no reason not to expect other linguistic variations from English which may, or may not, have epistemic significance for the similarities and differences between English and other languages such as Māori.

Even though English might be the language most investigated by researchers, Stich *et al.* wish to downplay the claim that English epistemic terms have some special role to play which have important implications for epistemology; rather they place English on a par with all the other languages. To this end they propose a universality thesis for discussion (even though they trend to reject it): the properties of the English word 'know' and sentences of the form 'X knows that p' are shared in translations into most or all other languages. Put in another way, the thesis proposes that there are certain epistemic universals to be found across all languages. For our purposes we need not go into the different ways in which researchers in this area understand this thesis and how they differ over whether it is true or false. But it is worth mentioning briefly one result by Anna Wierzbicka (Stich *et al*., 2018: chapter 10) in which, in a discussion of indigenous knowledge, it is claimed that 'know' is a universal but 'knows that' and 'knowledge' are not!

The Stich *et al.* research programme proposes an investigation into knowledge attributions, and its cognates, in the languages of the world. Its relevance is this. We have discussed six different linguistic forms the English verb 'know' might take and raised the question as to whether *knows that* is factive. In the light of the contested universality thesis we do not wish to claim without further evidence that there are in Māori exactly the same counterpart linguistic constructions for the English epistemic terms 'knows' or 'knowledge'. This is an under-investigated topic which we leave to future research along the lines of the Stich *et al.* programme. But we are writing this in English and so will continue to use the linguistic constructions to be found in it, e.g., the six forms in which even claims about Mātauranga Māori can be expressed.

4. Mātauranga Māori and Science

Mātauranga Māori is not wholly a system of beliefs; it also includes practical knowledge to do with the environment and its resources, including navigations skills, the cultivation and preparation of food, and some understanding of natural phenomena, including disease. It is here that we ask whether it can be integrated with science. Opinion is divided. At one extreme are Broughton and McBreen who write:

> 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 and McBreen 2015: 86).

This is contradicted, though, by Durie, who writes:

> … it is necessary to make a plea for an interdependent and innovative theoretical space where the two streams of knowledge are able to blend and interact, and in doing so, facilitate greater sociocultural understanding and better outcomes for Indigenous individuals or groups" (Durie 2006: 52).

Similarly, Macfarlane and Macfarlane write that "a blending of Indigenous and Western bodies of knowledge creates an approach that is potentially more powerful than either knowledge stream is able to produce unilaterally" (Macfarlane and Macfarlane 2019: 5).

To resolve these issues we will not consider proposals about the definition of science which might have a bearing on the epistemological status of science in contrast to Mātauranga Māori (though one of the authors has done so elsewhere; see Nola and Irzik, 2011). But we will briefly consider four papers in which various authors have alleged that Mātauranga Māori has been employed in science. We argue that this is so in the limited sense that hypotheses can come from Mātauranga Māori for testing (as they can come from anywhere else). More often than not matters are around the other way; science is employed in Mātauranga Māori for various purposes, including testing of its claims.

(1) Lawrence *et al*. (2019) describe a study on the potential control of kauri die-back in New Zealand, known to be caused by a pathogen called phytophthora. The task has been to find anti-phytophthora compounds, particularly those which might be generated by native plants growing in kauri forests. They tell us: "Mātauranga Māori was used as the basis for selection of four endemic plants for anti-Phytophthora screening. The knowledge used to select these plants descends from Te Whare Wananga o Ngāpuhi (the sacred house of learning of Ngāpuhi)" (Lawrence *et al*. 2019: 3). The house of learning suggested four plants: kānuka, karamu, kawakawa and nikau. In fact, the researchers considered the effects of preparations of the leaves and roots of each of these plants, thus generating eight hypotheses about the possible negative causal effects on phytophthora. These eight causal hypotheses were scientifically tested for their action against the pathogen threatening kauri growth, but only the extracts from the leaves (not roots) of one of the four, kānuka, proved promising. The authors are cautiously optimistic about their results saying: "These results suggest that, while not useful for treating existing plant infections, kānuka could have potential applications in limiting zoospore mediated spread of disease. … any potential applications will require significantly more research." (*ibid.*, 14)

To what extent was Mātauranga Māori involved in the processes of scientific testing? It did call on a "sacred house of learning" which suggested four-plant-hypotheses for test, or eight hypotheses about the casual efficacy of the roots and leaves of these four plants. But that is all; the crucial matters of scientific test (assumed to be correct by the authors of this paper) lie elsewhere and are not part of what is on offer from the "sacred house of learning". In fact, theories of confirmation, of refutation, and of hypothesis testing generally, are not part of Mātauranga Māori. We make three points about this.

The first is that, as far as science is concerned, hypotheses for test can be suggested from all areas of life, e.g., from other sciences, from common everyday beliefs, from myths, from religion, from "a sacred house of learning"—and from even dreams.[3] This is part of the universality of science; tests may be devised for any kind of hypothesis drawn from anywhere. Science arises in the *testing* of hypotheses (often called, in the philosophy of science, *the context of justification*) and not necessarily in the suggestion of hypotheses in the first place (often called *the context of discovery* or *invention* of hypotheses for testing).

The second point is that the model of science in which we separate out the context of justification from the context of discovery, is clearly suggested in Karl Popper's model of hypothetico-deductive test to be found in the first chapter of his *Logic of Scientific Discovery* (Popper 1959/1934).[4] Popper adopts the strong view that there is no method for *inventing* hypotheses in the first place. (The authors might not agree fully with this, but we can set this matter aside). We can find hypotheses anywhere, even in religion, myths or dreams. But once we have them, we can, if we wish, subject them to test. In this sense the science of testing is universal; no hypothesis is immune from testing. Here it is important to adopt the critical attitude in science and subject our beliefs to test and not venerate them or make them immune from test.

The third point is this: once tested, do the hypotheses fail or pass? Of course, we would like any "sacred house of learning" to suggest hypotheses which pass tests. (We do not know where the "house of learning" gets its hypotheses and we are not told; though we have no evidence, perhaps a case can be made for Maori protoscience at work.). But, alas, many of the hypotheses suggested by "the house of learning" fail their tests. Of the eight tested, seven failed. So the "house of learning" is not a reliable generator of true hypotheses, and in this case it has a failure rate of seven out of eight. But at least it got one roughly right! This illustrates why, at the beginning of section 3, we made qualified remarks about Mātauranga Māori being about *belief* and not *knowing that*. It might not give us knowledge in many cases, especially if we also hold that any knowledge claim involves truth (i.e., is factive). But it can give us beliefs for test (and beliefs are not factive)

From the above it is clear that the investigation into aspects of kauri die-back itself required detailed scientific procedures of test well beyond those provided by the house of learning, which merely provides hypotheses for test. Of course, there might be other ways of suggesting hypotheses for test[5]; but for the case discussed here we will stay with the sacred house of learning as the context of discovery/invention of hypotheses.

(2) Another example comes from the long-time practice among Maori of capturing crayfish (koura) in freshwater streams, using fine-grain nets made of fern bundles (whakawetu). Kusabs *et al.* (2019) provide detailed empirical data on the catches and compare different methods of effecting optimal capture. This again suggests that Mātauranga Māori can provide the impetus for scientific investigation, but the investigation itself depends on well-established scientific procedures, as outlined in (1) above.

(3) Again, Whaanga *et al*. (2018) examine Māori oral traditions recorded by early settlers to discover the frequencies of words describing fish as classified by Māori, and their relationships to other concepts. This revealed the names of some 50 fish species and identifies a number of ways in which different species are linked to Māori protocol and sayings. The authors describe their analysis as "qualitative" but in fact it depended heavily on an online counting tool and on statistical analyses. It is nevertheless an example of how Māori knowledge can usefully provide a lead into more exacting scientific understanding.

(4) Lyver *et al*. (2018) make an argument for a "biocultural" approach to conservation and environmental management but are mainly concerned with the neglect of indigenous worldviews and the spiritual linkage of Iwi to the natural environment. The word "science" appears only once ("The use of both customary and science-based tools and methodologies" (but as the above case studies show, the source for hypotheses is very different, *ibid.*, 11)). They outline how Kaitiakitanga strategies relate to ecological concepts, and can offset the decline in biological and cultural diversity, overlooking the fact that New Zealand is more culturally (and perhaps biologically) diverse today than it has ever been in the past. The colonial (*sic*) government may well have been remiss in ignoring indigenous views and practices, but the future of the environment on a crowded planet is too important for these not be subjected to scientific scrutiny.

Mātauranga Māori, and indeed religions, can therefore raise questions or hypotheses for scientific study, or point to problems specific to Māori. But as the four cases studied above show, the source of the hypotheses (their context of discovery) is very different from a core job of science, viz., their method of test in science (their context of justification). They can help guide the purposes for which scientific knowledge is used, but in modern terms they

are scientific in only a limited sense. Science is used for many purposes, both good and bad; these include educational, legal, medical, military, not to mention criminal. Unlike Mātauranga Māori, science makes no claim to incorporate values, other than the search for objective truth, and the use of science is a matter for society at large, with its material, ethical, and social concerns. This is not to say science can play no role in how it is used; Bayesian models, for example, can be used to compare different possible applications and sharpen decision-making.

5. The Question of Ownership

In their article on kauri die-back, discussed above, Lawrence *et al*. raise the issue of the ownership and acknowledgment of Maori knowledge:

> A legal framework for the protection of indigenous knowledge remains elusive, since most provisions for intellectual property law have evolved out of a western view of knowledge as a commodity owned by individuals, not by communities. Under current New Zealand law, researchers can use traditional Māori knowledge without consent or acknowledgement. Similarly, scientific research of taonga plant species is legally allowed to take place without input or consent from mana whenua. The question remains as to how mana whenua can protect their indigenous intellectual property rights and gain economically from the development and implementation of such intellectual knowledge (Lawrence *et al*. 2019: 150).

Another example involving the use and ownership of plant species, also discussed by Lawrence *et al*., is medicinal. Kānuka bark is used by practitioners of rongoā (traditional Māori healing) for the treatment of diarrhoea and dysentery. If such traditional information were to prove useful and become commercially viable, Maori may well claim ownership and at least part of any profit that accrues. Nevertheless, in an age with an over-abundance of false potions and unsubstantiated cures, we need scientific corroboration to establish what is effective and what is not. This is not to disparage Māori "knowledge" in this case, but simply to recognise that medicines are normally required to meet scientific standards in the interest of public safety and well-being. To be sure, scientific information is sometimes hidden in obscure journals, but there are attempts to alleviate this through "open access" journals and demands for greater transparency, and the suggestion that Māori knowledge is "owned" seems contrary to the spirit of scientific inquiry.

The idea of western knowledge as owned by individuals, as suggested by Lawrence *et al*., will make little sense to most scientists. Newton did not own the laws of motion, nor Einstein the general theory of relativity. Scientific knowledge is widely available in books and journals, and extensively taught in schools and universities. Some inventions or applications based on science might well be considered commercial property (which is not a development we applaud), and there may indeed be aspects of Mātauranga Māori that might be legitimately protected by Maori. This might occur when it leads to economic gain, but also when such knowledge is considered sacred or otherwise culturally protected. These are legal problems, not scientific ones. Science as a way of discovering knowledge is open to all, regardless of nationality or ethnic group, and scientific knowledge is widely and universally shared. Further, scientific advance requires objective verification and peer review, again amplifying its accessibility and universality.

It may well be considered appropriate for scientists to seek permission to use indigenous knowledge or even pay for it; these are matters that may need negotiation through funding agencies and the like. Such restrictions nevertheless fly in the face of the extraordinary accessibility of scientific knowledge, with the increasing sharing of large data banks and computational codes, and the free exchange of information through international conferences and the internet. Of course, individual scientists are often protective of their own work for fear that someone will purloin their ideas, but are all too willing to share when their work reaches publication and scientific acclaim. Science is often highly competitive, but gains much of its power through its accessibility and universality, and its pursuit of truth rather than profit.

6. The Continued Need for Science

We conclude with an appreciation of science itself, which is a human achievement of extraordinary power and intellectual challenge. We do accept, though, that science has the same origins and arose from the same sources as indigenous belief systems throughout the world—the need to understand the natural world and to solve practical problems. But science has been wrested away from the traditional and seeks to question the past and discover new insights and applications. It is traditional understanding that can lead us to "false starts" such as the Greek idea of humours in medicine. The history of science shows us that "false starts" were generally the norm and these had to be critically examined and either altered or discarded before science was to advance. Scientifically incorrect conceptual models, such as in astronomy and alchemy, along with many other theories such as racial superiority, have

traditional origins, but have been shown to have no foundation. In recent times, science has greatly informed us about memory, its biochemical and physical bases, how it develops in children, the various forms it takes, and what their properties are, taking us well beyond folk psychology. Failure to understand the nature of memory was an important element in the Christchurch Civic Crèche case of the early 1990s (Hood 2003).

The extraordinary advance of science is not evidence of superior intelligence. Scientific advance is rather the product of happenstance, such as the invention of writing systems that enabled information to be stored more efficiently and incremented over time. This has blossomed into sophisticated communication and storage systems that allow for global contact. The sheer size of the scientific community underlies its creative potential and application to global issues.

Science is not simply a European pastime, as it is sometimes portrayed, but has gained considerable momentum in Asia, the Americas, and Africa, and in indigenous communities. Indeed, the future of science may well be centred in Asia. In the past year, the international PISA[6] evaluation recorded a drop in the rankings of New Zealand 15-year-olds in science and mathematics, but well out in front were China and Singapore.[7] China now produces more scientific publications than the United States, the previous leader.[8] In 2019 alone, two of the authors have, between us, attended scientific conferences in five different countries: England, Ireland, Israel, Japan, and Russia. The language of science is the same in each, even though their cultures, and in some cases their spoken languages and scripts, are strikingly different. The system of peer review does not recognise national boundaries and ensures universality. Science, along with its bed-fellows mathematics and computer technology, may be the best international language we have. The sheer size and diversity of the science community adds to its power and creativity. In a small country like New Zealand, we cannot afford to lose contact with the international science community.

Two of the great strengths of science scarcely mentioned in discussions of its relations with indigenous systems are the experimental method and instrumentation. Experimental manipulations provide better understanding of causal processes than does mere observation of natural phenomena, and instrumentation, from the telescope to magnetic resonance imaging, provides access to information not otherwise available to our senses. These aspects of science are no better illustrated than by the construction and use of Large Hadron Collider in Europe to test various theories in particle physics and establish the existence of the fundamental particle known as the boson. Vastly expensive, of course, but motivated by an

insatiable quest for knowledge, not power. We do not agree with the slogan that "knowledge is power" (i.e., that these two things are somehow identical); but we do accept that increase in knowledge can, contingently, lead to an increase in our powers in some cases.

It is important to recognise that Mātauranga Māori, which has its own language, complexities and insights, may be for some a cultural necessity. But in section 3 in distinguishing the six kinds of knowledge, we show that even though science and Mātauranga Māori can be intertwined, the role of science comes to the fore in offering explanatory knowledge and knowledge of the natures of the things we encounter which Mātauranga Māori does not offer. Again in section 4, even though science and Mātauranga Māori can be intertwined, it is science that provides methods of test for any of the hypotheses that might be proposed from whatever source.

Our claim is simply that Mātauranga Māori is not the same as science. So it would be wrong, as is often envisaged, to include it in a science curriculum as though it were equivalent to science. If it were included, it would run into conflict with scientific knowledge that is widely accepted, such as evolutionary theory or mechanistic theories of brain function, sciences which are not obviously part of Mātauranga Māori. It would also conflict with the scientific dedication to change and progress, and it is antithetical to the strong features of science such as objectivity and universality. These are matters that can of course be debated, but in modern terms such debates do not belong in science itself; they are more questions of the presuppositions of science. There is in any case much more to education than science. We also need the humanities—the arts, history, music, philosophy. Science often addresses questions that arise in these various disciplines, but this is not a reason to include them in the science curriculum itself.

The former science advisor to the NZ Prime Minister, Sir Peter Gluckman, in the opening address to a public symposium on "Engagement of Indigenous and Western Science Knowledge Systems" at Te Papa Tongarewa National Museum, puts his finger on a crucial matter concerning science versus Mātauranga Māori:

> Our human values and personal ethics will inevitably inform the many choices that we make in the practice of science: what we choose to research; how we research it, how we interpret it; and most importantly, how we use the knowledge produced through science. But in the past 200 years, the techniques of science have crystalized into formal processes explicitly designed to ensure

> the collection of data is robust and analysis follows protocols that can be replicated and thus tested and validated by anyone. This submission to testing and retesting – across borders, generations and cultures – is what gives scientific knowledge its generally accepted reliability and universality. Indeed, progress in science particularly over the past 100 years has been about understanding and refining those processes on one hand, technological developments on the other and, by using these developments, massively enhance our understanding of the world around us, and within us (Gluckman 2015: 2).

Here there is an emphasis on science having developed over time methods of testing which have become *reliable* for the truth and *universal* in application (and they are provably so). No other way of making claims about the world have achieved the reliability and universality of science.

Our main purpose in writing this paper is to initiate a discussion among scientists, teachers, and Māori themselves concerning Mātauranga Māori before we rush to incorporate it into our educational and research institutions. Our contention is merely that Mātauranga Māori does not match science in its reliability, universality or discovery of truth, and is in many ways antithetical to science. Science is not immune from criticism, and indeed part of its success is based on its dedication to correction, the eradication or correction of false theories, and to the refinement of its methods. It is not clear to us that incorporating other belief systems into science curricula will contribute to its relentless quest for truth. At worst, it may be seen as condescending and damaging to Māori aspirations. There is much to admire in Māori culture, as in all cultures, but it may seem diminished rather than enhanced if placed alongside science, which we have argued, is distinctive enterprise owing to its reliability and universality.

Notes

[1] Michael Corballis and Robert Nola are fellows of the Royal Society of New Zealand. We all share authorship equally and list our names alphabetically.

[2] https://www.nytimes.com/2019/09/23/health/anti-vaccination-movement-us.html)

[3] The classic case of a dreamed hypothesis in the science literature is that of the organic chemist August Kekulé who tells us that he knew that the chemical composition of benzene was C_6H_6 but did not know what its structure was – until he fell dozing in front of a fire and saw a snake chasing its tail. And then he realized that benzene had a ring-like structure. Being a good scientist Kekulé did not

accept his dream as evidence for the structure. Rather, he then spent some time in the laboratory getting evidence for its hypothesized structure.

[4] Though Popper uses the distinction between the two contexts, it was first expressed in this way by Hans Reichenbach 1938: 6-7. See also Salmon 2005: chapter 5.

[5] One of the authors of this paper, RN, suggests that, in a Bayesian context, we can order hypotheses, before evidence comes in, on the basis of their prior plausibility given the general background of accepted science. This is not inconsistent with claims Lawrence *et al*. make, but they do not make use of the Bayesian stance. This matter will not be followed up here. For a fuller discussion of the Bayesian context, see Salmon 2005: chapters. 4, 5 and 6. Within Mautarangi Maori and its account of science, Bayesian philosophy of science is not commonly acknowledged.

[6] Program for International Student Assessment established by OECD and covering reading, mathematics and science in 70 different countries.

[7] https://www.stuff.co.nz/national/education/117890945/new-zealand-topend-in-oecds-latest-pisa-report-but-drop-in-achievements-worrying

[8] https://www.enago.com/academy/china-overtakes-us-with-highest-number-of-scientific-publications/

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