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On the multiplicity of scientific culture involving cases in China

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Scientific culture is among the focuses of academic research in China. It includes many disciplines, such as the philosophy of science, the history of science and technology, STS (science and technology studies), and traditional culture. Therefore, it involves interdisciplinary research that draws on the findings of many disciplines. Studies of scientific culture have achieved fruitful results and also involve some controversial ideas.

First, there are ambiguities concerning the word 'culture'. However, its general meaning can be grasped at least within daily language despite trivial differences.

Second, and more crucially, the word 'science' also has multiple meanings as observed from the perspective of disciplinary scope. Generally, the meaning of science can be simply divided into narrower and broader senses. Science in the narrower sense usually refers to a systematic and logical system of knowledge that has emerged since the scientific revolution in the West. It takes nature as its object of research and is based on mathematics and experiments. The broader sense of science, on the other hand, comprises all systems of knowledge formed in the interaction between humans and nature. It might (or might not) have some connection with modern and contemporary Western science and holds significance and value for independent exploration. In this sense, the sphere of science has been greatly expanded. For example, ancient science in China, as well as a lot of local knowledge found in various countries, regions and ethnic groups that were excluded from the narrower concept of science, can also be included. Therefore, if understood in a broad sense, the word 'science' will become a plural term; that is, there is more than one kind of science. Then, accordingly, there is naturally more than one kind of scientific culture.

The origin of the concept of scientific culture can be traced back to the 1950s, when the British scientist CP Snow talked about a split between two cultures (namely, the culture of science and the culture of literature or humanities). Here, Snow paid more attention to the culture of science, which had the narrower meaning and mainly referred to mainstream science in the contemporary West. In that regard, scientific culture is a monistic idea based on a monistic concept of science. This monistic idea of scientific culture may lead to more extreme views that consider modern and contemporary Western science, as well as its value judgements and development paths, as the only objective, correct and effective system of cognition.

At present, the monist view of science is still dominant in China, where most people believe that science in the narrower sense is science pure and simple, while science in the broader sense is often regarded as non-science or even pseudoscience. Traditionally, mainstream research in the history of science is directed at such monistic science.

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However, as the study of the history of science and STS goes forward, non-Western, non-mainstream sciences are attracting people's attention. Many philosophers and historians of science have begun to advocate a pluralistic view of science that does not seek unity and standardization. For example, the British scholar GER Lloyd adopted such a pluralistic view when he talked about whether there was science in ancient civilizations. If the answer is 'no', then historians of science will naturally face a crisis of legitimacy regarding their research. However, ancient science is obviously very different from modern science (or the contemporary Western mainstream science that grew from the scientific revolution). There was not a term in ancient language that can accurately correspond to the word 'science', despite the usually rich vocabulary about knowledge, wisdom and learning. After analysing various viewpoints on the issue of ancient science and their corresponding problems, Lloyd puts forward an extremely broad definition of science: we should describe science from its goal or purpose, which naturally includes understanding, explanation and prediction (and 'control' has also been added now because of the developing of knowledge for human purposes). In other words, we should understand objective non-social phenomena; that is, the phenomena of the natural world. Then, we could infer that all cognitive activities and achievements serving such purposes are naturally scientific.

In fact, the concept of 'technology' today is also one that involves contemporary Western understanding. Since the concept of science has been expanded so as to describe things that were different from the norms of Western science, then the technology (people have to use this term sometimes) in ancient China (and in other places and times) can also be included in this redefined concept of science, but we must remember that this 'science' is no longer pointing to that narrow sense of science.

Corresponding to such pluralistic sciences, scientific culture in a broad sense is also a plural and pluralistic concept. Moreover, some of those diverse sciences have continued their existence until the present. Although no longer in the mainstream, they still exert an impact in a limited part of society. With increasingly in-depth reflections on Western centrism in academic circles, related research involving multiple scientific cultures has been growing. We can see some characteristics of such pluralistic scientific cultures from these studies.

First, we no longer admire a particular way of thinking alone, but embrace an inclusive, open and eclectic attitude towards various ways and approaches. For postmodernists, science in a narrow sense is not superior to other sources of knowledge, because scientific knowledge is the same as other knowledge that attempts to control our thoughts and behaviours. The success of science (in the narrower sense) lies not in the correct value of its claims, but in its advocates imposing their understanding on others. Pluralistic scientific cultures would help to break such a monopoly.

Second, in the composition of knowledge, more content has been included in the field of science, and people can accept the broader context behind knowledge with more equal and open minds, so that cultures with different values and goals can be appreciated. In this context, knowledge in different cultural systems that are different from Western modern science is no longer to be regarded as something backward, and different knowledge systems are evaluated from the perspective of whether and how they accommodate the goals, values and purposes of the society in which they originated.

Third, in terms of benefit distribution, pluralistic scientific cultures could bring benefits to a wider range of people. When considering the double-edged-sword effect of science, one will find that science in the narrower sense sometimes does not enable humanity as a whole to make better use of natural resources, but benefits only those already in a superior position in a social hierarchy, who own and control not only natural resources but also the means of mining and processing these resources. Pluralistic scientific cultures, however, are supposed to be able to break such a monopoly and match different natural resources with the needs of local residents, local knowledge traditions and local cultural systems.

Fourth, when discussing their values, pluralistic scientific cultures are intended to explore the meaning of scientific and technological systems in specific situations. For example, what are people's needs and wishes in the worlds outside the West? What role can science and technology play in

creating and satisfying these wishes and in maintaining and transforming the social structure? Such questions can provide a framework for exploring science and technology in non-Western societies and can reveal many interesting things.

Fifth, the mainstream outlook on science in China, whether in academic circles or mass communication, is still a monistic one, resulting in a monistic scientific culture. Therefore, we should combine systematic review, reflection and theoretical discussion with case studies, especially those related to China's traditional culture, to promote research on the diversity of scientific cultures and provide inspiration for domestic research in this field.

In view of the above considerations, we have produced this special issue on the diversity of scientific cultures, which includes five distinctive papers. It introduces acupuncture as a basic way of understanding the human body from the perspective of historical study; explores the practice of postpartum confinement as a long-established Chinese tradition from the perspective of local knowledge; and discusses scraping therapy (*gua sha*) as a popular treatment in health care in terms of its history, current status, controversies and philosophical basis. Australian researcher Michael Matthews, who is influential in the field of science education and the philosophy of science, provides an original study of the scientific testing of *feng shui* and *qi*.

These studies of cases associated with traditional characteristics of China show the diversity and richness of the field of pluralistic scientific cultures and provide inspiration for people to understand scientific culture more completely and comprehensively based on the conceptual framework of pluralistic scientific cultures.

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Acupuncture as a way of knowing the body

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Abstract

Observation, speculation and experimentation are the means for the generation of knowledge about acupuncture, and they also provide basic ways to understand the body from the perspective of acupuncture. Observation involves external touching and internal anatomy. Through observation, the basic patterns of meridians and acupoints can be understood. The theory of meridians and acupoints was formed based on the two speculation methods of analogy and reasoning, but speculation does not necessarily lead to truth. Another approach—holographic thinking—provides a new method of knowing the body. The greatest contribution of acupuncture experimentation lies in discovering the correlation between the body's surface and its viscera, and this is of far-reaching significance.

Keywords

Acupuncture, body, way of knowing, traditional Chinese medicine

1. Introduction

The purpose of science is to understand nature, and transforming nature for the benefit of mankind is only a welcome side effect of science. However, if we were to suggest that the purpose of medicine is to know the body, and that curing diseases and improving health are only welcome side effects, that statement will inevitably lead to controversy. Nonetheless, it seems that there is nothing wrong with considering medicine as a science. On the question of how best to know the human body, people will differ in their answers; different approaches to exploring the body will be taken by scientists, artists, surgeons and gymnasts.

How, then, do acupuncturists view the body, and what is their way of knowing the body? This question can lead not only to a body schema with unique Chinese medical characteristics, but also to a necessary reflection on understanding acupuncture. Based on the theories of acupuncture, this paper seeks to discuss the presentation of the body across a long historical span from the perspective of knowledge generation. However, the question involved arises not because acupuncture provides a conscious expression of bodily knowledge, but because of the logical inferences made during the production of acupuncture knowledge.

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2. Observation

Observation is a source of all kinds of knowledge, and it is the basic approach to understanding nature and the body; its intuitive character makes it the easiest source of knowledge to accept and believe. The early theory of acupuncture was based to a great extent on observations, as can be seen in *Lingshu: Jingshui* (*Miraculous Pivot: Meridian Waters*), which says, 'For an average man, his skin and flesh are there, and his conditions can be known by measuring for the outside parameters, and by dissecting the body after his death'. Measurement by touching the skin and dissection were two major methods of body observation in early Chinese medicine. The theory of meridians and acupoints is an important cornerstone of acupuncture and moxibustion, and it is also the core of body knowledge in traditional Chinese medicine. Taking meridians as an example, *Lingshu: Jingmai* (*Miraculous Pivot: Meridians*) notes, 'The twelve meridians, lying among the flesh, are deep and invisible, with the exception of the spleen meridian seen on the lateral ankle, where the skin is shallow and there is nowhere to hide it. Those surfacing and commonly seen are all collaterals.' This makes a distinction between meridians and collaterals: those that are 'surfacing and commonly seen' are collaterals, while those that are 'deep and invisible' are meridians. However, the meridian of the spleen is visible because the muscles there are small and shallow. Another means of distinguishing between meridians and collaterals is also presented in *Lingshu: Jingmai*: 'Lei Gong, a minister, asked Emperor Huang: "How do you know the difference between meridians and collaterals?" The Emperor said: "Meridians are often invisible, and their existence is known by palpation, and those visible are collaterals".' Here, 'knowing by palpation' is an act of feeling for the meridians on the body's surface. Furthermore, a method for 'meridian feeling' is mentioned in the silk-bound book *Meridian Finding* unearthed at Mawangdui's Tomb of the Han Dynasty:

> Press the foot five inches from the ankle with your left hand and knock the foot's ankle softly with your right hand. If you find that other meridians are strong, and only this one is weak, it indicates a disease; if other places are smooth, and this alone is hindered, it shows a disease; if others are still, and this place moves alone, it is also an indication of a disease. (Ma, 2015: 97–98)

Compared with meridians, the shapes of acupoints are more apparent. Therefore, most of the acupoints were detected by observing the body's surface in the early days of the tradition. I once examined the descriptions of acupoints in *Huangdi Neijing* (*The Yellow Emperor's Classic of Medicine*), which states that acupoints are where morphological characteristics, such as cavitation, bone voids, crevices between bone voids, collaterals, pulsation, tendon knots and tenderness, are apparent on the body's surface (Zhang, 2011).

Early anatomical observations are also reflected in *Huangdi Neijing*. At that time, the ancients still found and measured the meridians by anatomy, although their anatomical techniques were relatively crude. Moreover, the description of the working of the 12 meridians in *Lingshu: Jingshui* states that, in the four limbs, they can be observed by palpation on the body's surface, but the paths inside the body were not entirely imaged by the ancients. As a one-to-one correspondence could not be established between the circulating meridians and the tissues of the body, and the ancients studied meridians mostly for practical purposes, there was no specialized discussion on the anatomy of meridians, so later generations have generally understood that meridians constitute a relatively independent physiological system.

When the meridian theory came into being, the ancients saw the meridians in terms of anatomy. Through 'dissecting and observing', as noted in *Lingshu: Jingshui*, we can know 'the rigidity and size of the viscera, the number of crevices among the joints, the length of the meridians, the cleanness of blood and the amount of *qi*'. A more concrete example is found in the biography of Wang Mang in the *History of the Han Dynasty*: 'Wang Sunqing, a follower in Zhai Yi's uprising, was captured, and Wang Mang ordered the imperial physicians, officials of the royal pharmacy and skilful butchers to cut Wang Sunqing alive, dig out his organs, explore their functions and states, and then pierce the blood vessels with sharpened bamboo thorns to

understand the start and end of his meridians, saying it can cure diseases.' This is a record of an anatomical exploration of the meridians found in a history book. In *Lingshu: Dongshu* (*Miraculous Pivot: Dynamic Transmission*), it is stated, 'Energy from the stomach is injected upward into the lung, and when its fierce force is injected towards the head, it follows through the pharynx, goes up to empty orifices before following the connective tissues between the eyes and the brain and entering the collaterals, going down to the *kezhuren* acupoints on the cheeks, following through the lower gum, and down to the *renying* acupoints on the neck through the *yangming* meridians.' Such a specific description could not have been made possible without anatomical practice.

The scalpels of the ancients failed to reveal the detailed and clear internal structure of the human body; even in the nineteenth century, when Wang Qingren, an anatomist in the Qing Dynasty, published *Corrections of the Medical Field*, the anatomical map presented was not particularly accurate. Furthermore, at the time, modern Western anatomy had been introduced to China, so Wang Qingren's anatomical consciousness had something to do with his reading of works at the confluence of Chinese and Western medicines. After Wang Qingren, Benjamin Hobson's *Quanti Xinlun* (*Treatise on physiology*) was published in 1851. This medical book published by a Western missionary and doctor resulted in a division between meridians and blood vessels in Chinese medicine, the influence of which has persisted to the present day.

Whether what is seen of the body is observed through feeling with the hands and fingers or through anatomy, the job is done via simple and intuitive observations. It is widely held that 'science is based on what can be seen, heard or touched, not on personal opinions or speculative imagination' (Chalmers, 2018: 1). Such an approach was adopted when the theory of acupuncture and moxibustion was established. Of course, the results of observation might not be accurate. For example, the anatomical map *Preserving the Truth*, drawn by Yang Jie, a doctor in the Song Dynasty, is inconsistent with anatomical reality in many places, and it is the result of Yang Jie's analysis and correction by 'proofreading against ancient books' (Zhang and Zhao, 2016). The method of 'proofreading against ancient books' means to correct the anatomical pictures against classical theories as the standard, and it was also a practice of the 'theory-ladenness of observation'. In the process of understanding the body by acupuncture and moxibustion, however, the essence of the theory infiltrated into the observation is in fact an introduction to another method for understanding the human body: speculation.

3. Speculation

The theories involving the 12 meridians, 365 collaterals and 365 acupoints cannot be derived purely by observation. How, then, did these classical bodily theories come into being?

As mentioned above, the theoretical basis for early human physiology is at least partly empirical facts, and partly something else that in theory can be regarded as the 'explanation' of facts, which has existed since concepts came into existence. The experiences we have undergone (let us say they are true to facts) are explained when they are described. For example, the ancients observed that there were depressions on the body's surface, and they used words such as 'bone voids' and 'air pockets' when referring to those depressions. These concepts themselves were expounded with theories: bone voids are related to positions and structure, and air pockets to functionality and morphology. Taking the theory of meridians and acupoints as an example, these can be regarded as an explanatory model, and with them, the theories can be demonstrated more conveniently. Now let us see what tools were used in the construction of the theoretical models for meridians and acupoints.

The first tool that was used was analogy. In classical acupuncture theories, analogy is found everywhere, probably due to the limitations of observation. The main target of analogy was nature, or what the ancients called 'the heaven'. As the saying goes, 'Man copies the heaven'; this was a basic concept for the ancients, as illustrated by the belief that 'man is related to the heaven and earth' (in *Lingshu: Weather and Man's Health*). The number, shape, functionality and pathology of the meridians were all explained by the ancients based on observation of man and nature. According

to *Lingshu: Jingshui*, 'The twelve meridians are connected and corresponding with the twelve waters in the nature outside but also belong under the internal organs of the body'. The 'twelve waters' mentioned here refers to twelve rivers (the Qing, Wei, Hai, Hu, Ru, Sheng, Huai, Ta, Jiang, He, Ji, and Zhang rivers). *Guanzi: Duodi* (*Master Guan: Measuring the Land*) clarifies that 'those which flow into the sea from the mountains are called the Flowing Rivers'. *Lingshu: Jingshui* also states that 'the twelve meridians of the internal organs have their sources outside and controllers inside, so that what is outside is connected with what is inside like an endless loop'. This explains the characteristics of the 12 meridians' endless flow, the functionality of which is also likened to that of a river. Similar analogies can also be found in other books. For example, *Guanzi: Shuidi* (*Master Guan: Waters and the Land*) states, 'Water, the blood of the earth, is like the flow of energy in meridians of the body'; *Lunheng: Shuxu* (*On Balance: The Falsity of Books*) reads, 'There are hundreds of rivers on the land, as there are veins in the body'. The rivers with smooth water flow are called the 'smooth' ones, and those of stagnation are called the 'reverse' ones. 'Therefore, those who work the waters must wait for the weather to thaw the ice, and those who bore holes in the ground must wait for the frozen land to soften, so that the water is flowing and the holes be bored in the ground, and the same are true of meridians of the body' (*Lingshu: Five Methods of Acupuncture*).

Regarding acupoints, there are no physical (or imaginary) lines like meridians, but they are isolated points on the body's surface. When the ancients looked for acupoints, they associated them with functions, as can be concluded from their names. The name 'acupoint' itself suggests a depression, which is likened to a 'wind cave' by analogy with nature. In nature, a cave is the place where the wind is stored, while the acupoints on the surface of the body, called 'air pockets' or 'voids', are where energy, or *qi*, is stored. Wind and *qi* are of the same kind but have different names, so they can be associated with each other. Some acupoints are classified in *Huangdi Neijing*. For example, the well-known Wushu Acupoints (or Five Acupoints, including the jǐng, xíng, shū, jīng and hé acupoints) are compared to running waters in *Lingshu: Benshu*. It says in *A Classic on Medical Problems: The Sixty-eighth Problem*: 'jǐng is likened to the source of water, where the *qi* of meridians goes out; xíng is likened to starting small water, where the *qi* circulates; shū is likened to water increasing in size and depth, where the *qi* starts to grow; jīng is likened to water going unhindered, where the *qi* increases enormously and flows smoothly; hé is where the *qi* converges in the body like rivers flowing into the sea'. Thus, by comparing acupoints to running waters, a group of scattered points are constructed into a group of acupoints flowing in a particular direction.

The second tool that was used in the construction of the theoretical models for meridians and acupoints was reasoning. Analogy can be used to explain the shapes and basic functions of the meridians and acupoints in the human body. However, analogy cannot be relied upon for systematic understanding. Hence, the ancients also used reasoning to complement analogy to construct a theoretical model of meridians and acupoints. There were two theoretical models for the meridians in the Qin and Han dynasties—the 11-meridian system in the silk book found at Mawangdui Han Tomb, and the 12-meridian system described in *Lingshu: Jingmai.* In the Spring and Autumn Period, there prevailed a concept that 'In Heaven, six kinds of energies work, and on earth five, and the numbers are constant'. Therefore, under the influence of this concept and the belief that 'man copies the heaven', both physically and spiritually, a model of the 11-meridian system (including five *yin* meridians and six *yang* meridians, lacking the dominant meridian in the palm) was established. This number of meridians could not be discovered through analogies but was found by reasoning. Similarly, an understanding of the 365 acupoints was also obtained by reasoning. In *Huangdi Neijing*, the part *Suwen: Qixue* (*The Fundamental Enquiries: The Voids of Energy*) states, 'The 365 air pockets are established in correspondence to 365 days in one year'. However, there is no definite number of air voids in the human body, so 365 is meant only to reflect the meaning of 'entirety'. Therefore, when talking about the 12 meridians or 365 air pockets, no real facts about the human body are referred to other than understandings obtained by reasoning under the concept 'man is related to the heaven and earth'.

The third tool that was used in the construction of the theoretical models for meridians and acupoints was holography; this is a new means of body cognition that has attracted increasing attention since the 1980s. Professor Zhang Yingqing of Shandong University, who was ordered to work as a peasant at a village in Inner Mongolia in the 1970s, after discovering an acupoint group on the second metacarpal, put forward the law of biological holography, which holds that every independent part of an organism can be regarded as the epitome of the whole body. This serves as a very powerful explanation for the micro-acupuncture system of the human body, which encompasses practices such as ear acupuncture, abdominal acupuncture and eye acupuncture.

A similar theory is also seen in *Huangdi Neijing*. For example, in the part *Lingshu: The Five Colours*, the question of whether the changes in the five facial colours are only reflected in the '*mingtang*' (nose) is discussed, and it explains: '*Mingtang* refers to the nose; *Que* refers to the part between the eyebrows; *Ting* is the forehead; *Fan* is the outside of the cheeks, and *Bi* is the parts immediately in front of the ear.' The theory of holography is a systematic approach. As a theory or model, the idea of biological holography triggered by acupoint holography is worth pondering and studying. However, it was labelled as pseudoscience in 1996 in China, which led to people neglecting this promising way of understanding the body. However, it is an entirely new cognitive approach that is completely different from the classical man-nature analogy and the modern mechanistic viewpoints about the anatomical body, and it may open up a new picture of the human body.

4. Experimentation

Experimentation is one of the most important means to acquire knowledge, and the application of experimentation to acupuncture research is at a very mature stage. At one time, the aim of acupuncture experiments conducted in laboratories was to find the essence of meridians and acupoints—that is, to intervene in the human body through physical and chemical means in the hope of demonstrating specificity in the meridians and acupoints—but this path has now largely been abandoned. Moreover, research seeking to find special physiological structures, strictly speaking, does not belong under 'experimentation', but is rather observation under specific conditions. Currently, the main objective of acupuncture experimentation is to stimulate some specific parts on the body's surface, such as the meridians and acupoints, and thus to observe the resulting effects on the body to better understand the mechanisms of acupuncture.

During an experiment, standard conditions are set up to verify a theory, and it is often necessary to compare two sets of results to reach conclusions. By constructing and adjusting conditions, the two sets of results can be compared under the same (theoretical) conditions, thus revealing the accuracy of a hypothesis. For example, we can design a very simple experiment to verify a classic theory of acupuncture that abdominal gastrointestinal diseases can be treated by working on the *Zu Sanli* acupoint (a point beneath the knee and on the lateral part of the lower leg). First, take mice infected with gastritis and divide them into three groups: one group is treated with acupuncture at the *Zu Sanli* acupoint, one group is treated with a known effective drug as the control group, and one is a blank control group in which the mice are not given any treatment. After a period, the effects on the acupuncture group are compared with those of the drug-controlled and the blank control groups to establish whether acupuncture at the *Zu Sanli* acupoint has a therapeutic effect on gastritis. The purpose of this acupuncture experiment is to verify the recorded experience of 'treating abdominal diseases via the *Zu Sanli* acupoint' (supposing this expression originated from experience). Assuming that the experiment is successful and positive results are obtained, the effectiveness of working on the *Zu Sanli* acupoint can be confirmed.

If the conclusion ends here, it can be said that the statement that working on the *Zu Sanli* acupoint can treat gastritis has been verified through experimentation. However, some experimenters may gild the lily by deducing from the experiment the existence of an acupoint; that is, they may conclude that there is a substantial *Zu Sanli* acupoint that is independent of adjacent tissues. However, this deduction is not valid, as, although the experiment may have shown

that stimulating the *Zu Sanli* acupoint can treat a stomach disease, the effectiveness of the working mechanism may have resulted from many possible factors, and those may involve the nervous system or some unknown factor(s), so it might not necessarily be the case that the acupoints themselves played a role. Moreover, the question of whether acupuncture *around* the *Zu Sanli* acupoint can also be effective on stomach diseases has not been answered. If the answer is 'yes', then the specificity of the *Zu Sanli* acupoint is even more untenable. Therefore, this experiment can prove only that stimulation of the *Zu Sanli* acupoint can effectively cure patients of stomach diseases. As for whether the acupoint area itself has an independent and substantial existence, that cannot be judged using this experiment. Therefore, when bodily knowledge is obtained through experimentation, conclusions should be drawn conservatively.

In fact, what could be inferred from the experiment is a correlation between the body's surface and its internal organs. The mechanism of this correlation is not yet clear. However, the finding of that correlation is already an important contribution from acupuncture to the understanding the human body, and its significance is no less than that of proving the legitimacy of acupuncture treatment itself.

5. Summary

Observation is the basis of knowledge, but not all of the knowledge obtained from observations is true to the facts. For example, early anatomical observations gave rise to misunderstandings due to crude anatomical techniques, and the knowledge obtained therefrom was far from fact.

The participation of speculation is what turns the results of observation into knowledge. Furthermore, almost all of the classical bodily theories are the products of speculative participation. For example, in the formation of the theories revolving around the 12 meridians, the 365 collaterals, the Five Acupoints and the eight extra meridians, analogy and reasoning are the major approaches. Holographic cognition, however, is a contemporary concept; its idea that 'the part reflects the whole' has its origins, to some extent, in *Huangdi Neijing*, but taking this as a systematic notion is something that has arisen from speculation in modern times. Although holography was once dismissed as a pseudoscience, it is at least a powerful tool for the theoretical explanation of acupuncture.

Experimentation is a means to verify theory, and acupuncturists can set conditions in the laboratory to verify the theory of acupuncture. However, most such experiments cannot prove that there is a certain essential structure with meridians or acupoints. In fact, the classical theories of meridians and acupoints are the products of speculation and can be regarded as physiological hypotheses that could not be verified by experiments. Experiments can only lead to the conclusion that a new physiological possibility exists; that is, a correlation between a specific part of the body's surface and a certain organ or another part of the body. The discovery of such a correlation is of more significance than the verification of the classical meridian and acupuncture theory.

Speculation is not only at the core of theoretical construction, but it is also involved in observation and experimentation. In fact, there is no observation and experiment without speculation, as speculation intervenes from the beginning of observation, and all the results of observation records are classified and screened through speculation. This is especially true for experimentation, during which, from design to results, the findings are all based on speculation.

Different approaches to understanding lead to revelations about different aspects of the body theory concerning acupuncture. Observation, feeling and dissection can provide evidence for the morphological signs of the meridian and acupoint theories, such as pulse and depression on the body's surface. Then, speculating methods such as analogy and reasoning enable the construction of the meridian and acupoint theories. Holography is tinged with the strongest colour of speculation, and its theory is formed as a result of observation; the application of holographic theory to the human body endows acupuncture with a holographic knowledge, the approach and findings of which have not been confirmed by scalpels or physiological experiments under the mechanistic view of the body. Physiological experiments conducted in the laboratory were originally intended to explain the existing meridian theory, but they inadvertently opened up a physiological picture of the body's surface–viscera correlation. Based on this correlation, one can establish that the body under the knowledge system of acupuncture is actually one full of connections, where the above and down parts,

the inside and outside parts, and the whole, are all connected by physical or imaginary means. Such a correlated body is different from the beautiful bodies in the artist's eyes, the strong bodies of athletes, and those under the surgeon's knife, where each minute part is clear and visible. However, it offers a unique and open approach to thinking about the body, and it proves the possibility of understanding nature in diverse ways.

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On the diversity of scientific culture and the tradition of postpartum confinement in China

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Abstract
This paper observes the practice of postpartum confinement by urban women in China with high educational levels from the perspective of cognitive conception and behavioural practice. It reveals the cognitive conflict and self-adjustment in these women between 'modern health notions' and 'traditional medical practices', and analyses the rationality of the long-standing presence of and local differences in the practice as a traditional postpartum nursing behaviour for Chinese women. Moreover, this paper emphasizes the important value of postpartum confinement as a kind of local knowledge and holds that adhering to and advocating the locality and diversification of knowledge, including scientific knowledge, is conducive to the long-term coexistence and sustainable development of different knowledge traditions.

Keywords
Postpartum confinement, local knowledge, diversity, scientific culture

1. Introduction

With the introduction of modern science into China and its popularization, the concept of science (including modern medicine) has produced great impacts on Chinese lifestyle and has also caused conflicts with some traditional life practices. One example that has been controversial in recent years is the issue of 'postpartum confinement' after women's childbirth. Postpartum confinement is one of the few traditional practices that persist in Chinese daily life, although the practice conflicts with modern scientific concepts in some ways.

Postpartum confinement is a traditional practice that shows a distinct localization and remains popular amid today's wave of economic and cultural globalization, as it is an important part of Chinese women's lives. Taking as the object of investigation the local knowledge associated with postpartum confinement, this paper discusses the practice's collision with modern scientific knowledge and the resulting changes it has experienced. The paper also analyses the process of pregnant women's conceptual and behavioural self-adjustments. Finally, it reveals the important value of this special, local, knowledge-based practice in the current context of scientific popularization.

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As women with relatively high educational levels, female teachers in colleges and universities have generally received some education in modern science, medical care and health. When faced with the traditional conception and practical requirements of postpartum confinement, their cognition and behaviours can typically reflect the collision between local knowledge and so-called universal knowledge. Compared with obstetricians and other women who have lower educational levels, an investigation of female teachers' understanding and behaviour involving postpartum confinement can better reveal the vitality and value of local knowledge. Therefore, I conducted in-depth interviews with 30 female teachers who had postgraduate educational levels at a university in Beijing from 12 March 2015 to 19 June 2015. This small sample cannot entirely present the overall situation of postpartum confinement and the cognition of female intellectuals regarding the practice. Nevertheless, this microscopic lens permits a glimpse of the entirety.

2. Theories and practices involving postpartum confinement

The following questions were asked in the interviews to analyse the interviewees' views and personal practices regarding the custom of postpartum confinement in China: What do you think of the phenomenon that Europeans and Americans do not practise postpartum confinement while Chinese women generally do? What do you think of the conflict between commonsense ideas about modern health care and the taboos observed during the month of confinement? What is your own experience of postpartum confinement? Do you think the practice of postpartum confinement can be evaluated and regulated with the standard of modern science?

2.1 Theoretical basis of postpartum confinement

Why, we ask, has the practice of postpartum confinement maintained its vitality as a traditional form of local knowledge? The most direct way to answer this question is to understand the practitioners' thoughts. Regarding the fact that new mothers in Europe and America do not engage in postpartum confinement while those in China generally do, the interviewees' explanation is that traditional Chinese medicine emphasizes the necessity of postpartum confinement for postpartum recovery.

When asked whether and why they participated in the practice of postpartum confinement after childbirth, only one of the 30 respondents thought the practice was unnecessary, but she was confined at the insistence of her elders at home. The rest of the interviewees considered postpartum confinement a necessary practice and took it seriously. This result shows that even today young women in China with high educational levels still adhere to the practice of traditional postpartum confinement. They believe the main reason for adhering to this tradition is that childbirth is detrimental to a woman's vitality, her *qi* (energy) and blood would be weakened, and her bones would endure great change. Therefore, the woman's body needs the period of recovery known as postpartum confinement. Otherwise, the woman would contract 'postpartum diseases' that are difficult to cure and may last a lifetime.

The respondents were also asked 'Why do you think new mothers in Europe and America do not need postpartum confinement?' Most of the respondents thought it is because Chinese women have weaker physiques, caused by differences between Chinese and Western diets. For example, Chinese women do not consume as much animal protein as do Western women. Among the respondents, some also believed that Western women do not treat diseases like rheumatism as postpartum diseases because they do not believe in such a thing as postpartum confinement.

In addition to referring to traditional Chinese medicine, some respondents believed that postpartum confinement is an old tradition, and it naturally makes sense for it to be popular for so long. Some also believed that postpartum confinement was helpful for the new mother as she adapted to her new identity, clarified her position in the family, and laid the foundation for subsequent engagement in professional work. These replies help to show that the practice of postpartum confinement has continued due to many factors, such as medicine, society and culture. Conversely, as a kind of knowledge-based practice, it is involved in

the construction of the cultural norms and social relations found in local societies. Additionally, as an experiential, knowledge-based practice, postpartum confinement has pervaded individual experiences and social networks, creating a unique cultural space for practitioners. Through the practice of women in postpartum confinement and their families, its effect and efficacy are recognized. Therefore, it constitutes a powerful tradition that is difficult for the tide of modernity and science to sweep away.

2.2 Experiential practices in postpartum confinement

In ancient times, new mothers learned or acquired practical knowledge related to postpartum confinement mainly from female elders at home, and the knowledge was primarily passed down by personal demonstration. At present, however, there are various channels to acquire such knowledge. Such knowledge is increasingly becoming commercialized, as manifested in obstetricians, traditional media and new media, which are convenient sources for obtaining this kind of knowledge. In addition, the spaces for those in postpartum confinement have changed from private families to public spaces such as confinement centres. Caretakers for new mothers in postpartum confinement are no longer limited to a family's female elders but also include confinement nurses hired from housekeeping companies. This reflects the commercialization of the practice. This situation means that confinement nurses, like obstetricians and relevant media outlets, have become sources, competitors and even new authorities in postpartum confinement knowledge in addition to a family's female elders.

However, since the Song Dynasty, most of the taboos involving postpartum confinement have been largely followed. The practice of postpartum confinement mainly consists of three aspects (diet, exercise and health care, and environmental control) that constitute the core of the knowledge and practice. Diet mainly encompasses two categories: one is to meet the need for maternal physical recovery and health care, and the other is to promote the mother's milk generation. For the latter, dishes mainly include pig trotter and peanut soup, crucian carp and bean curd soup and so on. For the former, *Coix* seed and red bean porridge, millet porridge and *sheng hua tang* (a special Chinese herbal soup used to clear blood stasis after childbirth) are used. When asked about dietary taboos, the respondents generally said that they should not eat raw, cold or hard food, which they thought would damage their health. Regarding exercise and health care, the respondents mentioned that they refrained from brushing teeth and washing hair, reading books and electronic products, and getting out of bed and walking around. Although many of them knew that it was neither sanitary nor scientific not to wash their hair, bathe or brush their teeth for one month, they still followed those practices to make their elders feel at ease and to maintain peace in the family. As for environmental control, almost none of the respondents strictly abided by the old practice of closing doors and windows and having no ventilation, but they all stressed that, even if premises were ventilated, it was necessary to avoid the brunt of the wind.

In summary, the knowledge sources, practitioners and spaces for postpartum confinement have changed with time in modern society, but the taboos during confinement have been largely preserved and have persisted as the core of the practice. The social function of postpartum confinement is also fully affirmed by its practitioners. Most of the interviewees are glad that they conformed to various taboos about confinement. They believe that because they conformed with the traditional requirements they have not been burdened with such postpartum diseases as dentine hypersensitivity, wrist pain or lumbago. Ju (2021) noted that local knowledge is an integral part of culture, and is formed, expressed and contributed to by members in a certain cultural background through the times. It serves the functions of judging and narrating the surrounding world, conducting exchanges and initiating actions, and it meets the needs of local people for survival and development. From this perspective, as a local, knowledge-based practice, postpartum confinement is obviously part of China's traditional culture. The practice is inherited generationally by women and plays an important role in explaining and building a healthy body and a good family relationship. In addition, the practice shows strong adaptability and functionality, and its effects have been continually confirmed and

strengthened by its practitioners throughout the ages. Therefore, even amid today's globalization, the practice remains vital.

3. Postpartum confinement and the diversity of scientific culture

3.1 local knowledge as a part of a specific culture and its stability

Chinese women's tradition of postpartum confinement has lasted for thousands of years as a kind of local knowledge. Its endurance is not only because of the theories and conceptions present in traditional Chinese medicine but also because of complex social and family contexts, which have caused the women in postpartum confinement to naturally concede to and accept those practices and pass them on from generation to generation, forming a cultural tradition.

As women with high educational levels, the 30 interviewees agreed that postpartum confinement is necessary for postpartum recovery. Although they were not very clear about the relationship between the various practices and taboos for physical recovery and specific Chinese medical theories, they insisted on their importance. The major reason for this belief was their fear of suffering from incurable postpartum diseases, although they could not establish a clear causal relationship between postpartum diseases and not undergoing postpartum confinement or not doing it well. In addition, some interviewees mentioned the need to use postpartum confinement to transform their familial role as mothers, to obtain spiritual comfort, to establish their position in the family, or to strengthen their body condition for subsequent professional work. They followed the practice of postpartum confinement for fears of health detriments, because of respect for their family elders, or because they hoped to confirm their family status and social identity. All of these considerations indicate that their cognition of and attitude towards the practice were influenced by multiple social and cultural factors. Postpartum confinement is a kind of culture and lifestyle beyond the scope of medicine and health care. It is a hybrid of knowledge, culture and belief that is not only the product of a specific cultural tradition but also an organic part of the whole culture.

Therefore, as local knowledge in a specific cultural tradition, postpartum confinement is a strongly stable practice. Almost all the interviewees thought that taking care of a woman in postpartum confinement is a female's duty. Only two of the interviewees hired specialized postpartum nurses, while the others were taken care of by their mothers or mothers-in-law, and all the postpartum confinement spaces were within the family's space. The interviewees can acquire knowledge about confinement through various channels, and they are armed with modern health-care concepts; they also know that no postpartum confinement tradition exists in Europe or America, and that many confinement centres engage in scientifically guided confinement services. However, they essentially followed the practices outlined by their female caregivers even if they engaged in arguments and negotiations. Those few respondents who did not comply with or strictly follow the requirements of their mothers or mothers-in-law experienced relatively low satisfaction regarding their postpartum confinement, and some even felt regret.

In this context, modern science, which advocates a unified and standardized knowledge criterion based on mathematics and experiments, has encountered difficulties. The respondents made their choices and adjustments between modern scientific knowledge and health concepts and traditional confinement rules based on their consideration of complex factors besides science. This shows that the acceptance of a certain knowledge or cultural tradition is not based solely on science. Furthermore, there exists no pure science or knowledge that is divorced from social culture and practice. Additionally, the negotiations and arguments about the practice of postpartum confinement have shown that power relations permeate knowledge activities; that is, theoretical knowledge is understood in use rather than in static conformity (or inconsistency) with the world, and power relations constitute the world in which specific actors live (Rouse, 2004). The long-standing tradition of postpartum confinement shows that specific cultural and social factors and even power relations constitute internal parts of knowledge, and that there is no universal knowledge independent of a specific culture. Therefore, the power of knowledge is manifested in its overall strength after its integration with culture

and society. Moreover, that power is often consolidated by and manifested in long-term practices in daily life, thus gaining tremendous stability. As Tian (2021) states, 'The longer the history of a knowledge system, the stronger its historical basis; the value of traditional knowledge is endowed and developed in practice.'

3.2 The contextuality and heterogeneity of knowledge and the long-term value of cultural diversity

The dependence of knowledge on culture or context leads inevitably to knowledge heterogeneity and diversity. Even within a certain local knowledge found in a particular culture, obvious heterogeneity can be found. In this study, which takes as its object only a small number of women with high educational levels, although the traditional taboos associated with postpartum confinement are basically similar, different new mothers showed differences in their confinement practices due to such factors as personality, dietary habits, locality and caregivers.

Regarding the diet, a major difference is that rice is a staple for those in the south of China while wheat is mainly consumed in the north. The south and the north also differ in how the diet should affect a new mother's milk production and postpartum recovery. For example, drinking more rice wine is advocated in the south, while millet porridge is favoured in the north. These differences become more prominent when a mother-in-law in the south takes care of her daughter-in-law from the north or a confinement nurse from the south cares for a new mother in the north. The process requires mutual accommodation and compromise between the mother- and daughter-in-law as well as better communication between the new mother and the nurse. In other words, how to conduct the confinement depends on negotiations between each new mother and her caregiver, so the 'confinement diet' will be different. The same is true for the practices of shampooing, bathing, brushing one's teeth and exercising. Therefore, in the greater custom of postpartum confinement, a number of small traditions are local and have strong contextual characteristics that vary by person and place. For this reason, when they were asked 'Do you think it is possible to evaluate and standardize postpartum confinement with modern health care as the standard?', most of the respondents held that it would be difficult to evaluate the practice by a single scientific standard of modern medicine. Moreover, they held that it would be difficult to implement in practice a modern medical standard to uniformly guide and standardize postpartum confinement.

Joseph Rouse explained Martin Heidegger's concept of 'understanding' as follows: 'Understanding is local and concerns survival, which means that it is subject to specific contexts and embodied in the tradition of explanatory practice handed down from generation to generation, and exists in people shaped by specific contexts and traditions. And understanding is not a conceptualization of the world, but a performative grasp of how to deal with the world' (Rouse, 2004: 65). This explanation illustrates well the different understandings of postpartum confinement traditions and practices among the interviewed women as well as their understanding of and persistence in the diversity of the traditions themselves. As revealed by Bruno Latour and Steve Woolgar in their ethnographic research on the science laboratory, the constructive, contextual and heterogeneous characteristics of knowledge have also been demonstrated in this investigation and analysis of postpartum confinement.

The interviewees' different attitudes and the constructive, contextual and heterogeneous characteristics of knowledge show that any kind of arbiter's knowledge that proclaims to be universal does not exist. Thus, the rationality and value of knowledge need to be understood and explained in the cultural tradition on which it depends for survival and continuation; and local knowledge in a particular culture cannot be measured against a so-called arbiter who is divorced from any context. The survey reveals that authority over postpartum confinement knowledge remains with a family's female elders and new mothers; however, that authority is facing increasing challenges. For example, as postpartum confinement institutions are established, such a service market becomes more popular, and various scientific postpartum nursing manuals are published. Women's postpartum confinement has increasingly become a competitive

field for the rights to make statements, claim power and earn capital. From a local knowledge perspective, the so-called universality of knowledge is a process of knowledge's standardization or generalization; that is, the process of a power struggle for knowledge (Liu, 2021). While recognizing this fact, one cannot devalue other knowledge-based traditions (including women's experiential knowledge traditions) in the name of science; nor can one deprive women practitioners of their choice among daily life practices in the name of science. Furthermore, the diversity of knowledge, like that of genes and culture, has long-term significance for the overall sustainable development of human civilization.

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Understandings and misunderstandings of *gua sha*: A discussion from the perspective of scientific multiculturalism

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Abstract
As a traditional therapeutic practice, *gua sha* (刮痧) has been controversial because of its differences from the theoretical understandings of modern Western medicine. This paper presents an analysis of the historical evolution of the concept, treatments and theoretical origins of *gua sha* based on previous studies and examines the practice of *gua sha* from the perspective of scientific multiculturalism. It stresses that the body concept and the medical theory represented by this therapy are also parts of science in a diversified and broader sense. The resolution of disputes about *gua sha* requires a change in people's conservative mindset to adopt a position of scientific multiculturalism.

Keywords
Gua sha, body concept, traditional Chinese medicine, scientific multiculturalism

1. Introduction

Gua sha (刮痧)[1] is a traditional medical therapy that is popular in China. Recently, a female star's photos on the internet of her bloody back from *gua sha* treatment started an online debate: some people thought that excessive 'dampness evil' in the body had caused such a heavy concentration of scar-like markings on her back; some believed it was dangerous to scrape the skin to such a degree, as it might lead to rhabdomyolysis and acute renal failure. In 2001, the film *The Gua Sha Treatment*, directed by Zheng Xiaolong, presented a plot in which misunderstandings relating to *gua sha* therapy were the main theme. The film tells a story in which a grandfather treats his grandson using *gua sha* while they are in the United States, and this raises suspicion of child abuse by the authorities. Because *gua sha* involves the creation of areas of purple–red 'blood stasis' marks on the skin, it can be viewed as torture in the eyes of Westerners. This kind of traditional Chinese medicine (TCM) practice is difficult to explain and is not recognized by modern Western medical theorists. The film shows the many kinds of difficulties that Chinese immigrants in the United States have encountered because of cultural conflicts, and it highlights the great differences between Chinese and Western medical cultures.

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Since the 1990s, *gua sha* has become popular and widely recognized in China as people pay more attention to health care. However, not only it is difficult for Westerners to accept this mysterious oriental therapy but *gua sha* is also controversial among Chinese people. On the one hand, some people like it and believe in its therapeutic effects; on the other hand, some people question its validity and suspect that it is a pseudoscience. Coverage of *gua sha* by the media has also focused on publicizing its modes of treatment and purported curative effects. Its particularities are also manifested in the fact that, as an external therapy with strong local cultural characteristics, it has been widely applied in rural areas until the present day. Nonetheless, the history of its development is one of ups and downs. It flourished in the Qing Dynasty, attracting the attention of doctors and leading to the publication of dozens of medical monographs. However, in contemporary vocabulary and professional books, there are still different opinions on the definition of '*sha*' (痧) (Ji, 2008). This phenomenon has not been paid enough attention in the history of science, medicine, science communication, health communication and other related fields. It is difficult to explain the kinds of disputes and problems that have arisen around *gua sha* without an in-depth analysis of the above-mentioned state of *gua sha*. Therefore, by summarizing the historical evolution of the concepts and theoretical origins of *gua sha* in China's medical history, and from the perspective of the theory of scientific multiculturalism combined with social-background factors, this paper presents an in-depth analysis of the body concepts reflected in this therapy and the medical culture it represents so as to seek out an understanding of *gua sha* and find solutions to its problems.

2. Historical evolution of *gua sha* therapy

2.1 Concept and historical connotations

There is no uniform definition of the concept of the *gua sha* therapy in the major contemporary dictionaries and medical reference books, as there was no authoritative and prevalent definition of the therapy in ancient medical books. Therefore, referring to Ji's (2008) systematic study of the therapy in his doctoral thesis, this paper briefly describes and interprets the history and development of its concept in combination with general analyses by several other researchers in the history of TCM. In the related TCM literature, we find that the therapy has had different meanings in different historical periods.

First, *sha* was understood to come from water worms as stated in one study (Yang et al., 2007), *sha* had its origin in the Chinese word for 'sand' (沙), and scholars from the Ming and Qing dynasties and in modern times declared that the *sha* syndrome originates from diseases associated with water (stream poison, worm poison and sand-lice poison). Among these, the worms and poison are reflected in the early Chinese idiom 'han sha she ying' (含沙射影, meaning that a water worm called Yu can attack people and cause similar symptoms to typhoid fever by shooting at people's shadow with water mixed with sand). Sand-lice diseases, as mentioned in the Jin Dynasty, were said to need to be picked and scraped out, as exemplified in the *Handbook of Prescriptions for Emergencies* in the Eastern Jin Dynasty, the *Excerpts of Prescriptions* in the Southern and Northern dynasties, and the *Supplement to Materia Medica* in the Tang Dynasty, all of which make mention of the symptoms and treatments for diseases caused by worms. However, the names of diseases with the same concept as the syndrome of *sha* were not found before the Song Dynasty; nor was there any description of any therapy similar to that referred to in later generations (Ji, 2008).

Second, the concept of *sha* disease was established the Song, Yuan and Ming dynasties were important periods for the development of medicine concerning the *sha* syndrome. The concept of 'sand disease' was recorded for the first time in the Southern Song Dynasty (Wang and Yang, 2010), after which mentions of *sha* increased, and its name, etiology, pathogenesis, symptoms and treatment were described. For example, in the *Complement to the Secret Prescriptions of Sun Rencun's Living Therapy* in the early Yuan Dynasty, *sha* was called 'sand disease', the cause of which was considered to be mountainous evil air rather than poison spurted from worms. It was noted that 'the place where blood stasis marks are caused by the skin being rubbed on a rope today is the place through which the Yang meridians pass. Then the pathogenic

factors are purged, and the disease is cured' (Sun, 2008: 319). The described therapeutic mechanism is closer to the therapy for the *sha* syndrome mentioned in later generations, and especially to the method of rubbing out purple spots on the skin with a rope, which is referred to as 'outing of *sha*' in later generations. In the Yuan Dynasty, 'twisted intestinal disease' was regarded as a subcategory of *sha* for the first time. Later, 'typhoid fever', 'the watery sand disease' and other names appeared. On the basis of understanding the *sha* syndrome in the Song and Yuan dynasties, its etiology was further discussed in the Ming Dynasty, the *sha* syndrome was differentiated into cold and heat variations, and the scope of *sha* was further expanded.

Third, various epidemics were included in *sha* the epidemic in the Qing Dynasty gave birth to a group of experts and medical books on *sha*. The first monograph—Guo Zhisui's *Sha Zhang Yu Heng*— appeared, which, together with Wang Kai's *Encyclopaedia of Sha Disease* (*Sha Zheng Quan Shu*) and the monk Pujing's *Profound and Subtle Works of Sha Disease* (*Sha Zheng Zhi Wei*), established a system of theories different from those of earlier generations. This drew more attention to *sha* from the public and medical circles, and the content concerning 'swelling *sha*' evolved into treatment against epidemic diseases, especially those with characteristic symptoms of 'swelling and inner pressurizing'. The causes of these diseases were considered to be plague, as with other epidemic diseases; they were also understood to be caused by foul gases, summer heat and unhealthy vapors, which were related to 'sand disease' described before the Qing Dynasty. In its heyday, it was considered that 'no one is free of *sha*, and there are no symptoms without *sha*'. Therefore, different names, such as 'swelling *sha*', 'smelly drugs', 'foreigners' *sha*', 'yin–yang toxins', 'plague *sha*', 'epidemic *sha*', 'spotted *sha*' and 'inner evils' were coined: there are more than 100 kinds of diseases and syndromes named after *sha* (Wang et al., 2012).

2.2 Evolution and development of the skin-scraping therapy

Most scholars believe that *gua sha* therapy is closely related to stone needle, acupuncture, hot ironing, massage, cupping and blood-letting in their sources and evolution. In this sense, the history of *gua sha* therapy can be traced back to the pre-Qin era more than 2000 years ago (Yang et al., 2007). For example, the *Prescriptions for Fifty-Two Ailments* recorded: 'roast the cloth for ironing' and 'caress the skin with the cloth'; although this was still in the primary stage of *gua sha* therapy, more specific technical requirements were imposed (Ming, 2004). In medical books such as the *Handbook of Prescriptions for Emergencies*, the methods of brushing, scraping, picking and moxibustion were adopted to expel sand lice invading the skin. Although the exact date when scraping therapy was invented is unknown, it had been widely developed and popularized among the public for a long time. Later still, during the Song and Yuan dynasties, the methods of scraping the back with a spoon and using copper coins dipped in water or oil to treat abdominal pain were widespread and attracted the attention of medical scholars. The 'rope rubbing' and 'hemp scraping' methods that appeared in the Yuan Dynasty further laid the foundations for the scraping method and made it clear that these external treatments can cause dots or spots on the skin in an approach aimed at 'opening up the muscular interstices, relieving stagnation, promoting the circulation of *qi* and blood, and expelling pathogenic factors' (Ji, 2008: 64).

By the Qing Dynasty, the therapy of *gua sha* was very popular, and some new progress was made in the treatment. The sources, prevalence, manifestations, classification, methods, tools and comprehensive treatments for more than 80 kinds of disease were discussed in detail in Guo Zhisui's *Sha Zhang Yu Heng*. In addition to traditional methods of detecting *sha* points, checking *sha* tendons and testing *sha* prescriptions for diagnosis, the theory that 'strange diseases are called *sha*' was also put forward, which meant that there were no definite pulse signs or symptoms for *sha* syndrome. As for the specific treatment, Guo (1675: 5) put forward three methods: scraping, blood-letting and drugs. 'If *sha* is on the skin, scrape the skin; in the flesh and blood, release the blood; in the stomach, intestines, meridians, spleen, liver or kidney, use medicine. If it is widespread and rampant, existing both outside and inside, the three methods shall be used at the same time.'

The treatment proposed by Pujing in his *Profound and Subtle Works of Sha Disease* includes scraping, pricking, moxibustion, ironing and medication, with a combination of scraping and pricking the acupoints as the main external treatment, and there are great changes in the parts for scraping and pricking, which cover the acupuncture points over the whole body (Ji, 2008). Wang Kai's *Encyclopaedia of Sha Disease* declares that 'for *sha* treatment, the most important factor lies in the use of the hand', and it provides the method of touching the spot with the end of a burning lamp wick as external treatment for 'patients with *sha* on the muscle surface'. It also proposes that scraping is for 'patients with *sha* within the skin which cannot let out', while pricking is used to let out blood (Wang, 1876: 62–63). Later, a method of 'pricking with the tip of one finger' appeared in association with a massage school. Literature covering acupuncture and relieving *sha* treatments was thus greatly enriched in the Qing Dynasty. Due to the over-expanded scope of *sha* therapy, epidemic diseases and many unknown diseases were classified as *sha*. However, with the introduction of epidemiology from Western medicine in the late Qing Dynasty, *sha* disease began to fall sharply in scope (Ji, 2008).

After the founding of the People's Republic of China, until 1960, a book by Jiang Jingbo titled *Therapies for Gua Sha* was published, in which the term '*gua sha*' as *sha* therapy was used to encompass scraping, blood-letting and patting. This initiated modern research into the scraping therapy for *sha* and made it possible for the therapy—which had previously been confined to the *sha* disease and to bringing about blood stasis marks—to become established in academic circles and gave the therapy its due (Yang et al., 2007). *Gua sha* therapy appeared as an approach to achieving good health under the advocacy of Professor Lv Jiru in the 1990s, and the instruments, tools and media for scraping were updated accordingly. As the works of Lv's followers came out one after another, the therapy was not only brought onto the stage of medical care, but was also promoted to be included in textbooks, and it finally became a more accepted aspect of health care (Ji, 2014).

Gua sha therapy has experienced ups and downs, but, on the whole, it has evolved 'from superficial, intuitive, singular and experiential therapy to one of natural therapies with systematic theoretical guidance, complete techniques and improved tools, which are suitable for a wide range of diseases' (Yang et al., 2007). *Gua sha*, in parallel with acupuncture, massage and cupping, has become to be one of the four basic skills of TCM practitioners.

3. The theory of *gua sha* and its body concept from the perspectives of TCM and Western medicine

As described above, *sha* disease had different characteristics in different historical times. With people's constant struggles against disease, experience in *gua sha* therapy has been continuously improved, and theoretical research examining the therapy is constantly changing and developing.

3.1 The traditional theoretical basis of TCM

Before the Yuan and Ming dynasties, *gua sha* was widely conducted as an external therapy among people, yet there are only sporadic records of it in medical classics, and it is not valued by orthodox Chinese medicine. Although ancient physicians held different views on the names, symptoms and pathogenesis of *sha*, they had basically the same understanding of the mechanism of its treatment; that is, by scraping. By the Yuan Dynasty, Sun Rencun and Wei Yilin began to elaborate on the principles of *gua sha*, which were further improved by various physicians in the Ming Dynasty. In summary, it was described as mainly serving to 'open up the muscular interstices, promote the circulation of *qi* and blood, dredge collaterals and expel pathogenic factors' (Wang and Yang, 2010). Ancient physicians' scattered research on *sha* finally made a breakthrough in the Qing Dynasty. The theoretical system of 'swelling from *sha*' represented by Guo Zhisui's classification of the nature of *sha* swelling as a heat-excess disease was developed, for which an educing method was mainly adopted, and that was quite different from the methods used in the Song and Ming dynasties. Although it also caused controversy, this laid the foundation for the differentiation of *sha* in the Qing Dynasty (Ji, 2008).

In terms of therapeutic mechanisms, the theory of meridians in TCM was introduced to treat *sha*. Guo described a corresponding relationship between the diseased location and symptoms from the perspective of the six meridians and viscera, but he failed to explain the internal relationship and transmission between each meridian and the viscera (Ji, 2008). In the early Qing Dynasty, syndrome differentiation and the theories of experts regarding *sha* appeared to be in a state of disorder, and that laid the groundwork for the disorderly expansion and final decline of *gua sha* therapy (Ji, 2008).

Researchers considering *gua sha* in recent years also recognized the theoretical basis of the meridian theory (Chen et al., 2014). For example, Cao et al. (2019) revealed the reasons that *gua sha* works through the theory of skin and collaterals: 'The skin is the direct part where *gua sha* works as well as the external part through which reaction with *qi* and blood of viscera and meridians is achieved; collaterals are scattered all over the body, communicating the exterior and interior, connecting the viscera and infiltrating *qi* and blood, which are closely related to the skin.' Huang (2018) further pointed out that scraping the body parts along the meridians not only follows the theory of acupoints in the meridians but also conforms to the theory of viscera state, holography, blood stasis and the bodily-axis theory.

The method for achieving good health by scraping is represented by the ideas of Professor Lv Jiru, who put forward the possibility of reinforcing or reducing the intensity of scraping by using different postures of the fingers. He holds that 'scraping brings *qi* to the body', thus restoring the circulation of *qi* by meridians and bringing recovery (Lv and Lv, 1997). It is considered that 'according to the direction of meridians, forward scraping is for reinforcement, and reverse scraping is for reduction' (Lv, 1995: 19–22). Lu et al. (2016) also emphasized that 'in scraping therapy, as in acupuncture, an appropriate method (i.e., reinforcement of good *qi* or reduction of bad *qi*) can be used according to the patients' physical constitutions and specific diseases for the purpose of strengthening the body's immune system, eliminating pathogenic factors and adjusting *yin* and *yang*'. Traditional physicians hold the view that *gua sha* 'is purely for reducing bad *qi* rather than reinforcing good *qi*', whereas contemporary physicians, represented by Professor Lv, believe that, similarly to acupuncture, acupoints have a two-way benign regulatory effect on the body; scraping serves not only to eliminate evil factors but also to strengthen the body, and its reinforcing and reducing effects are closely related to the selection of acupoints and the skill of the practitioner in using the scraping tools (Gan et al., 2021).

The meridian theory of TCM is thus the main theoretical core governing scraping. TCM states that external stimulation (including acupuncture, massage, etc.) of the meridians and collateral systems can accelerate the movement of *qi* and blood in the corresponding parts of the body, thereby contacting the viscera, liver and other organs and changing the state of the whole body to adapt to different environments in the diseased state. In addition, TCM also holds that various diseases appear as different symptoms under different conditions, including the directions of various meridians. The distribution of *qi* in collaterals enables its connection with the *qi* and blood in meridians and viscera in the body. As an external therapy, scraping for *sha* serves to dredge meridians and collaterals, regulating *qi* and promoting blood circulation, thereby playing a role in both diagnosis and treatment. *Gua sha* thus embodies the body concept in TCM, which is a philosophical and comprehensive way of thinking with integrity and harmony, advocating a balance to be struck by moving *qi* and blood to follow meridians, strengthening the body's immunity and eliminating evil energy, and connecting *qi*, meridians and viscera (Zhang, 2016).

3.2 Modern theoretical medical explanation

Under the influence of modern Western medicine, there is a tendency within research in contemporary Chinese medical circles involving *gua sha* to attempt to further explore the modern scientific (medical) theories underlying scraping based on traditional medical theories and clinical practice. Professor Lv Jiru carried out experiments on the effect of scraping on haemorheology in rabbits and concluded that the mechanism of *gua sha* could strengthen metabolism (Ji, 2014). Wang and Yang (2010) continued that work, and they believed that

the mechanism of *gua sha*—opening up the muscular interstices, promoting the circulation of *qi* and blood, and dredging collaterals and expelling pathogenic factors—was basically consistent with the functions of improving microcirculation, regulating immunity and strengthening metabolism formulated in modern research. Huang (2018) summarized the traditional medical theories concerning *gua sha*, pointing out that the mechanism of *gua sha* in the treatment of some related diseases is difficult to explain based on modern medical theories; he suggested that the theoretical mechanisms of modern medicine should be explored from the perspectives of morphology (observing the morphological changes of local tissues after *gua sha*), immunological research (causing the release of immune factors by conducting the stimulation produced by scraping into the immune system), microcirculation (the blood perfusion of local skin microcirculation after *gua sha* is higher than that in patients treated by other methods), antioxidation (*gua sha* serves to improve certain peroxide indicators) and nerves–immunity–internal secretion. Xu (2015) put forward the hypothesis that *gua sha* stimulates the skin to release neurotransmitters, which are then transmitted to the central nervous system to release corticotropin-releasing hormones to regulate human metabolism, strengthen immunity and maintain the homeostasis of the internal environment.

In recent years, with the wide application of *gua sha* in clinics and in health care, the theory of 'scraping following the direction of the meridians' was put forward when Wang et al. (2021) pointed out that mature science and technology should be the perfect combination of theories, methodologies and techniques. It is thus necessary to theoretically sublimate and clinically improve traditional scraping therapy within the theoretical system of TCM. They also suggested that quantitative research should be carried out on the force used in *gua sha*, alongside objective research evaluating the degree of blood stasis marks and other signs manifested. This helps to strengthen scientific support for *gua sha* and promote the perfection of theories and the construction of disciplines regarding 'scraping following meridians', and thus to standardize the clinical application of the therapy and improve its therapeutic effects.

4. The philosophical position behind the pluralistic understandings of *gua sha*

Gua sha, as an experiential therapy, has been rooted in folk medicine in rural areas since ancient times, and it was incorporated into orthodox theoretical medicine by doctors in the Ming and Qing dynasties. Since the 1990s, it has taken on a new perspective through its combination with health care. It could therefore be said that *gua sha* is not a surprise for anyone who has been immersed in Chinese culture (Ji, 2008). However, there are still a large number of people with scientistic views who question or deny the value of the therapy. Even among Chinese medicine researchers, there seems to be a lack of sufficient confidence in TCM theories concerning *gua sha*. Either by advocating to improve the existing theory of 'scraping following the meridians' using quantitative research and objective evaluation or by directly borrowing theories and concepts from Western medicine to explain the clinical effects of *gua sha*, they are trying to build a 'coincidence' between Chinese and Western medicine in many theories to show the 'modernity' contained in TCM (Liu, 2011). However, the curative effects of *gua sha* can be only partially proved with the help of various explanations from Western medicine, and it is still difficult to explain its mechanism; it is thus necessary to resort to the theory of Chinese medicine (Ji, 2014). Judging from the tortuous development of the therapy, although doctors' opinions have been controversial in different periods, they have continued to borrow statements from TCM until their discoveries were fully incorporated into the theoretical framework of TCM, thus avoiding the blindness and limitations of folk scraping to move towards obtaining stable support and development. This indicates that the therapeutic principles and the effects of *gua sha* remain essentially the same despite all of its apparent changes, and this reflects the body concept in TCM and the inclusiveness and stability of TCM theories and culture.

The phenomenon of TCM being judged from the perspectives and methodologies of Western medicine leads one to a realization that reveals a very typical philosophical standpoint about science and culture. In reality, some people are sceptical about

gua sha therapy because they are not only unfamiliar with the theories of TCM and its underlying body concept, but they are also under the inevitable influence of the monistic science (medicine) culture that currently occupies the mainstream position in China. This holds that only Western medicine, which is quantifiable and verifiable with double-blind experiments, has an objective, correct and effective cognitive system. Therefore, if we maintain the position of Western science (medicine) monism and think that there is only one 'truth', then TCM therapies that cannot be verified using Western science are not true and not convincing. The theory and standard of Western medicine should not be used to measure the treatment of TCM. *Gua sha* conforms to TCM theories—treatment following the meridians and strengthening the body's immunity and eliminating evil energies. It would inevitably seem to be far-fetched when verified and explained with modern scientific (medical) theories. In addition, as the health-care boom of recent decades continues, some pseudo Chinese medicine practitioners falsely using the name of TCM have also caused some adverse effects with their abuse and misuse of *gua sha*. Therefore, dirt has inevitably been thrown at the theories and therapies associated with TCM, and the public might easily regard these incidents as evidence of inherent problems in TCM.

In terms of the philosophy of science, TCM and Western medicine belong to different theoretical systems under different paradigms, so they have a degree of incommensurability. Elements of the body in TCM include the mind, *qi*, meridians, collaterals and viscera; conversely, in Western medicine, the human body is dealt with from the aspects of cells, molecules and genes. The dualism of body and mind in Western medicine removed obstacles to the development of modern medicine and anatomy, but at the same time it led to the neglect of psychological factors and to the separation of 'diseases' and 'the person', and this dualism of body and mind has gradually come to be criticized due to its deficiencies and negative effects. TCM adheres to the philosophy of the unity of the body and mind; the ancient body theories found in TCM constitute a simple and unified understanding of the body and mind, form and spirit, and this provides theoretical resources for modern people to better understand life, health and diseases using a holistic and interactive view of the body (Zhang, 2016).

Looking at the formation and development of *gua sha*, it can be seen that it evolved as a product of long-term practical experience accumulated by ancient folk doctors. It moved towards the orthodox theories of TCM occasioned by the great epidemic in the Qing Dynasty, before finally entering the academic sphere, when it expanded along a professional road to medical treatment and health-care provision with the help of commercial promotion. We thus find that it is not only closely related to the traditional social culture of China but is also inseparable from the diversity, inclusiveness and openness of the Chinese medicine system itself. If we mistakenly pursue all the paradigms and theories of Western medicine to understand and evaluate *gua sha* therapy, that is tantamount to cutting one's feet to fit one's shoes. In short, from the standpoint of monism in science, 'traditional medicine such as TCM can never be properly treated, nor can it be developed ideally' (Bao and Liu, 2017). Therefore, what urgently needs to be changed is first and foremost a matter of our standpoint.

5. Discussion and conclusion

To summarize: it is of great practical significance to analyse and explain the phenomena of *gua sha* from the perspective of scientific multiculturalism and to promote the role of reflective science communication.

First, the controversy around *gua sha* reveals the standpoint of ubiquitous monism regarding Western science on the part of not only Western people but also the public in China, and this is inevitably permeated with the influences of social science and culture. What contemporary society is therefore facing is the lack of an educational environment that can promote scientific multiculturalism. Since Western medicine has gradually become the mainstream discipline worldwide, including in China, near-universal trust in and admiration of Western medicine exists widely in education and mass-media communication; inevitably, it has even infiltrated vocational education, training and development in TCM.

Second, the concept of scientific multiculturalism has so far been the outcome of interdisciplinary research

that has absorbed the achievements from many disciplines, including the philosophy of science, the history of science and technology, and the study of science, technology and society; there have been many research achievements that have seriously criticized the concept that science is universal, de-contextualized and de-localized. From this philosophical standpoint, science is not only diachronic, but also contextual, and in essence belongs under the umbrella of local knowledge. A concept of diverse sciences that does not pursue uniformity and standardization should be advocated, and a broad cognitive and receptive attitude towards local ethnic medicine should be adopted. Traditional therapies such as *gua sha* are also kinds of local medicine (science) that have arisen from traditional Chinese culture and history, so they should be included, and in fact they are already in a diverse and multicultural system of sciences.

Finally, the above analysis reminds us of the importance of instilling the concept and importance of scientific multiculturalism in the public. This is also the essence of replacing traditional 'science literacy' with 'science culture literacy', as currently advocated by science culture researchers. To promote the public's understanding of science (medicine), what we need to disseminate should not be just scientific (medical) knowledge, or rather, the first priority is not knowledge, but a diversified concept of science in a broader sense. People's overall understanding of science should be promoted so that their recognition of science as a human cultural and social activity that also has cultural and social attributes can be enhanced (Yue and Liu, 2019). This places greater requirements on researchers and practitioners of science communication, especially practitioners in the medical and health fields, in which a change towards the concept and position of scientific multiculturalism is required.

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1. The current universal translation of '刮痧' is the transliteration '*gua sha*'. This is the general term that is used for this traditional Chinese medicine therapy in this article, while 'scraping' emphasizes the specific scraping actions that are used in the therapy.

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Feng shui and the scientific testing of chi claims

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Abstract

This paper documents the long history of *feng shui* belief and practice in Chinese culture, and its spread worldwide in the past half century. It shows that commitment to the peculiar *qi* or chi entity is central to *feng shui* and more generally to traditional Chinese writings on medicine, astrology, philosophy, politics, literature, natural philosophy and science. Despite their centrality and omnipresence, chi claims have rarely been scientifically appraised. This is, in part, because they are stated so vaguely and mysteriously that no definite test is possible. This paper examines, and refutes, the claims of one rare but well-credentialled, multi-university-based research programme affirming the reality of chi. The paper shows that the cost of seriously endorsing a chi-based explanation of any putative effect is a rejection of the entire ontological, epistemological and methodological edifice of modern science. Chi explanations are incompatible with both a methodological and an ontological naturalist understanding of science.

Keywords

Feng shui, chi, *qi*, energy, holism, naturalism, Qigong, Yan Xin

1. Introduction

Feng shui (wind–water) is an ancient East Asian cosmological, seemingly naturalist, world view. It is a system of beliefs and practices that grew out of Chinese Taoist culture some 3000–4000 years ago.[1] It is concerned with identifying, charting and utilising the supposed all-encompassing flow of chi or *qi*—the universal life force that binds together humans, nature and the cosmos. Kuang-Tai Hsu, a Taiwanese historian of science, surmised:

> One can say that Chinese culture is a kind of culture of *qi* with many ideas expressed in terms of *qi*, including fields of natural knowledge or so-called science. According to the natural philosophy of *qi*, everything, including heaven, earth, the myriad of things, human beings, and so on, is composed of *qi*, which moves everywhere in the cosmos. Thus, *qi* was seen as the most fundamental reality for the Chinese in ancient times. (Hsu, 2016: 92)

The core idea of *qi* has, with some modifications and elaborations, persisted through Chinese history across a spectrum of religious, ideological and political regimes. The idea is omnipresent in long traditions of Chinese writings on medicine, astrology,

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philosophy, politics, literature and natural philosophy or science, through to, and including, the contemporary Communist Party regime.[2] The theory and practice of *feng shui* fully embrace *qi* and are unintelligible without it.

Despite its naturalism, and its avoidance of supernatural entities and their oft-related worldly interventions,[3] the scientificity of *qi*, or chi belief, has been subjected to only minimal investigation; nor have the claims of *feng shui* regarding the effects and mechanisms of chi been scientifically tested. Many 'studies' have been devoted to chi-based treatments and interventions in acupuncture, housing design, interior decoration, and even divination, but almost no attempt has been made to isolate how much of the identified effect is a chi effect and how much is a more routine and scientifically explicable effect.[4]

This paper, in part, examines the claims of a rare scientifically credentialled research programme on *feng shui* that is capable of being scientifically tested. The paper shows that the cost of seriously endorsing a chi-based explanation of any putative effect is a rejection of the entire ontological, epistemological and methodological edifice of modern science. The practice of science and serious belief in chi are incompatible with each other.[5]

2. The origins and spread of *feng shui*

The term *feng shui* was introduced to Chinese culture by Guo Pu (276–324 AD) in his *Book of Burial* in the early fourth century AD (Guo, 2004). It was originally a low-level and pragmatic system of eclectic advice for coping with rural and town life; it consisted of a mixture of transmitted craft knowledge, astrology and traditional medical practices. Since at least the nineteenth century, the concept and content of *feng shui* have become more sophisticated and more theoretically grounded. It now presents itself as a natural science—a system that, just like modern science, lays out the basic energy-centric ontological and causal features of the world. For adherents, *feng shui* knowledge enables the harmonisation of people's lives and habitat with the universal life force. Human life can thus be lived more consistently with nature to become more natural and healthy, leading to physical and psychological improvements. The cosmic naturalism of *feng shui* informs town planning as well as residential and commercial architecture; it is used to identify auspicious days and, with informed guidance, reveal the future by underwriting personal divination.

Feng shui has long spread beyond Asia to assume a global commercial and personal presence. As one writer opined, 'feng shui is no longer just an ancient Chinese secret. While slow to take root outside of its original heartland, it is now global and transcends culture and politics' (Knoop, 2001). *Feng shui* is a routine part of town planning and architecture programmes at universities (Mak and So, 2015). Many municipal and local authorities have in-house *feng shui* consultants who pass judgement on building applications, land subdivisions and a variety of other issues. In most of Asia and much of the US West Coast, real estate sales and prices are contingent upon *feng shui*-based evaluations of the sites or buildings. One scholar has noted the following:

> In recent years, feng shui has grown surprisingly popular in Western Europe despite a lack of clear understanding about how and why it is practised. Its proliferation within the architectural profession can be observed at all levels from the selection of building sites to interior design. (Hwangbo, 1999: 191)

Articles on *feng shui* are regularly published in respectable town planning and architecture journals.[6]

The advent of the internet has dramatically expanded the influence of *feng shui*, predictably including full-blown charlatanism or the 'dark arts'. The latter term describes how Matteo Ricci in the sixteenth century, Ernst Eitel in the 19th and Chen Duxiu in the early twentieth century, and so many others down to the present day, have denounced *feng shui* as fraudulent.[7]

It is an important philosophical and legal point whether a distinction can be made between genuine and fraudulent *feng shui*-based advice. There are hundreds of thousands of websites that are devoted to *feng shui* such that the relevant consultation is now only a click and a credit card charge away even in the most isolated places on Earth. The following are examples of *feng shui* services found in a one-minute English-language online search:[8]

> (1) Jerry specialises in both residential and commercial feng shui, utilising Xuan Kong Feng Shui. In addition,

> Jerry is an expert in Four Pillars of Destiny, Plum Blossom and Qi Men Dun Jia divination. Jerry is currently researching on a higher level of divination known as Da Liu Ren. Jerry has taught Chinese Metaphysics, which included topics in feng shui and destiny in London [of the UK], Hong Kong [of China], Singapore, Australia, Russia, Spain and Mexico.[9]

> (2) There are many schools of feng shui, and we utilise as many as we can in order to give our clients optimum results. Some of the schools of feng shui we use are: Four Pillars of Destiny, Flying Stars, Bagua and the Form School. In laymen's terms, it is about laying out rooms, furniture, and introducing colours, elements and objects in order to create a positive change in one's life, family, home and/or business.[10]

> (3) Feng shui is a dynamic *living energy* that shifts and changes with the months and year. That's why there is so much emphasis on the annual feng shui, that details about each year—whether it's a rooster, dog, or boar—play a role in the energies that occur during the year and that act differently upon your home, you and everyone in your home.[11]

Are the above people practitioners of the 'dark arts' or genuine *feng shui* advisers? How can a distinction be made between them? Advice based on *feng shui* is not restricted to the domestic realm either. Major multimillion-dollar buildings, roadwork, tunnelling, bridge construction, cemetery location and railway projects have been litigated in China's mainland, Taiwan and Hong Kong, Australia, the US and elsewhere. The cases hinged on whether genuine or specious *feng shui* advice had been provided.[12]

3. *Feng shui* and chi

Stephen Field, a translator of Guo's classic, claims that '*Qi* is the *sine qua non* for any discussion of feng shui' (Guo, 2004). The philosophically informed anthropologist Ole Bruun writes:

> The concept of *qi*, which may be translated into 'breath' or 'breath of nature', is fundamental to Chinese natural philosophy. It is strongly indicative of an organic predisposition in Chinese thinking in general, as opposed to the mechanistic orientation that became dominant in European natural philosophy after the Middle Ages. (Bruun, 2008: 108)

Despite the centrality of chi claims throughout the theory and practice of *feng shui*, including in all variants of traditional Chinese medicine (TCM),[13] precious little effort has been expended to scientifically test these claims. The scientific appraisal of the core chi claims of *feng shui* is of the utmost importance because it can shed light on both *feng shui* and science. Such appraisals go well beyond mere *feng shui* and touch upon what might be called an 'organicist' world view or a holistic Asian world view (Vogel and Dux, 2010).

The naturalistic and 'scientific' core of *feng shui* is a commitment to the existence of a putative all-pervasive special energy, or life-force chi (or *qi*), that has existed since the beginning of time and occupies the entire cosmos—the universe, solar system, Earth and everything on it, including the bodies of animals and humans. In all bodies, chi moves in defined meridians that can be manipulated by acupuncture and other treatments. Chi lies at the intersection of physics, metaphysics, pseudoscience and theology. Its proper location is the subject of lively philosophical and scientific discussions. Predictably, its preferred home changes with the philosophical commitments of the discussants.

Simon Brown, the author of *The Feng Shui Bible*, gives an account of chi that can be found in thousands of popular books on the subject:

> Chi is the subtle charge of electromagnetic energy that runs through everything, carrying information from one thing to another. The chi flowing through your body predominantly carries your thoughts, beliefs and emotions. At the same time, some of your chi is floating off, while you are also drawing in new energy … Your energy field connects you to everything else, whether you like it or not. The secret to making this energy work is understanding the process and finding out how you can make it help you in life. (Brown, 2005: 24)

Edmund Ryden, the translator of Zhang Danian's authoritative book on Chinese philosophy, revealingly says:

> Perhaps the best translation of the Chinese word *qi* is provided by Einstein's equation, $e = mc^2$. According to this equation, matter and energy are convertible. In [some] places, the material element may be to the fore, in others, what we term energy, *qi* embraces both … *Qi* is both what really exists and what has the ability to become … *Qi* is the life principle but it is also the stuff of inanimate objects … As a philosophical category … [this] meaning is then expanded to encompass all phenomena. (Zhang, 2002: 45)

Ryden well captures the explicit identification of chi with energy, the basic construct of modern science. Chi beliefs are not meant to be removed from, outside of, or alien to science. Chi theorists warmly embrace the most sophisticated foundational energy statement of modern science. However, it is the word that is co-opted, and not the institutional and intellectual edifice of science from which it originates, and which gives it meaning. Remarkable, provocative chi claims are advanced on hundreds of thousands of *feng shui* websites, in countless books and articles, and, increasingly, in university lecture halls. However, this acceptance should be accompanied by the recognition that *feng shui* needs to be subjected to rigorous scientific testing. This has rarely happened.

The US Department of Energy (DoE) has published an educational guide that specifies a person's 'energy literacy' as:

> an understanding of the nature and role of energy in the universe and in our lives. Energy literacy is also the ability to apply this understanding to answer questions and solve problems. (DoE, 2012: 4)

The DoE further elaborates that such a person 'can assess the credibility of information about energy'. This is an open invitation to *feng shui* theorists to come forward and lay out, for a receptive audience, the scientificity and veracity of their core chi claims, and perhaps even have *feng shui* incorporated into school and university science programmes. It might be expected that *feng shui* advocates would be lining up at the door for acceptance into science programmes at schools and universities. This paper details why they should not be admitted.

Richard Taylor, the author of a contemporary manual that provides advice on using *feng shui* in the modern city, relates the following: 'By interpreting the hidden and mysterious forces of the universe, feng shui provides a practical approach to environmental planning' (Taylor, 2002: 9). He goes on and states its foundational principle as follows:

> The theory of feng shui, just like Chinese medicine, is based on the five elements. The five elements control and oversee everything in the universe, and channel and balance the chi of the individual and of his surroundings. Each of the elements—fire, earth, metal, water, and wood—represents a specific energy. These energies are found in a perpetual interrelationship, and their composition, or 'arrangement', creates harmony or disharmony. (Taylor, 2002: 20)

As with most, if not all, *feng shui* advocacy, the above gives the initial appearance of being science as scientific language has been used. The manual talks of positive chi lines (curvy) and negative chi lines (straight and angular), and over many pages advises on how, in building construction and fit-out, to maximise the former and minimise the latter. For instance, do not build in the shadow of a tall building that blocks sunlight, do not build at the crown of a T-intersection, build near water, and so on. If negative chi cannot be avoided, the manual lists the eight traditional *feng shui* remedies for alleviating the situation: mirrors, light, plants, water, crystals, wind chimes, flutes and colour (Taylor, 2002). It offers homely, so to speak, advice on the location of toilets (do not have them opening into a living room) and bedrooms (they should be located away from the front door). It recommends building a good entrance to a house because:

> The entrance to the house is of primary importance. It must be well lit, welcoming, inviting, and pleasant to the eye, and it must be sufficiently broad to permit the easy entrance of beneficial chi to the house … A sufficient amount of space in the entrance area is an important characteristic in good feng shui. It enables a greater amount of chi to enter the house, broadly and freely. (Taylor, 2002: 89)

Needless to say, there is no specification of how wide the entrance should be, or how the entrance area should relate to the area of house. There is also no mention of chi-measuring instruments in order to determine the

arrangement that will maximise chi. The entire domain of chi is a 'measurement-free' zone and has been so for over three millennia. There is the appearance of science, maybe even the pretence of it, but no actual science is involved because measurements, and concern with exactitude, are requirements of established scientific practice. They are not sufficient, but they are necessary. Many pseudosciences are awash with measurements and numbers that are revealed to be simply smokescreens upon closer examination.

4. 'Scientific' testing: Dr Yan Xin

An explicit, well-documented and rare attempt to bring *feng shui* to the bar of scientific appraisal is constituted by the *feng shui*-related operations of Dr Yan Xin, a former TCM practitioner who has worked in, and lectured at, different Chinese and US universities. His research group, the International Yan Xin Qigong Association, affirms the fundamental universalist *feng shui* principle:

> The basic principle of Qigong is to coordinate the human body with the universe. It was assumed that all things in the world had spirit and intelligence. People were to keep in harmony with nature and absorb vital energy from outside the body to supplement their needs. The whole philosophy regarding the relationship of the human body with the universe gradually formulated the theory of Chinese Traditional Medicine. (Wozniak et al., 2001: 8)

Yan has been a celebrity super-Qigongist, with a national reputation for healing thousands of patients at a distance by generating and casting his own *qi* over them. He made and sold personalised *qi*-infused drinking water and was reportedly able to increase the alcohol content of wine by using *qi* power (Lin et al., 2000). Some of his lectures in China and the US were attended by tens of thousands of people. Yan's claims were not modest:

> The mind power or *qi* emitted by a trained Qigong master can influence or change the molecular structure of many test samples, including those of DNA and RNA, even if these test samples are 6 to 2000 kilometers away from the master. *Qi* can also affect the half-life of radioactive isotopes and the polarization plane of a beam of light as emitted from a helium–neon laser.[14]

In 1986, Yan was attached to the Qigong Cooperative Research Group at the prestigious Tsinghua University in Beijing. He published papers with colleagues that purportedly showed how the external *qi* (chi) that he had generated could travel over several, and even thousands of, kilometres to bring about phase changes in liquids and alter infrared absorption spectra in biological media. Ten of his 'scientific' papers have been reproduced in the Yan Xin Qigong Association's handbook (Wozniak et al., 2001), while a number have been reproduced and discussed by Lu (1997). One paper, for example, was 'The study of Qigong effect on bacteria strain improvement', which claimed to show that the 'high-yield strain produced by this method showed promising potential for industry' (Wozniak et al., 2001: 123).

Another paper by Yan's research group was titled 'Experimental research on the external Qigong effect on substances over a distance of 2000 kilometers'. It made the front page of Chinese newspapers and was showcased on TV news bulletins. Unsurprisingly, Yan became a media sensation and lectured to packed auditoriums throughout China and, in 1990, in the US, where his Qigong lectures were, for their enthusiasm and credulity, matched only by those of auditorium-filling evangelical preachers and populist politicians.

Yan's followers founded the International Yan Xin Qigong Association. In 2022, the association affirmed on its website[15] that the external *qi* generated by Yan Xin Qigong

- physically exists.
- can interact with and affect matter from molecular to atomic levels.
- can affect the fundamental components of living organisms (water, sugar, cell membrane, proteins, DNA and RNA).
- can recognise and optimize genetic properties without adverse effects.
- can be applied in biotechnology, materials processing and chemical reactions.

On 7 March 1990, the *Xinmin Evening Paper* reported that at the 18,000-seat Shanghai auditorium:

> The great super-Qigongist, Yan Xin, was delivering a six-hour Qigong lecture in one session. By means of

> the microphone and 48 loudspeakers, his voice resounded through the whole conference hall … He talked slowly, telling the meaning of Qigong, and mentioned some diseases that can be cured … Less than five minutes into the lecture, some in the audience began to shout, laugh, cry, and swing to and fro as if they were drunk. (Lin et al., 2000: 56–57)

This is precisely the behaviour routinely witnessed at Christian Pentecostal religious services. The similarity is not accidental (Hardy, 2021).

Dr Yan's research career continued. In a 30-page paper in 2002 in the *Journal of Scientific Exploration* that was co-authored with 10 Chinese and American scientists,[16] he made the following claim:

> According to the different circumstances, external *qi* of Dr Yan Xin can display different attributes such as being distance transcending, bi-directional, reversible or targeting. Although external *qi* of Yan Xin Life Science Technology has not been identified with any of the four known and accepted fundamental physical forces, its influence on physical reality is robustly confirmed. (Yan et al., 2002: 381)

Following several pages that are devoted to molecular formulae, atomic weights, spectrometer specifications and Raman laser spectra readings, we are told:

> The *qi*-effects on the structure and properties of liquid water were also observed using a different technique later in 1991. Changes were repeatedly observed in the ultraviolet (UV) absorption of de-ionized water treated by external *qi* emitted by Dr Yan from the US to Beijing, China. (Yan et al., 2002: 392)

All of this attracts attention, and, if true, is very impressive. Full marks for making explicit falsifiable claims. The study reported a three-hour *qi*-emitting lecture by Dr Yan to a packed auditorium of the Chinese Academy of Sciences in Beijing. Sophisticated monitors were set up in the hall to record positive changes in the audience after people were radiated by Yan's *qi*, and to measure the increase in 'high-energy' *qi* in the auditorium. A five- to 10-fold increase in the latter was recorded at different locations. It was claimed that this was comparable 'to the impact of gamma rays and neutrons' on the measurement equipment. Similar results were reported from an 11-hour *qi*-emitting lecture by Dr Yan at another auditorium in Beijing.

Yan's self-generated *qi* can supposedly influence molecular structure and behaviour at a distance of 10,000 kilometres, across a continent and the Pacific Ocean. Remarkably, scientists from half a dozen reputable universities signed off on this, and it was published in a supposedly scientific journal.[17] This has been passed off as an example of quantum entanglement, and thus another vindication of the advanced scientificity of *feng shui*. But this is not the case. Entanglement is a completely orthodox notion in quantum theory that has been well known since Schrödinger's relevant publication in the mid-1930s. However, such entanglement is a property of non-local paired electrons and quantons (Cramer, 2015) and has precisely nothing to do with changes in molecular structures at a distance.

Entangled entities in quantum mechanics were once together as a microsystem; they were localised, with their own range of system-dependent properties. When separated, they still have their 'at-birth' system properties. Quantum mechanics has revealed that effects do not have to be the outcomes of 'local' (adjacent or contiguous) causes, and that some non-local, at-a-distance and instantaneous causes are operative. Further, each member of paired entities (electrons, quantons) has properties that are consequential to the pairing. If one member is separated from the other, it retains its properties; once it is part of a system, the properties obtained by an entity in the system are maintained even if it is no longer in the system. Separated 'twins' are thus entangled even at a distance (Hobson, 2019).

The above idea of entanglement is something that the deterministic Einstein, who famously claimed that 'God does not play at dice', could never accept. He labelled non-local action at a distance as 'spooky'. He, and others, thought that there must have been 'hidden variables' that accounted for the seemingly non-local action.[18] Eventually, the search for such hidden variables was abandoned, as they were not needed once quantum theory had been finalised. The final theory was physics but was not classical Newtonian physics. Surely, chi cannot be smuggled into physics as a hidden variable to explain non-local action. As is common in *feng shui* advocacy, some imitation of science

(entanglement, in this case) has been used to claim that *feng shui* is scientific—indeed, at the cutting edge of science, as it purportedly accounts for non-local action at a distance. But, once again, there is the mere appearance of scientificity without any actual science.

Yan claimed that his *qi* powers interfered not only at the difficult-to-see microscopic levels, but also at the easy-to-observe macroscopic levels. He speaks of moving cups of tea by using his *qi* and, 'when friends come, transporting a pot of tea for them'; if a large number of people visit, Qigong masters can 'convert earth into cups'. But he cautions that the latter 'demands a lot of *qi*', and that 'the energy of the human body is limited and should be used ingeniously' (Wozniak et al., 2001: 74–75). He especially does not like to use his precious *qi* when video equipment is present, and relates how, during a 1986 visit to Japan, someone tried to videotape his use of transportational powers against his instructions but 'their video camera stopped working' (Wozniak et al., 2001: 73). Perhaps a cosmic spirit was on Dr Yan's side.

Dr Hui Lin of the Chinese Chi Research Centre, and the co-author with Yan of the above study, offers the following striking example of chi power:

> Consider a simple experiment on Qigong potential. In this experiment, people used their *qi* to shake pills out of a sealed bottle. However, the intermediate process was undetectable by any available means. The pills passed through the bottle (analogous to experiments in which a person passes through a solid wall), even though the bottle was completely sealed and intact, without any possibility of tampering.[14]

Accepting the results at face value, he concludes:

> This demonstrates the probable existence of a form of energy associated with *qi* which transcends the three or four [gravitational, electromagnetic, strong and weak interactions] fundamental forces.[14]

This sounds very scientific and would certainly cause a revision of our understanding of science and the world view that it offers. But in Hui Lin's 'experiment', no independent witness to such 'transportation' is noted; and no replication study has been reported. Independent observation and replication should be the starting point of any effort to bring these 'truly remarkable results' into the scientific fold.[19] They should be among the first pieces of evidence of the soundness of the above experiment required by any scientifically literate person, and their absence is a powerful indicator that *feng shui* is pseudoscientific.

Remarkably, Dr Qian Xuesen (1911–2009),[20] a famed mathematician, the 'father of Chinese rocketry' and chairman of the Chinese Association of Science and Technology, promoted Dr Yan's research as good science and encouraged Qigong research. This was a huge, though temporary, boost for *feng shui*.[21]

5. *Feng shui* appraisal and naturalism in science

Assertions about the kinds, distribution and powers of chi can be appraised by science. Appraisal simply follows from the necessity of adopting 'methodological naturalism' (MN) in science, and such adoption is required for any investigation to be considered properly scientific.[22] In Robert Pennock's words:

> science does not have a special rule just to keep out divine interventions, but rather a general rule that it does not handle any supernatural agents or powers since these are taken by definition to be above natural laws. (Pennock, 1999: 284)

The US National Academy of Sciences affirms the same position: 'Because science is limited to explaining the natural world by means of natural processes, it cannot use supernatural causation in its explanations' (NAS, 1998).

While MN has been widely supported,[23] some have argued for the stronger claim that ontological naturalism (ON) is a requirement of science. For Martin Mahner:

> metaphysical naturalism is a constitutive ontological principle of science in that the general empirical methods of science, such as observation, measurement and experiment, and thus the very production of empirical evidence, presuppose a no-supernature principle. (Mahner, 2012: 1437)

The simple reading of an instrument assumes that no supernatural entity or process is interfering with the causal chains linking the instrument to the

natural process or event to which it is responding. The conduct of science does not simply rule out non-natural entities (angels, jinn, devils, etc.) on an entity-by-entity basis, but rejects the entire class of non-natural entities. Thus, not only does science require MN; it also requires ON. But it needs to be recognised that ON is not committed to physicalism. Real, existing natural 'things' need not be physical, but they do need to have energy, be energetic, and enter into energy relations.

Mario Bunge has defended a detailed *emergent* materialist ontology that has the scientific benefits of physicalism without its defects (Bunge, 2003, 2006, 2009, 2012). On the limitations of historical naturalism, he writes:

> The great merit of naturalism is that it rejects magical thinking, in particular, supernaturalism. But naturalism is limited, for it denies the emergence of qualitative novelty and consequently the qualitative distinctions among levels of organization—physical, biological, and social, among others. In particular, naturalism does not account for the specificities of the social and the technological … This alone suggests that naturalism should be expanded to encompass the artificial and the social. (Bunge, 2009: 60–61)

In Bunge's amended naturalist ontology, *all* scientific entities have 'emergent properties'; when entities join, the aggregate has properties that the components do not have. Therefore, no viable natural or social scientific ontology can be reductionist. At every level, there are more complicated, but still natural, entities, and at each level—atoms, molecules, cells, organisms, people, populations and societies—the behaviour of the whole cannot be resolved into those of its parts. Reductionism is simply an unscientific programme (Bunge, 2001).

6. Humanistic naturalism

Liu JeeLoo, a US philosopher and *feng shui* advocate, argues for a distinctive chi-naturalism:

> By emphasizing its *naturalistic* dimension, this chapter aims to show that even though this whole tradition of *qi*-cosmology falls outside the scope of contemporary natural sciences, it is nonetheless a rational, coherent and respectable view of nature. (Liu, 2015: 33)

She elaborates:

> However, between physicalism and supernaturalism, there stands a spectrum of diverse views, many of which have been identified as naturalism. Therefore, 'naturalism' in today's usage is a fuzzy term that covers a variety of views. (Liu, 2015: 35).[24]

Liu advocates a more relaxed 'liberal naturalism', and specifically a 'humanistic naturalism' that gives legitimacy to chi talk. Such a naturalism legitimizes chi-ontological claims, such as:

> the flow of *qi* runs freely within and without a person's body; hence, one's bodily conditions are constantly affected by changes in the external environment. (Liu, 2015: 37)

However, the argument of *feng shui* opponents has never been about legitimacy. All manner and means of views, including the outright silly or fanciful, might be legitimate in the sense that they might be genuinely held. The issue here is whether the chi-based view of nature is 'rational, coherent and respectable', to use Liu's words. Bodily conditions are obviously affected by 'changes in the external environment'. This is a truism—just think of sunburn or hay fever. *Feng shui* realists claim that chi is a component of the external causative changes and has distinctive effects. There is simply no scientific evidence for this: the causal connection has never been shown. As with Dr Yan above, this is being asserted but not shown.

Humanistic naturalism does not rescue *feng shui* from scientific appraisal. Liu sensibly and uncontroversially says:

> The world consists of nothing but entities of the natural world and humans are part of this natural world. Furthermore, there can be no supernatural interactions with entities in the natural world. Natural entities are accessible to humans' cognitive capacities, and statements about the existence and nature of natural entities are truth-apt. (Liu, 2015: 36)[25]

Scientific naturalism concurs with all of the above, and there is nothing specifically 'humanistic' about this characterisation of naturalism. For instance, Mario Bunge, a defender of scientific naturalism, is explicit in claiming, against all reductionist

programmes, that 'naturalism should be expanded to encompass the artificial and the social' (Bunge, 2009: 61). The issue with Liu's argument above pertains to whether the veracity of 'truth-apt' claims about natural entities can be determined beyond science. Are there non-scientific ways of determining the truth of truth-apt claims about nature?

The expansion, or refinement, of scientific ontology and epistemology as proposed by humanistic naturalism needs be consistent with the core of science. Humanistic naturalism was meant to be an *expansion*, and not an abandonment, of science; not the substitution of non-science for science. Any ontological expansion that is inconsistent with the established science of energy is a departure from, and not an expansion of, science.

7. Chi as an intervening variable

For chi theorists who wish to maintain the scientificity of their system and the chi construct, while acknowledging that chi has never yet been identified or measured in a scientific laboratory, one recourse is to abandon the referential dimension of chi, to give up realism about chi, and to transition to considering it as an intervening variable having no referent rather than a hypothetical construct with a referent. This is a legitimate empiricist interpretation of theoretical terms in science. For empiricists, theoretical terms do not make existence claims at all, but are just shorthand for linking together the measured variables of interest; they are 'intervening variables', and not hypothetical constructs.[26]

Thus, according to empiricists, it is a mistake to look for intelligence in a person; it will never be found because it is not there. To say of someone that they possess intelligence is merely to say that their performance on test X is regularly correlated with their performance on test Y and maybe with that on test Z. We consider high scores on tests X, Y and Z to mean that the relevant person has intelligence. Analogous but more complicated reasoning applies to magnetic fields, gravitational attraction, and so on. A 'field' is shorthand for the alignment of the needle of a compass and current appearing in a moving wire; it is a mathematical construct representing ordered observations; 'attraction' is shorthand for bodies falling and planets remaining in orbit, and so on.

The distinction between theoretical terms that are hypothetical constructs and those that are intervening variables can be traced to the positivist Ernst Mach. It was developed by the logical empiricists and was given prominence by the psychologists Kenneth MacCorquodale and Paul Meehl in their much-cited paper, 'On a distinction between hypothetical constructs and intervening variables' (MacCorquodale and Meehl, 1948). This paper was the focus of methodological discussion in psychology for decades.

For MacCorquodale and Meehl, to consider theoretical terms (atom, field, electron, intelligence, libido, class consciousness, conscience, drive, instinct, magnetism, habit, will power, mind, and chi) as having referents—as referring to entities that, though unseen, nevertheless exist and exert influence—is to see them as 'hypothetical constructs'. This is the standard realist interpretation of theoretical terms. The referents may or may not exist, but they are supposed to exist if the term referring to them is a hypothetical construct.

The option of considering chi as an intervening variable or a disposition might appear attractive to chi theorists. We do not have to believe in chi and can admit that there is no chi; there are simply certain things that uniformly go together, and 'chi' names this uniformity. For instance, contentment goes hand in hand with living by a lake where the view is pretty, and it is not too windy. To say that there is good chi by the lake and, hence, the opportunity for comfortable living adds nothing to what is already known. Performing certain Qigong exercises is conducive to feelings of mental and physical ease. To say that these exercises have manipulated one's internal chi contributes nothing to what is already known. This is the position of the numerous chi theorists, who ultimately claim that chi talk is simply common sense. Here, chi occupies conceptual space but pays no theoretical or scientific rent.

Consider the claim of two chi-theorists:

> 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. An invisible force known only by its effects, *qi* is recognized indirectly by what it fosters, generates, and protects. (Beinfield and Korngold, 1991: 30)

Or the claim of Elliot Tanzer, a *feng shui* master and consultant:

> *Qi* is the Chinese word for 'energy'. Everything animate and inanimate, real or conceptual, has *qi*. Different people have different *qi*. Each kind of animal has its own kind of *qi*. A nation has its *qi* and a religion has its *qi*. There is roadway *qi*, rock *qi*, locational *qi*, and vocational *qi*. There is soft-yin *qi* and hard-yang *qi*. There is children *qi*, male and female *qi*. Each item of food has its unique *qi*. To identify the *qi* of anything animate or inanimate, real or conceptual, is to understand its essential nature. *Qi* is the Isness of whatever is—the essence of the thing or situation. If your goal is good health and success in all areas of your life, there is no other concept more important than the study and understanding of *qi*, and how *qi* flows.[27]

For these theorists and the thousands of others like them, there is nothing that can be found or isolated that is separate from what we already know about nature. This interpretation of chi parallels Aristotle's doctrine of hylomorphism,[28] whereby everything in nature, living and non-living, is constituted by matter and form. But Aristotelian forms do not have independent existence; they have to be a form *in something*. Thus, chi cannot be passed off as an Aristotelian form. *Feng shui*'s empiricist retreat, or interpretation, therefore, has its own problems.

1. Intervening variables link measured variables to the corresponding phenomena. However, theorising about chi is never accompanied by stable and reliable measurements in the way that this has been achieved over decades by using, for instance, electrical meters, pressure meters, thermometers, radiation counters and hundreds of other routine measuring instruments. There are no stable, measured chi-related variables; everything is chaotic, subjective and unmeasured. The presence or absence of chi varies with every observer and theorist, and, for many, changes vary with the time of day and the day of the year. This represents chaos from which stable, scientifically useful, intervening variables can never be rescued. After three millennia of chi talk, writing, acupuncture needling, house design and Qigong exercises, there is still no 'chi meter'. This is, to put it mildly, embarrassing. It is a powerful argument that the concept of chi is neither scientific nor useful. Even if the relevant measurements were somehow made available, the effects could not be said to have been *generated* by chi, as it is an intervening variable. Such a claim would be viable only if chi were considered to be a hypothetical construct. Thus, there is no reason to use the term 'chi' as the name of any particular correlation.
2. To abandon realism about chi (that is, to deny that it is a hypothetical construct) is to abandon the entire three-to-four-millennia-long cosmological tradition that underpins so much Chinese and Asian culture. Chi is supposedly the ultimate explanation of everything; if it explains nothing but merely names associations, then it is on course to lose its cultural value and purpose.

In the nineteenth century, Ernest Eitel observed:

> Well, if Feng-shui were no more than what our common sense and natural instincts teach us, Chinese Feng-shui would be no such puzzle to us. But the fact is, the Chinese have made Feng-shui a black art, and those that are proficient in this art and derive their livelihood from it, find it to their advantage to make the same mystery of it, with which European alchemists and astrologers used to surround their vagaries. (Eitel, 1873/1987: 1)

8. Chi as metaphor

The final option for chi theorists who wish to retain the concept, while acknowledging that there is no scientific evidence for its existence, is to say that chi talk is metaphorical, and not literal. On this interpretation of the concept, when it is claimed that chi is a special form of energy, what is meant is that chi is not *literally* a special form of energy, but rather is *like* energy. The chi construct is thus a metaphor. This is not exceptional: mainstream science is replete with metaphorical constructs, as was shown 60 years ago by Max Black (1962) and Mary Hesse (1966). The very ideas of natural selection, current flow, electron layers, light waves and particles, covalent bonds, the 'invisible hand' and so on are deeply

metaphorical. Likewise, the chi theorist inclined to its metaphorical interpretation will say that chi exists and does all the things traditionally attributed to it, but that it is ineffable, and the best we can do is to say that 'it is like energy'.

The above provides to the chi theorist some immediate relief from investigative discomfort that, however, is temporary. Concepts in science can begin as metaphors, but if they last—if they do work and get incorporated into an established theory or become the basis for a new one—then they have to be cashed out; they have to be connected to observations or measurements. In chemistry, for instance, the strength of a bond, what a given substance can and cannot bond with, and the mechanisms of the bonding need to be specified. In addition, quantification, prediction and experimentation are needed to provide theoretical insights into how the given chemical bonds develop. Without this, the concept of the chemical 'bond' is not scientific. It would not even be protoscience, as it goes nowhere and stagnates. The same applies to such theoretical concepts as natural selection and electron layers. *Feng shui* theorists are lazy to continue to insist that the core concept of the practice, chi, is metaphorical. This is the mark of a pseudoscience.

9. Conclusion

Chi (*qi*) is not supernatural; yet it is peculiar and unknown to science. It is not supernatural because it is supposed to be a part of nature and putatively has an all-encompassing range of impacts. Once this is acknowledged, chi claims are within the realm of legitimate scientific inquiry. The amount of scientific testing of chi theory is inversely related to the vastness of the extraordinary empirical claims made for it. But the testing that has been done confirms the obvious: no chi-effect mechanism has been found or isolated, and the bulk of the purported scientific confirmations have simply repeated the fallacy of affirming the consequent. Other scientifically verifiable explanations are available for the phenomena explained as the effects of chi. Importantly, *feng shui* has no tradition of sustained engagement with orthodox science, the scientific community, and respected research publications in the area. The rare cases of engagement, such as those related to Dr Yan Xin and the International Yan Xin Qigong Association, highlight only the scientific failings of *feng shui*. This paper has been focused on *feng shui* and the philosophy of science. An altogether separate and deserving investigation is of *feng shui* and social psychology: why have so many people believed so much, for so long, on so little verified evidence?

Feng shui ideology and Qigong chi theory is a barrier to the modernisation of thought. Everyone benefits from appropriately arranging their lives, environment and social circumstances. This is a difficult and complex enough task just considering naturalistic, economic and graspable factors; to add completely unmeasurable, ungraspable, imaginary factors such as chi flow and its accumulation into the equation of balanced life is a thoroughly unhelpful distraction. Moreover, it is not merely unhelpful, but it can be positively dangerous and damaging; it sends people down a false path and allows charlatanism to flourish.

Feng shui belief in society and in classrooms presents not so much a problem for teachers as an opportunity. Its considered and informed examination is a way for students to learn about the nature of science and other important social processes—the impact of marketing, the cultural determiners of gullibility, and much more.[29]

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Notes

1. The origins, history, philosophy, and applications of *feng shui* have been the subject of extensive research. See, among others, Bruun (2008), Bruun and Kalland (1995), Henderson (2010), Matthews (2019, 2021), Parkes (2003) and Smith (1991).

2. Many works have discussed the notion of chi and its place in Chinese philosophy and protoscience. See Chan (1969), Fung (1947) and Zhang (2002).
3. There are no gods, devils, spirits, or other such non-natural, non-scientific-law-defying entities in *feng shui* cosmology.
4. Thus, for instance, can the positive psychological effects of living in a sunny place, by water and out of strong winds, be accounted for without recourse to the presence of good chi in the neighborhood? Conversely, can the prevalence of illness in a settlement be accounted for by viral or bacterial factors rather than bad chi?
5. This claim is about *objective* incompatibility, and not *subjective* incompatibility; it is about *serious* belief, and not *notional* belief. It is well known that people can hold any combination of objectively contradictory beliefs. The claim in this paper pertains specifically to chi belief, and not to more general religious or other ideological beliefs. Details of this argument are provided in Matthews (2019).
6. See, among many others, *The Journal of Architecture*, *Journal of Architectural and Planning Research*, *The Journal of Design Research*, *Journal of Geographical Sciences*, *Building and Environment*, *Land Issues Research Quarterly*, *Journal of Housing Studies*, *Architecture and Culture* and *Journal of Asian Architecture and Building Engineering.*
7. For elaboration and references, see Matthews (2019, chapters 6, 7, 8 and 9).
8. Searches in other languages reveal hundreds of thousands, if not millions, of websites on *feng shui*.
9. See: http://www.whitedragonhome.com/about/masters/jerry-king.
10. See: http://www.globalpalaceoffengshui.com.au/.
11. See: https://redlotusletter.com/classical-feng-shui-and-western-black-feng-shui-the-6-critical-differences-confessions-of-a-former-black-hat-practitioner/.
12. Literature and numerous examples are provided in Matthews (2019, chapter 4).
13. On chi and TCM, see Matthews (2019, chapter 5).
14. See: www.item-bioenergy.com/infocenter/chinesechi research.doc.
15. See: https://www.yanxinqigong.net/.
16. The authors' institutional affiliations included Harvard University, Massachusetts General Hospital, University of Oklahoma, Massachusetts Institute of Technology, and the Institute of High Energy Physics of the Chinese Academy of Sciences, Beijing.
17. A major contemporary problem is the explosive growth of imitation academic journals. No longer can a journal title give credence to what is published. Scientific-sounding titles are everywhere and provide ready homes for *feng shui* and similarly dubious programmes.
18. See literature at: https://en.wikipedia.org/wiki/Hidden-variable_theory.
19. The magician (illusionist) James Randi has rendered a great public service by replicating, exposing and debunking these sorts of claims (Randi, 1995).
20. See https://en.wikipedia.org/wiki/Qian_Xuesen.
21. Qian's ill-informed and ideologically motivated interventions have been recorded by Fang (2016: 100–101).
22. On naturalism, see the literature in Papineau (2009).
23. The rich philosophical literature on the methodological and ontological presuppositions of science is reviewed in Fishman and Boudry (2013).
24. See Papineau (2009) for a comprehensive survey of various views categorized under the umbrella of 'naturalism'. He claims that it would be 'fruitless to try to adjudicate some official way of understanding the term.' (See details at: http://plato.stanford.edu/entries/naturalism/.)
25. The label 'truth-apt' refers to claims about nature that are propositional/truth-functional: they are statements about the properties of nature that can, in theory, be ascertained to be true or false. They are distinct from emotional, artistic or aesthetic responses to nature that are not truth-functional and describe or express certain expressions conveying subjective mindsets. 'The sunset is dramatic' is a claim about nature, but it is not a truth-apt claim; it is entirely subjective. In contrast, 'The sun set at 17:35' is truth apt.
26. Bas van Fraassen is a well-known defender of this position (Van Fraassen, 2002).
27. See full text at: https://abodetao.com/feng-shui-guidelines-to-energy-%20flow-analysis-what-is-qi-and-how-qi-flows/.
28. See literature at: https://en.wikipedia.org/wiki/Hylomorphism.
29. See contributions to Matthews (2021).

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Traditional farm tools observed from an ecological and health perspective

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Abstract
All walks of life actively promoted emerging technologies when modern agricultural science and technology from the West were introduced to China in the late Qing Dynasty. Despite agricultural machinery being highly popular during the more than 100 years since, traditional farm tools have not been completely replaced and have instead gradually become symbols representing traditional farming culture. From the perspective of ecology and health, this paper discusses the values, scientific notions and corresponding styles of production and life associated with traditional agricultural tools as well as the multicultural values regarding traditional agricultural culture in modern society in China.

Keywords
Farm tools, science and culture, nature education, farming culture, horticultural therapy

After the invention of the steam engine and the Industrial Revolution that followed, the application of steam power spread rapidly to various industries, resulting in a new era for agriculture. The British developed the steam-powered cable plough, steam plough and steam-powered tractor from the 1930s to 1950s. The Chinese were amazed to witness these scientific and technological achievements because, at that time, agricultural tools in China were still mainly operated by manpower.

1. Use of Western ploughs in Chinese fields

The establishment of an agricultural society was made possible more than 5000 years ago in China. After thousands of years of development, a rich experience in farming methods, agricultural instruments, animal and plant domestication and so on had been gained, forming China's farming culture. However, compared with Europe at the same time, China's traditional agriculture was behind by a long way during the Qing Dynasty (Zeng, 2012). Europe had developed modern agriculture due to the progress in natural sciences; that is, 'agricultural science and technology based on and guided by modern Western sciences, plus agricultural institutions and management systems under the capitalist

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system' (Wei, 2012: 3), which greatly exceeded other contemporary systems in agricultural output and efficiency.

After the Sino-Japanese War in 1894–1895, the gap between China and the West aroused extensive discussions; as a result, China attempted to revive its momentum by attaching importance to agriculture. 'The rise of agricultural thoughts was precisely the crystallization of Chinese people's deepening understanding of agriculture under the influence of Western agronomy, and their understanding of the reality, which was revealed as a desire to develop a new agriculture under the new conditions' (Zhao, 2000). Western agricultural machinery was undoubtedly a very noticeable one among the many advanced technologies, as steam-powered machines' production efficiency greatly exceeded that of traditional farm tools in China.

Records of ancient agricultural tools in China were made, as instantiated in *Wang Zhen's Farming Book.*[1] In the 'Pictures of agricultural instruments' section of the book, agricultural instruments were divided into 20 categories used for farming and food and clothing production, such as the wooden and later iron shovel, the wind-powered water scoop, the hat and cloak woven with straw or hemp, the mortar and pestle, and instruments for raising silkworms and silk reeling. Most parts were made of wood, and only a few of iron. Their manufacture was usually low-cost, and they could be made by individuals or in family workshops. Most were powered by humans or animals, although some were powered by wind or water.

The huge gap between China's traditional farm tools and modern Western agricultural machinery gave people insight into the urgency for changes.

> The force of six million farmers in the United States has turned out produce otherwise enabled by more than 53 million horsepower, while China's workforce of 62 million farmers has only provided a force made possible by 44 million horsepower, with a difference of more than 11 times and more … In the United States, it takes one-third of its people to work as farmers to supply the American people with food, with excess for sales abroad. However, in China, eight out of ten people are farmers, but this is not enough to feed the Chinese people, who often suffer from hunger. Thus, it is conceivable that farmers in China lack machinery and their production efficiency is low. (Xie, 1935)

Agricultural modernisation in China has been developing for more than a century, and agricultural mechanisation has become widespread so that traditional farm tools have greatly decreased. However, traditional farm tools have been gradually emerging as cultural symbols, as can be seen in various records.

2. Transformation from farm tools to cultural symbols

Taiping Fengwu, a novel collection by Li Rui published in 2006, is based on the traditional agricultural tools in Li's home village in the Lvliang Mountains, Shanxi Province, where the instruments are the same as those used thousands of years ago. In the preface, Li wrote that in the summer of 1987, by chance, he bought a pamphlet titled *Ancient Chinese Agricultural Machinery and Tools* at a second-hand bookstall. In that booklet, a humble one, the history of agricultural tools is covered, which stirred his soul.

> All the farm tools used by farmers have an incredibly long history and have experienced various changes in their development, especially those referred to by farmers in dialects, as I had always thought that they were words that didn't exist in the dictionary at all, and just reflected the stubborn and self-contained preferences for the language characteristic of rural people. Unexpectedly, however, they completely coincide with those that had existed since two or three thousand years ago, and are exactly the same as those ancient words … Thus, all of a sudden an encounter between man and history took place then and there, as sadness and reverie were reverberating for a long time. (Li, 2006: 4–5)

Of course, the description of traditional farm tools in *Taiping Fengwu* also contains criticism of backward farming culture to a greater extent. In recent years, the image of traditional agricultural tools in the mass media has undergone some subtle changes, as can be seen in the 2014 documentary *A Bite of China*, in which a scene of ancient oil refining with traditional wooden equipment is revived with close-ups. In 2022, in the documentary *Fields in Painting*, all kinds of traditional farming equipment

in rural areas of China are shown, such as the oil mill, the mortar and pestle, the plough and the hemp or straw cloak and hat; these are not only shown in pictures in ancient books, but are also the daily farming and living tools of local people.

After the large-scale adoption of agricultural machinery, why has attention to and affection for traditional agricultural tools in popular culture been increasing? To answer this question, we need to move beyond just agriculture and think from the perspective of science and culture. In the initial stages of its expansion around the world, the superiority of modern science in improving productivity and efficiently using natural resources gave local people a strong motivation to learn and imitate. However, a lot of local knowledge is in fact matched with the ecological environment, the physical and mental characteristics of local people, and even cultural psychology. With the passage of time, the marginal effects from productivity improvement gradually decrease, while the deep differences and contradictions between modern science and local cultures begin to emerge, which causes impacts on the ecological environment and the psychological status of local people. Therefore, as symbols representing farming culture, traditional farm tools provide a cultural and psychological buffer against those contradictions and even the 'crisis of modernity'.

2.1 Ecological value

The documentary *Fields in Painting* introduces Mabaoquan Village in Xishe Town, Jishan County, Shanxi Province and Shichao Village in Yanshan Town, Wuchuan County, Zunyi City, Guizhou Province, where many of the farm tools used are similar to traditional farm tools described in ancient books. The narrator in the film attributed this to the limitations of the natural environment, as there is less flat land and more mountains that are inaccessible for large machines.

In fact, traditional farming and large-scale mechanical agriculture not only correspond to different terrains (mountainous areas and flat land, respectively), but also differ more deeply in their respective notions of land use ('fragmented' on the one hand and 'idyllic' on the other). These differences were compared by Zeng Xiongsheng, an agricultural historian. According to Zeng (2015), the traditional farming model corresponds to the idea of 'piecemeal' land use, which can mostly meet the needs of producers' own material lives under natural economic conditions, and protects the diversity of agricultural organisms and the stability of production by adapting to the natural environment. This model is conducive to improving the output per unit area, making full use of the labour force and increasing farmers' income. The mechanised farming mode, on the other hand, reflects the idea around 'idyllic' land, which is to implement singular-mode or larger scale farming under the condition of transformed natural environments for improved competitiveness of agricultural products. Pastoralization is a revolution on fragmentation, but the latter can still provide some enlightenment for the former.

Traditional agriculture in Europe and America features a proportion of animal husbandry much higher than that in China, as there has not been excessive deforestation and reclamation, and the proportions of areas for forestry and fishery are much higher than in China. Moreover, much Western land is flat and fertile, with good conditions for agriculture; therefore, intensive planting can be conducted vigorously, all of which results in 'idyllic' land use and mechanised farming (Wei, 2012). In contrast, in some areas of China, a long history of farming has led to the soil being poor and prone to frequent natural disasters. In addition, complex terrains (such as wetlands and mountains) also hinder the development of intensive operations; thus, a fragmented approach to land use is appropriate to this particular agricultural environment.

Composite farming has always been prevalent in China. While rice is mainly cultivated in the south of China, and millet and wheat in the north, neither the north nor the south has ever been the site of monocultures (the planting of single crops). Take rice as an example. Different strains are often planted; some are drought-resistant, some are flood-resistant, some are insect-resistant and others are animal-resistant (Zeng, 2011). In the north, in addition to millet and wheat, beans, sorghum and other grains are also grown, which not only provides more choices for the taste buds but also improves the soil fertility and reduces the risk of potential disasters caused by single crops. Take another example,

regarding functional planning. Many areas in China are also more suitable for complex and elaborate models. For instance, in Sichuan Province, there is a typical 'piecemeal' mode of land use in Chengdu Plain and hilly areas, as can be seen in Linpan, West Sichuan, which refers to the rural residential environment formed by organic integration of farmyards and the surrounding natural environment, such as tall trees, bamboo forests, rivers and peripheral cultivated land. Of course, we must also admit that the value for tourism and cultural creation of 'the Forest Plate of West Sichuan' today is far greater than its worth for residence.

One's fascination with traditional farm tools, to a certain extent, lies in the 'piecemeal' mode of land use they represent. As mentioned above, fragmented farming has more advantages than large-scale agriculture in resisting natural disasters and protecting biodiversity.

2.2 The value for physical and mental health

When it comes to the advantages of agricultural machinery, efficiency is the most highly valued, and 'one person managing a large farm' becomes a beautiful dream about the mechanised future. The implicit idea is that farming is regarded as an activity that, ideally, needs as little human labour as possible; the higher the ratio of agricultural output to human input, the better. However, people's feelings are varied and are not normally dominated by a single value. Many literary works, scientific essays and investigations have held that traditional 'hands-on' farming not only brings people fatigue and pain, but is also a price they must pay in exchange for their subsistence; however, it means much more for most humans.

In medicine, there is a kind of treatment called horticultural therapy, which promotes people's physical and mental health through interaction between humans and plants. The earliest recorded horticultural treatment took place in the seventeenth century, when some poor people had to work in a hospital garden to pay for medical expenses that they could not afford. That was when the role of horticultural labour in promoting patients' recovery caught people's attention. Since then, some hospitals have provided opportunities for patients to engage in activities, such as farming and harvesting, which both provide food for the hospital and help patients to recover (Sun, 2015). One explanation for the principle of horticultural therapy is the physical activity theory. Since the Industrial Revolution, as mechanisation and automation have spread, radical changes have taken place in people's lifestyles, one of which is that people's physical activity has been greatly reduced. Many studies have confirmed that insufficient physical activity is an important factor for many chronic diseases that are very harmful to human health. According to Macera et al. (2003), an increase in physical activity could decrease the risk of death by 20%–35%. In general, diabetes, hypertension and other common diseases in modern society can be ascribed to the industrial transformation of agriculture, in that the energy intake of human beings through diet far exceeds their output of energy, which leads to widespread 'wealthy diseases'.

In addition to the physiological impacts, the reduction in agricultural activities also has a bearing on people's psychological status. Accelerated urbanisation has led to greater separation between human beings and nature. The negative effects on children have been noted, and a concept of 'nature deficiency' has been put forward; that is, children in modern cities have too little contact with the natural environment, which leads to various psychological and behavioural problems. Children with nature deficiency suffer from a series of physical and psychological diseases, such as inattention, sensory degradation, obesity and depression (Louv, 2009).

This laid the foundation for 'nature education'; that is, the full involvement of children's senses in nature through various activities. Participants' perception of other creatures and the natural environment is cultivated in the process of interacting with nature, thus healing their hearts, enhancing their personalities and enlightening their thoughts. Engaging in agricultural activities is an important means of nature education.

In North America, Germany, Britain and other regions and countries, farming gardens or allotments in urban communities have been widely popular and are considered as a way to effectively strengthen social relations, increase social assets and improve diet structure so as to cultivate a healthier lifestyle. Most studies on the health benefits from community farms show that participating in the labour in those farms can play a positive role in one's health, communities' cohesion, education, job satisfaction and leadership (Yu and Du, 2022).

Recent decades have witnessed rapid urbanisation in China, where a large demand exists for nature education and horticultural treatment. However, due to their source in Western cultural soil, many concepts and methods thereof are not acclimatized to or naturalised in China. Therefore, although concepts such as nature education were introduced to China long ago, the public's awareness and acceptance of them are relatively low, and most of the related practice has been confined to small circles. Thus, research about this has been conducted mainly on Western cases.

Looking back on history, we would find that the traditional farming culture in China was a form of nature education and horticultural therapy, as self-healing through farming activities was a very common endeavour in Chinese traditional culture. This can be instantiated in the poems by Tao Yuanming, an ancient Chinese poet, in which he described his village life, his comfortable and free state of mind and the heartwarming social environment. In his poems, farm tools became objects of poetic expression, such as in 'I weed early in the morning and return home with a hoe and the moonlight' (晨兴理荒秽，带月荷锄归), 'I hope the crop grows well and everything goes smoothly in the spinning month' (但愿桑麻成，蚕月得纺绩), and 'Although farming is tiring, I can relax with a drink' (虽有荷锄倦，浊酒聊自适).

At present, there are few studies on the influence of Chinese farming culture on humans' physical and mental health from the viewpoint of medicine, except for the principle governing horticultural treatment. For example, horticultural therapy takes on various forms and types, through which all parts of the human body can be exercised, which can train and strengthen patients' sense of balance, spatial perception and action coordination. In fact, agriculture and horticulture are similar in many cases in China, because the Chinese have the traditional habit of growing vegetables and mixed grains in yards and on balconies. Thus, the principles of horticultural therapy are equally appropriate for such less intensive farming activities.

Horticultural treatment integrates sports into activities that are vital and vivacious. The achievements from these activities are visible and tangible, which makes otherwise boring and exhausting training interesting and vigorous. In particular, some horticultural therapists are able to design auxiliary gardening tools especially suitable for the disabled so that the benefits for health care and rehabilitation via horticultural therapy can reach a wider population (Sun, 2015). A considerable proportion of agricultural tools in ancient China were invented to save manpower; these kinds of agricultural tools enable people to exercise without being too tired. Therefore, from the viewpoint of keeping fit, they can also be regarded as good aids for exercise.

Some studies have discussed the healing value of ancient gardening activities in China. Horticulturists in ancient China noticed that gardening can rid people of sundry thoughts, allowing them to remain pure and abstinent and to stay spiritually self-restrained, calm and thought-free. In other words, growing flowers and plants can enable humans to maintain *qi* or energy, preserve bodily essence, keep *qi* and blood flowing smoothly, and be relaxed and at ease, thus pleasing the body and mind and strengthening the body (Zhang and Zhang, 2012).

2.3 Maintenance of values and social order

In addition to healing the body and mind, Chinese nature education also attaches great importance to its efficacy for moral cultivation. In some aristocratic families in classical China, even if the family members did not need to work in person for financial purposes, the parents would encourage their children to engage in some farming activities as a way to cultivate their bodies and minds. One example was Zeng Guofan, the first of four famous ministers in the late Qing Dynasty. He repeatedly mentioned the importance of farming in his family letters. In a letter to his brothers in August of the fourth year of the reign of Emperor Xianfeng, he demanded that:

> Besides studying, it is an excellent thing for our sons and nephews to be taught to sweep the house, clean tables and stools, collect dung and weed the fields, and they must not refrain from doing them simply to preserve their face. (Zeng, 2014: 280)

In another letter, Zeng wrote:

> Our sons and nephews ought to work at farming while studying, so as to keep the old habits of their ancestors and be careful not to be ruined by any sign of bureaucracy. Don't allow them to sit in comfortable chairs

> or demand the services of servants for water and tea. It is a prerequisite that they collect firewood and dung for fuel; they should also learn from time to time about things like ploughing the fields and planting crops in fields. (Zeng, 2014: 275)

As for the economic conditions, the Zeng family's children certainly did not have to do any of the above. That he paid so much attention to 'farming while reading' was mainly for the cultivation and morality of the younger generation.

In March of the 10th year (1861) during the reign of Emperor Xianfeng, Zeng Guofan wrote a letter to his fourth younger brother about Zeng Yuping's (Zeng Guofan's grandfather's) way of managing the family, which was characterised by a four-character formula of 'books, vegetables, fishery and pigs' (书蔬猪鱼); that is, 'reading, growing vegetables, raising fish and feeding pigs'. He wrote another two letters to his fourth younger brother in October and December, saying:

> I have nothing to worry about though away from home, but I am always afraid that any member of our younger generation might be accustomed to arrogance, extravagance and ease. Family failure is inseparable from luxury; failure of a person cannot come about without ease; annoyance cannot arise without one being arrogant. My brother, refrain from them. (Zeng, 2014: 837)

> The state of affairs changes all the while, and our sons and nephews always give priority to modesty and diligence, avoid arrogance and laziness, and the way to protect our family is also to refrain from arrogance and leisure. (Zeng, 2014: 847)

In Zeng Guofan's view, doing some agricultural work personally can overcome the bad habits of the younger generation, shape a good character and family style, and thus maintain the family's prosperity.

In fact, when agricultural machinery was first introduced into China, some people had a premonition that machinery would cause a moral crisis. For example, Liu Xihong, a Chinese ambassador to Britain, after inspecting lots of advanced agricultural machinery and understanding the then British society, thought that it was not a good thing to use agricultural machinery, which could save manpower, but which, on the other hand, would induce people to start to hate labour. Machines could enable the rich to save money on hiring employees, but they would deprive the poor of food and clothing. While it is easy for people to seek comfort and harbour desire, it would also easily cause them to do evil things; and, when people lose their basic means of subsistence, they are also more prone to do evil.

Naturally, not much attention was given to these moral concerns at that time. Thousands of years of intensive cultivation and reclamation had burdened the cultivated land in China with increasingly scarce natural resources and frequent natural and man-made disasters. Under such circumstances, living a frugal and diligent life had become a habit engraved in the bones of the Chinese, and most people would learn to live a hard life by themselves, which was not something that needed 'active learning'. Only a few families in the wealthy class (such as Zeng Guofan's family) were aware of the significance of a farming culture in shaping people's values and actively taught their children the values by words and examples.

In recent years, with the general improvement of people's living conditions, 'hardship education' is not only valued by parents of the wealthy class but has also gradually come to be regarded as necessary by parents of most ordinary families. Agricultural activities are one of the means of hardship education. In the third episode of the documentary *Fields in Painting*, *Memories of Farming and Weaving* recorded the farming life of farmer Wang Luliang's family for three generations. Wang says that, at the age of 13 years, his father could get full marks with his labour, and he wants to inherit his father's hardworking quality. Furthermore, he wants to pass that quality on to his children because on his farm children from different families can experience the labouring process of transplanting rice seedlings in the fields. After a hard day's work, the family could sit around and enjoy an outdoor dinner, the narrator says: 'If you plant a grain of millet in spring, you will reap ten thousand seeds in autumn. The land never fails to live up to those who treat it well.' That touches upon the core of Chinese farming education—the education for better personality and morality imperceptibly integrated in the process of labour—so that the traditional values can be maintained and passed down.

3. Conclusion and discussion

At the end of the Qing Dynasty and the beginning of the Republic of China, agricultural machinery was gradually introduced into China. This resulted in traditional farm tools that had lasted for thousands of years in China being gradually withdrawn from the historical stage of the country. However, their significance as cultural symbols has gained increasing attention. This paper has examined the cultural significance of traditional farm tools from the perspective of scientific and cultural diversity.

In terms of the ecological environment, traditional farm tools match the prevalent practice of 'piecemeal' land use—a kind of 'fragmentation' meant to meet the needs of a farmer's life to the maximum extent under natural economic conditions by diversified planting. The advantages of this kind of land use lie in it being beneficial for biodiversity, stable production and full utilisation of the labour force. On the other hand, mechanised planting accommodates 'garden-style' land utilisation; that is, monocropping or large-scale operations within a transformed natural environment, the advantages of which are promoting the commercialisation of agriculture and improving the competitiveness of agricultural products. The two styles of land use, each with its own advantages, can suit different natural environments. Fragmentation, for example, has irreplaceable advantages in mountainous areas with cultivated plots of land and frequent disasters. However, an important problem facing agriculture in China is that where 'pastoral' cultivation is not suitable, the tradition of 'fragmentation' in some places has also been lost. For those areas, with the help of traditional farming, it may be a direction worth exploring to turn them into eco-agricultural demonstration areas, thus increasing their value for tourism, leisure, scientific research, culture and education.

What impact does a reduction in agricultural activities have on humans' physical and mental health? This paper has discussed the significance of traditional farm tools from medical aspects. One of the trends of modern medicine is that the medical model has changed from a simple biomedical one to a complex mode of biological–environmental–psychological–social medicine, in which biological research is not excluded, while an emphasis is laid on the influence of environmental, psychological and social factors on health and disease as well as on the complete unity among humans' psychology and physiology, spirit and body, and the collective internal and external environments (Guo, 2009). Moreover, as humans' agricultural activities have been greatly decreasing in modern society, their physical and mental health has been affected. Therefore, disciplines such as environmental education and horticultural therapy have emerged, while similar functions can also be undertaken by traditional farming cultures, in which farm tools can be the carrier for healing the soul and expressing one's poetry and can be used as auxiliary sports equipment in pastoral activities.

For the inheritance of values and maintenance of social order, traditional farming can make people feel that agricultural products are precious, and it can also help them acquire virtues such as modesty, diligence and frugality. Therefore, the role of farming culture has been emphasised once again in modern education. Japan provides a good example; in the Japanese drama *Little Forest* and films and television programmes about pastoral healing, it can be seen that the mainstream culture in Japan is willing to display an original ecological, harmonious and beautiful rural scene through farming activities.

> Japanese rice is a product of a highly successful traditional political strategy and one out of an effort in constructing modern national unity around an imaginary past. Japan, as a nation, is connected with its ancient roots by virtue of its naive, frugal and patriotic farmers' work. This nostalgic style has always been serving Japanese nationalist goals quite well and is still very popular today (Bray, 1997: 25).

In contrast, a singular value system of 'developing productive forces' for agriculture has been dominant since modern society came about in China; therefore, there has always been an inferiority mentality, a habit of self-denial and a resulting desire for all-out innovation in the traditional farming culture. Although a revival of traditional culture is currently being advocated, understanding of that culture remains at a superficial level for most Chinese people. In fact, traditional science and technology cannot be equated with a backward society. It has also evolved and changed through

history to become what it is today. Facing impacts from foreign cultures at different times in history, it has been making careful and subtle choices. As a result, tradition is a product of concentration after purification through time, and it is still growing. Thus, we should open our minds more in order to ask: Is traditional culture valuable for universal application? Is it a cultural heritage with only ornamental and commemorative values, or a knowledge system that can still perform a variety of social functions?

Science and technology are skills exercised in a social context, which gives exact meaning to the goods produced and the people who produce them (Bray, 1997). When the context disappears, the meaning carried by and endowed in it is naturally gone. If we look at those technologies that existed in history from the perspective of scientific and cultural diversity and explore their rich meanings, it may be helpful for us to understand and deal with the dilemmas that mankind faces, such as the alienation of people from nature and the resulting physical and mental health problems.

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Note

1. *Wang Zhen's Farming Book* (*Wang Zhen Nong Shu*), which was published during the Yuan Dynasty, is an encyclopedia of ancient Chinese agriculture. Its record of agricultural implements is the most typical and representative in the agricultural history of China, and most of the agricultural tools recorded in later agricultural books are based on it.

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'The Northern chemist'—Truth behind the stereotype in the British scientific elite?

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Abstract
In a prosopographical study of the British scientific elite, defined as Fellows of the Royal Society born since 1900, chemists were found to be distinctive in their social origins and schooling, being more likely than Fellows in other fields to come from relatively disadvantaged class backgrounds and to have attended state rather than private secondary schools. In thinking of possible explanations, we called to mind the student stereotype of 'the Northern chemist'. Could this give some indications of how it should come about that those chemists who enter the scientific elite—a small minority—tend to differ from other elite members in the ways in question? Our more detailed analyses of the biographies of elite chemists, comparing those of different class origins, point to the following conclusions. The Northern chemist was a male stereotype, and chemists prove to be more predominantly male than other members of the scientific elite. Young people, mainly male, often growing up in industrial areas of the North of England (or in Wales) and in families whose male members were in manual work, were particularly likely to develop an interest in chemistry rather than in other sciences, and it was in chemistry that state education gave them their greatest comparative advantage over those privately educated. Generalising from these analyses, we suggest that a larger pool was created in chemistry than in other scientific fields of people who were of relatively disadvantaged social origins and state educated, and that this difference was then maintained through into the social composition of the small number of chemists who eventually gained elite status.

Keywords
Scientific elite, Royal Society, prosopography, chemistry

1. Introduction

In a recent paper (Bukodi et al., 2022), we have reported on research into the social class origins and secondary schooling of the UK scientific elite, understood for the modern period as Fellows of the Royal Society born since 1900.[1] The research follows a programme previously set out (Bukodi and Goldthorpe, 2021) for the grounding of elite studies in prosopographies—collective biographies—of their members.

We have obtained relevant data on the scientific elite, as we define it, from a variety of sources. For deceased Fellows, we rely mainly on the Royal

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Society's excellent *Memoirs* and on the *Dictionary of National Biography*; but we have also drawn on other biographical material that can be found on the web. For living Fellows, we rely mainly on results from a web-based questionnaire sent out in late 2020 to all of those falling into our target population, for which we achieved a response rate of almost 70%; but also, and especially for non-respondents, we have consulted *Who's Who* and Debrett's *People of Today* and have again sought out web material. Overall, we obtained data adequate for our purposes for 1691 of our target population of 2112 Fellows or, that is, an 80% coverage. In view of this, we have taken Fellows on whom we do have full information as being representative of our target population with the possibility of only very minor, if any, biases occurring. We do not therefore apply any tests of statistical significance to our results.

In the light of other elite studies, certain of our findings are not at all surprising. Over the period covered, members of the scientific elite have been disproportionately recruited from among individuals of more advantaged class origins—UK National Statistics Socio-economic Classification Classes 1 and 2 (NS-SEC)—and from among those privately educated. We do, though, also observe that, within Classes 1 and 2, Fellows are clearly more likely to have come from professional rather than from managerial families and, in more recent cohorts, from professional families in which at least one parent was engaged in an occupation involving scientific, technical, engineering or mathematical (STEM) knowledge and expertise. Also, Fellows from professional families, if privately educated, were more likely than their counterparts from managerial families to have attended day rather than boarding schools. One further finding was, however, of a quite unexpected kind. Across all birth cohorts, Fellows who were *chemists* showed, in both their class origins and their schooling, a notable degree of deviation from the general pattern.

As regards class origins, only 34% of chemists came from higher professional and managerial families (NS-SEC Class 1), a lower proportion than Fellows in any of the other nine subject areas distinguished by the Royal Society, in which the corresponding proportion ranged from 41 up to 55%. This difference was then largely offset in the following ways. First, 16% of chemists, a larger proportion than of Fellows in any other subject area, came from the families of small employers—mainly farmers, builders or workshop owners—or from those of self-employed men, mainly in skilled trades (NS-SEC Class 4). Second, 5% came from families headed by foremen, factory supervisors or lower-level technicians (NS-SEC Class 5).[2] And, third, a further 16% came from the families of wage-earning, mainly manual workers (NS-SEC Classes 6 and 7). That is to say, in all, some 37% of chemists could be regarded as being of relatively disadvantaged class origins and also as having grown up in social milieux in which manual work predominated. Among Fellows in the other subject areas, the corresponding proportion ranged from 31% down to as low as 22% (Bukodi et al., 2022).

As regards schooling—and focusing on Fellows whose schooling was in the UK—only 36% of chemists had been to private schools, while among Fellows in the other subject areas this proportion ranged from 39 to as high 57%. And, correspondingly, it was among the chemists that the highest proportion of Fellows was found who had attended state schools (i.e., grammar, technical or, among those in the youngest birth cohorts, comprehensive schools).[3] This was the case with 57% of chemists as compared with the corresponding proportions for Fellows in other subject areas ranging from 55 down to 39% (Bukodi et al., 2022).[4]

These results were intriguing. Research has previously been carried out (Xie, 1992) into the social origins and education of scientists working in different fields—showing in fact a broad homogeneity apart from a distinctive tendency for individuals of farm origins to work in biology. But in the history of studies of stratification within science (e.g., Cole and Cole, 1973) and, more specifically, of the formation of scientific elites (e.g., Zuckerman, 1977), the possibility of differences in the underlying processes across fields has attracted little attention. The case of British chemists would therefore seem to be one meriting further investigation.

As a starting point, what, perhaps unworthily, came to mind was the student stereotype of 'the Northern chemist': that is, a man—not a woman—seemingly somewhat out of his depth socially, dour and recessive. Could this stereotype, taken from the

student level, provide any hints as to the nature of the social processes that result in the small minority of all chemists who enter the scientific elite varying, to a non-negligible degree, in their class backgrounds and in their schooling from members of this elite working in different fields?

In seeking to answer this question, we focus on chemists coming from the two class backgrounds in regard to which, as noted, the most marked differences arise from others in the scientific elite: that is, on those of higher professional and managerial—NS-SEC Class 1—origins and those of relatively disadvantaged—NS-SEC Classes 4–7—origins. The former account for 87, or 34%, of the total of 255 chemists included in the scientific elite on whom we have biographical information, and the latter for 82, or 32%. Our two main concerns are then the following.

First, how far is there an association between class origins and geographical origins—are chemists from less advantaged social origins more likely to be northerners? Second, are there differences between chemists, associated with their class origins, in how their interest in chemistry originated, as in the contexts of their families and schools, and in how they came to study chemistry in moving on to university? In this latter respect, we draw on the cases of those chemists for whom we have been able to obtain more detailed biographical information of a relevant kind: that is, for 38 of the 87 of Class 1 origins and 49 of the 82 of Classes 4–7 origins.

Before moving on to these questions, one preliminary point may be made on gender. Chemistry has often been seen as an area of science in which women are especially poorly represented, and especially at higher levels. Although, as Rayner-Canham (2008) shows, there were in fact from the mid-nineteenth century onwards some hundreds of women working as chemists, and members of the Chemical Society and/or of the Royal Institute of Chemistry, these women were very largely confined to supportive roles and rarely gained access to positions of any eminence. Shortly after the end of World War II, the Chemical Society published a collection of 16 biographies of eminent British chemists born between 1830 and 1880 (Findlay and Mills, 1947), all of whom were men. The representation of women among the chemists in our scientific elite of Fellows of the Royal Society born since 1900 is then of some interest.

Our target population of Fellows numbered 2112. Of these Fellows, 155, or 7%, were women. Of the 1691 Fellows for whom we were able to obtain information on their class origins and schooling, 125 were women or, again, 7%. However, of the 255 chemists, only 12, or less than 5%, were women. There is, in other words, some indication of greater male dominance among the elite chemists than among the elite scientists as a whole. In this context, at least, the student stereotype of the Northern chemist as being male may not be all that misleading.[5]

2. Geographical origins and social origins

If we compare the places of birth of elite chemists with those of elite scientists in other subject areas across the nine official English regions, plus Wales and Scotland,[6] no very distinctive tendency appears for chemists to be more often born in the North-East, the North-West and Yorkshire and Humberside than elsewhere. Chemists are indeed more likely to be northerners than elite scientists in biological fields with medical and health connections—38% as against 25%—with whom they also contrast most sharply in their class origins and schooling (see note 4). But other biologists—biochemists, structural biologists and molecular cell biologists—are 39% northerners, with mathematicians, astronomers and physicists not all that far behind the chemists at 32%.

However, if we consider differences in geographical origins *among* chemists in relation to their social origins, distinguishing between those of Class 1 and of Classes 4–7 origins, more interesting results emerge. We have been able to obtain information on place of birth for 68 of the 87 chemists of NS-SEC Class 1 origins and for 64 of the 82 chemists of Classes 4–7 origins. And we can further supplement this information by that on their place of secondary schooling in the case of 53 of the former and 70 of the latter (discounting instances where individuals were sent away to private boarding schools). However, in order to avoid unduly small numbers in cross-classifications, we have now to collapse the English regions as follows. North-East, North-West and Yorkshire and Humberside become the 'North', East Midlands, West Midlands and East become the 'Midlands', and South-East and South-West become the 'South'.

On this basis, we obtain the results shown in Table 1. It can be seen that, whether we consider place of birth or place of secondary schooling, chemists of relatively disadvantaged, Classes 4–7, origins are in fact clearly more likely to be northerners than those of Class 1 origins. Offsetting this, chemists of Class 1 origins are more likely than those of Classes 4–7 origins to have grown up in London and the South.[7] Once social origins are taken into account, the Northern chemist stereotype does then again find some echo.

The question can, moreover, be raised of whether it is merely physical, or rather economic, geography that is chiefly reflected in our results. It may further be noted from Table 1 that, while among chemists of Class 1 origins very few were born or had their secondary education in Wales, the proportion of those of Classes 4–7 origins who were of Welsh origins is larger. If, then, we are ready to think of chemists of less advantaged class origins as tending to come from regions that are, or at least were, characterised by extensive industry, extractive as well as manufacturing, a still sharper contrast can be made. Among chemists of Classes 4–7 origins, 46% were born in the North or in Wales, and 45% had their secondary schooling in these regions, as against only 19% and 17%, respectively, of chemists of Class 1 origins. What is also of interest is that, if with the former group we go into somewhat more detail, we find that they grew up not only in the major cities of the North and Wales but also in the smaller coalmining, textiles and metalworking towns of these regions, such as South Shields, Hyde, Wigan, Todmorden, Pudsey, Neath and Llanelli.

Table 1. Distribution of chemists by class origins and place of birth and by class origins and place of secondary schooling.

	Class of origin			
	Class 1		Classes 4–7	
Region	N	%	N	%
Place of birth				
North	12	18	24	38
Midlands	6	9	8	12
London	15	22	11	17
South	16	23	7	11
Scotland	6	9	5	8
Wales	1	1	5	8
Abroad	12	18	4	6
Total	68	100	64	100
Place of secondary schooling[(a)]				
North	8	15	25	35
Midlands	8	15	9	13
London	12	23	10	14
South	11	21	11	16
Scotland	7	13	6	9
Wales	1	2	7	10
Abroad	6	11	2	3
Total	53	100	70	100

Notes: (a) Private boarding schools discounted.

We move on next to the information that we have been able to gather about how our elite chemists first became interested in and gained enthusiasm for the subject, leading on to their eventual study of chemistry at university. In the case of those of relatively disadvantaged class origins, various linkages with early years spent in industrial settings become apparent.

3. The entry into chemistry: The influence of families and schools

In this connection, we draw on the more detailed biographical information that, as earlier noted, we were able to obtain for 38 of our elite chemists who were of Class 1 origins and for 49 who were of Classes 4–7 origins. For deceased individuals, this material comes mainly from Royal Society *Memoirs* or other obituaries, so that we are not dealing directly with these chemists' own recollections and views but rather with these as reported by their memorialists or obituarists—who have usually consulted family members, colleagues and friends. We are, though, in some cases able to draw also on accounts of interviews, lectures or speeches made by the chemists themselves, available on the web, and for those of our chemists who are still living, it is material of this latter kind that is our main resource.[8] Almost all of the material we use is therefore in the public domain. However, in using it, we refer to individual chemists only by their index number in our data files and not by name, since we do on occasion make links with

information deriving from our web questionnaire, respondents to which were assured of anonymity.

3.1 Families

The family is an obviously important context within which individuals may develop interests that influence the subjects they choose to study in school and, in turn, the course that their future careers take. In Table 2, using the more detailed biographical data that we have referred to, we distinguish for elite chemists of Class 1 and of Classes 4–7 origins between those where a positive family influence on their careers as chemists is reported and those where no mention of family is made or a negative influence is reported. What is most notable is that family support for their careers is less apparent among chemists coming from Class 1 origins than among those coming from less advantaged Classes 4–7 origins.

Light can be thrown on these bare numbers by considering individual cases. With chemists of Class 1 origins, where the family did appear to be a source of their interest in chemistry, this largely arose as the result of their fathers being themselves chemists, being in some way involved with chemists or with the chemicals industry, or being natural scientists in some other field. The following eight cases of the 12 are illustrative.[9]

91, father a professor of chemistry, birth cohort 1900–09.

> His father had a laboratory at home that from a very early age he was encouraged to use to carry out his own experiments.

Table 2. Role of family in influencing study of chemistry and choice of chemistry as a career by class origins.

	Class of origin			
	Class 1		Classes 4–7	
Role of family	N	%	N	%
Positive	12	32	25	51
Not mentioned	24	63	24	49
Negative	2	5	0	0
Total	38	100	49	100

115, father an educationist, birth cohort 1910–19.

> Her father had a close friend who was a chemist. He interested her in the subject and bought her a chemistry kit so she could do her own experiments. Her mother then supplemented this by buying chemicals from the local pharmacy.

813, father owner of a chemicals firm, birth cohort 1920–29.

> He was born into a family long established in the chemicals industry. It was expected that he would follow in the family tradition, and he was encouraged to study chemistry at school and at university.

761, father a professor of chemistry, mother a research chemist, birth cohort 1920–29.

> He was told by his father at an early age that he was to become a great scientist and was encouraged to concentrate on chemistry. He learnt a great deal of chemistry from his father and mother.

1172, father an industrial chemist, birth cohort 1930–39.

> His father was the research manager at a large chemical plant, which he visited regularly as a child. He was encouraged to specialise in chemistry at school.

419, father an electronics engineer and inventor, birth cohort 1940–49.

> My father told me when I was very young that I should aim to be a great scientist. I specialised in science at school and found chemistry particularly attractive because it needed less maths than physics, and I decided to study it at university.

436, father a professor of chemistry, birth cohort 1940–49.

> I was introduced to science, and especially to chemistry, by my father. I grew up in a scientific world. As a schoolboy, I met many famous chemists.

192, father an academic chemist, birth cohort 1960–.

> My father encouraged me to take natural sciences, including chemistry, at the time when I had to decide which subjects to study in the sixth form at school. I then went on to study chemistry at university.

The two cases in which there was no family support for a career in chemistry were rather different. In one, the father wished his son to work in the family transport business rather than going on to university. In the other, the family was much involved in literature and the arts and had no interest in, and was rather dismissive of, science.

With chemists of Classes 4–7 origins, family support for the study of chemistry did not, as might be expected, come in entirely the same way as with chemists from Class 1 origins. But fathers' or other family members' occupations and their links with chemistry were often influential.

196, father a farm foreman, birth cohort 1900–09.

> He came from a farming family in which there was some knowledge of the chemistry involved in farming through fertilisers and pesticides. In this way, he became interested in chemistry more generally from an early age.

199, father a smallholder, birth cohort 1910–19.

> He had an uncle who was a chemical technician at a nearby steelworks, with whom he spent most of his school holidays. He was allowed into the laboratories, saw how experiments were done, and started doing his own experiments at home.

543, father a warehouse foreman, birth cohort 1920–29.

> His grandfather had worked in an explosives factory and talked to him a lot about the chemistry involved. This greatly interested him, and he decided to concentrate on chemistry at school.

778, father an industrial painter, birth cohort 1920–29.

> His father's work gave him an interest in what was involved in the mixing of paints of different kinds and colours. He first learnt about chemistry as a subject from an uncle who worked in a chemicals factory. He visited him on most Saturday mornings and was allowed to watch experiments being carried out in the firm's laboratory.

660, father a mechanic and garage owner, birth cohort 1920–29.

> He helped his father in running his garage and became interested in how cars worked. He learnt some chemistry from scientific encyclopaedias that his father owned, and was able to use old car batteries in experiments that he made in electrolysis, and also as a source of sulphuric acid for other experiments.

130, brought up by an uncle, a semi-skilled worker in a chemical plant, birth cohort 1920–29.

> His uncle, who was a shop steward and active in the labour movement, encouraged him to get a scientific education. After studying chemistry in the sixth form and working in the chemistry industry during the war and afterwards, he took a degree in chemistry through evening classes.

769, father a cabinetmaker, birth cohort 1920–29.

> His father also worked part-time as a photographer, and his interest in chemistry originated through helping his father and learning about the processes involved in developing film. With his father's support, he started doing experiments at home while still a schoolboy.

720, father a works carpenter, birth cohort 1930–39.

> His father encouraged his early interest in science, especially chemistry, and impressed upon him, from experience in his own trade, the importance of accurate measurement and good design. This advice proved to be of great value to him in his later experimental work.

846, father a coalminer, birth cohort 1930–39.

> He had an early interest in chemistry that his father encouraged, knowing its importance in mine production, as through shot-firing, and in safety through the detection and control of methane gas. His father brought him detonators and supplies of cordite from

> the mine, which he was then able to use in experiments at home.

Apart from there being such family occupational influences that helped to lead them into chemistry, elite chemists of Classes 4–7 origins would also appear to have often come from homes in which great importance was given to books and to the acquisition of knowledge, including of science.

431, father a village shopkeeper, birth cohort 1900–09.

> Her father had a passion for books, including encyclopaedias and science books, which he bought from junk stalls. He encouraged her to read everything, and especially on science.

142, father a market gardener, birth cohort 1900–09.

> His father was an autodidact with a large library including many books on science. He sought to teach his son basic science, including chemistry, from an early age.

150, father a mechanic in a bicycle factory, birth cohort 1900–09.

> His father was an autodidact and owned many books, including on chemistry, which he encouraged his son to read. He also had a microscope and a telescope, which he taught his son to use.

999, father a small builder, birth cohort 1920–29.

> His father was widely read and very interested in science. He gave his son an upstairs room that he could convert into a laboratory and bought chemicals from the local pharmacy for him to use in experiments.

616, father a cloth cutter in a textile factory, birth cohort 1920–29.

> His father had read a good deal of science from magazines and helped him to set up his own laboratory in a garden shed where, as a schoolboy, he carried out experiments. He also emphasised, on the basis of his own work, the importance of accuracy in measurements.

1437, father a printer, birth cohort 1940–49.

> Like many printers, his father was widely read, including in popular science, and stressed the importance of education. He encouraged his son to try to qualify to study chemistry at university as it could mean secure employment.

What is brought to mind by the foregoing are accounts, such as that of Rose (2001), of the working-class intellectual life that flourished in industrial areas in Britain up to World War II, sustained by mechanics institutes and, later, by the Workers' Educational Association—although in cases where the focus was on science rather than on literature or sociopolitical issues. In a wide range of primarily manual occupations, chemistry was involved at a practical level, and a concern to acquire a deeper knowledge of the subject could then arise, which might be further pursued and, in the case of the chemists in question, was so pursued in the filial if not in the parental generation.

In this connection, however, one other more general point has to be noted. Whether through the degree of scientific background that came from their own work or from their self-education, it is *fathers* or other male family members—grandfathers and uncles—rather than mothers, who would appear to have been the main sources of influence on the children who became eminent chemists. Mothers have often been regarded as of particular importance in encouraging children in their education, and especially in the case of children coming from less advantaged social backgrounds. But at least with the children here in question, the influence of mothers on their education and their careers would appear to have been very limited. References to such influence are in fact almost entirely confined to cases where the father had died early or was away from home for long periods, as at war or at sea. The extent to which the world of chemistry would appear subject to male dominance is thus in another way brought out.

3.2 Schools

Schools are a further obvious context within which young people may develop an interest in a particular field of study, as, say, because of particular emphases in schools' curricula or through the influence of

outstanding teachers. What part, then, did their schools play in the scientific careers of the elite chemists we consider, and how far do differences arise in relation to their class origins and to the type of school —private or state—that they attended?

In Table 3, drawing on the more detailed biographical material that we have available, we provide some basic numerical information on how the chemists with whom we are concerned appeared to view their schooling. As with family, we distinguish between cases where, indirectly or directly, positive views were reported, those where we find no mention of schooling, and those where views were negative.

Although we are dealing with rather small numbers, Table 3 reveals some striking differences. With chemists of Class 1 origins, what we learn from the material to hand is that for those who were privately educated—the large majority—their experience of their schools would appear to have been very mixed. No mention of their schooling in relation to their future careers is the most common outcome, while a negative view is reported slightly more often than a positive one. It is in fact only in the case of this group of chemists that negative views about their schooling emerge. Among the minority of chemists of Class 1 origins who went to state schools, positive views are the most frequent. And similarly, among the large majority of chemists of Classes 4–7 origins who were state educated, positive views of their schooling in relation to their careers are predominant, while among the few who went to private schools (all but one through scholarships) no mention of their schooling is again the most common outcome.

Some indication of what lies behind these results can once more be gained from details taken from particular cases. We begin with the nine chemists of Class 1 origins whose experience of their private schools could not be regarded as favourable.

398, father a landed estate owner, birth cohort 1900–09.

> He learnt nothing of value to his future career as a chemist from the teaching at the school he attended, only from the science books that he found in the library. He turned a room in his parents' house into a laboratory, in which he did experiments during vacations.

102, father a technical college headmaster, birth cohort 1900–09.

> There was no chemistry teaching at his school. He learnt science mainly through teaching from his parents and left school for university to study chemistry at age 16.

117, father a chartered accountant, birth cohort 1900–09.

Table 3. Role of school in influencing study of chemistry and choice of chemistry as a career by class origins and type of school.

			Role of school			
Class of origin	Type of school		Positive	Not mentioned	Negative	Total
Class 1	Private	N	7	13	9	29
		%	24	45	31	100
	State	N	6	3	0	9
		%	67	33	0	100
Classes 4–7	Private	N	3	7	0	10
		%	30	70	0	100
	State	N	28	11	0	39
		%	72	28	0	100

He did not do well in science at his school and disliked the teaching. He was thought to be 'only average'. He did not become interested in chemistry until taking a general sciences course at university.

86, father a GP, birth cohort 1910–19.

He learnt his chemistry mostly at home through reading the textbooks of an elder sister and from experiments that she did in the family potting shed. He learnt little at his school, where the standard of teaching was low, and he was always well ahead of his class.

433, father an inspector of education and mother a secondary school headmistress, birth cohort 1910–19.

There was no teaching of chemistry on the science side of his school, only of mathematics and physics. At university, he became interested, through mathematics, in theoretical chemistry.

772, father a dentist, birth cohort 1920–29.

At school he was put on the classics side and only allowed to make 'the forbidden transition' to such science teaching as was available through the intervention of a teacher who recognised his scientific abilities. He started learning chemistry seriously only at university.

916, father a GP, birth cohort 1930–39.

He did not do well in science at his school and left to go to a technical college in order to qualify for university admission. It was only at university that his interest in chemistry developed.

613, father a corn merchant, birth cohort 1940–49.

He was taught little chemistry at school and specialised in mathematics. He became involved in chemistry only at university through the application of mathematics in theoretical chemistry.

1361, father a financier, birth cohort 1960–.

I became interested in chemistry as a child but already through my experience of the teaching of chemistry at my school, which was not very encouraging, I became aware of the difficulties for women to make their way in this field.

These observations may then be set in contrast with positive ones concerning their school experience in the case of chemists of Classes 4–7 origins who were state educated.

474, father a hill farmer and slate quarry worker, birth cohort 1900–09.

His interest in science and in particular in chemistry was aroused at his grammar school. The head gave him special lessons to help him gain university entry.

156, father a blacksmith, birth cohort 1910–19.

His secondary school had excellent chemistry teachers and also had regular visits from a chemistry lecturer from Manchester University.

441, father a worker in a clothing factory, birth cohort 1910–19.

His grammar school had a strong science tradition. Laboratories were kept open during vacations, and students were also encouraged to carry out chemistry experiments at home.

183, father a policeman, birth cohort 1910–19.

His secondary school was part of a technical college and so had excellent laboratories and good chemistry teachers.

776, father a textiles worker, birth cohort 1920–29.

His grammar school specialised in science. He was 'taken in hand' by the chemistry master and prepared for university entrance to study chemistry.

570, father a railwayman, birth cohort 1930–39.

He attended a technical school where his interest in chemistry started. Inspired by the teachers there, he moved on to a related technical college where he took a London External degree in chemistry.

126, father a loom overlooker and a cotton weaver, birth cohort 1930–39.

> I went to a grammar school that had produced two Nobel Prize winners and all science teaching was of a very high standard.

163, father a door-to-door salesman, birth cohort 1950–59.

> I left school at 16 to work as a laboratory technician with a large pharmaceuticals firm. I was 'talent spotted' and encouraged to take a degree in chemistry through evening classes at a technical college. The teaching was excellent and made me want to become a research chemist.

936, father a case-maker and packer, birth cohort 1950–59.

> I was inspired by the chemistry teachers at my grammar school—Isaac Newton's school!

1364, father a factory parts inspector, birth cohort 1960–.

> I found chemistry difficult when I first went to secondary school, but my teacher was excellent and it wasn't long before I was borrowing chemicals from him to do experiments in my bedroom. I was hooked on bright colours, noxious smells and loud explosions.

What is reflected in the foregoing are in fact certain well-recognised features of the history of secondary education at least in England and Wales—Scotland being perhaps a somewhat different case. In the later nineteenth century, Francis Galton (1874) criticised the 'public' (i.e., private) schools of his day for their concentration on classics and their neglect of, and often hostility towards, science. They constituted, he claimed, a 'gigantic monopoly' of the clergy that was yielding only very slowly to the demands of modern society. And indeed science teaching at private schools would appear to have remained, with only a small number of exceptions,[10] quite limited and of indifferent quality until after World War II; and even then, while teaching in mathematics and to some extent in physics did become more common, teaching in chemistry was particularly deficient because few schools had adequate laboratories. Only from the 1960s did things begin to change. 'Modern sides', which had been introduced as an alternative to classics, increasingly covered the sciences as well as modern languages and history. The number of science teachers increased, and, through the Industrial Fund for the Advancement of the Teaching of Science, business firms provided millions of pounds to private schools to build new science laboratories (Turner, 2015). It may then be that the very mixed experience of private schooling among the elite chemists we have studied will be less evident among their successors. Nonetheless, it would appear—though the numbers we can draw on are not large—still to persist through into the later birth cohorts we cover. One possibility is that, despite the improved provision for the teaching of chemistry in private schools, its status as a subject in these schools has tended to remain relatively low, and that this is reflected in the often ambivalent attitudes towards their schools of the especially talented pupils in chemistry who were destined for elite status.

In state secondary schools, the situation was historically clearly different. After reforms in the early twentieth century, the classics no longer dominated curricula, and science teaching, including practical work in laboratories, steadily increased in importance, becoming not a matter of choice for schools but a requirement under state regulation. In some grammar schools, the reverse situation to that found in many private schools in fact existed: there was no sixth-form teaching in arts subjects, only in the sciences.[11] By the inter-war years, science teaching in grammar schools, and also in various forms of technical schools and colleges in which chemistry flourished,[12] was generally accepted as being superior to that in private schools, and this continued to be widely the case into the postwar years (Turner, 2015).

Over the period we cover, children who went to state schools could then be seen as having something of an edge over children attending private schools so far as making progress in chemistry was concerned. Among those of our elite chemists who were privately educated, their schooling would often appear to have done little to nurture an early interest in chemistry, whether deriving from their families or otherwise, or to encourage its pursuit to university level. In contrast,

among those who went to state schools, and especially from relatively disadvantaged social origins, their schools often played a major role either in first creating an interest in chemistry or in developing a pre-existing interest so that studying chemistry at university became a possibility. And as regards entry into the scientific elite, the route through chemistry could thus be regarded as offering somewhat more equal chances of success than did those through other fields, in relation to individuals' type of secondary schooling and their social class backgrounds.[13]

4. Conclusions

We have started from the finding that within the British scientific elite, defined for the modern period as Fellows of the Royal Society born since 1900, chemists appear distinctive in coming more often than Fellows working in other fields from relatively disadvantaged social origins and in having more often attended state rather than private secondary schools. In thinking of possible explanations for this finding, we called to mind the student stereotype of 'the Northern chemist' and wondered if this might give some indications of how it came about that those chemists who succeeded in entering the scientific elite—a small minority—should still tend to differ from other elite members in the ways in question.

'The Northern chemist' was taken to be male, and we do in fact further find that, while the scientific elite is in general male dominated, women are yet more poorly represented among chemists than among Fellows in most of the other subject areas that the Royal Society defines.

As regards geographical origins, chemists taken overall do not appear to be especially northern, as judged by either place of birth or of secondary schooling. But if we consider those chemists who are of more disadvantaged origins (i.e., NS-SEC Classes 4–7) we do see that they are more likely to be northerners by birth and/or schooling than their counterparts of Class 1 origins, who come more often from London or the South. And this difference is widened if we also take into account origins in Wales, as another region in addition to the North in which extractive and manufacturing industry has been concentrated.

In turning then to the influences that led to entry into chemistry, we find, from those cases for which we have the most detailed biographical information, that further clear differences arise among elite chemists in relation to their class origins.

Family influence appears to have been generally less important for chemists of Class 1 origins than for those of Classes 4–7 origins, and to be largely confined to cases where fathers were chemists, had connections with the chemicals industry or were scientists in other fields. With chemists of Classes 4–7 origins, the influence of fathers or of other—male—family members could again arise through these men being workers in the chemicals industry, but also through their having other mainly manual occupations in which some degree of chemistry at a practical level was involved. And of further importance was fathers' interest in science, including chemistry, as reflected in their acquisition of scientific books, instruments and materials and the encouragement that they gave to their children—mainly sons—to share in their interests and to gain some knowledge of chemistry outside of school.

As regards the influence of schools themselves, differences are further apparent between chemists of more and less advantaged social origins. Chemists of Class 1 origins mostly went to private schools, and those who did so appear to have been as likely to express negative as positive views of the experience, so far as their future careers in chemistry were concerned. In contrast, the majority of chemists of Classes 4–7 origins attended state schools and were very largely positive about the education in chemistry that they received, as also were the minority of those of Class 1 origins who went to state schools. These findings, we have noted, are much as might be expected, given what is known about differences in standards in the teaching of chemistry in private and state schools up to at least the 1960s.

How then, in the end, would we wish to account for the unexpected finding on the social distinctiveness of chemists within the scientific elite from which we began? In the light of what we have learnt from the data we have available, the explanation for this finding that we would suggest is on the following lines—and it is one that would in various ways be open to further empirical evaluation.

Over the period we cover, young people, predominantly male, coming from families relatively

disadvantaged in class terms, and often growing up in the North or in Wales, were led to study chemistry at school and then at university in significantly larger numbers, and more successfully, than their counterparts who turned to other sciences. Children from such families were more likely to gain an interest in, and some initial knowledge of, chemistry, rather than of other sciences, such as physics or biology, as a result of their fathers' or of other male family members' work in the chemicals industry itself or in a range of other largely manual occupations that required in some degree the practical application of chemistry. Moreover, in so far as these children did develop scientific interests, whether in this way or simply through encouragement from fathers following in a working-class tradition of self-improvement, it was in chemistry rather than in other sciences that their education, mainly in state secondary schools, gave them their greatest comparative advantage; that is, both over those studying other sciences and over those seeking to study chemistry in private schools. In this way, a larger pool was created in chemistry than in other scientific fields of people working in universities and research centres who were of relatively disadvantaged class origins and state educated. And this difference was then maintained through into the social composition of the very small number of those chemists who eventually, after all the processes of selection involved, gained entry into the scientific elite.

Finally, though, to return to the Northern chemist stereotype, we might note that in one respect this could be thought quite misleading: that is, in suggesting a somewhat socially limited and withdrawn individual. The more detailed biographical information that we have of chemists of Classes 4–7 origins gives the impression that they did in fact tend to have high levels of social participation, and especially through playing, and in later life administering or watching, sports. It is, though, further notable that it was soccer and cricket, the dominant sports in the northern industrial areas from which many came, that were by far the most frequently referred to—with one man having played soccer professionally and another being a double Oxford blue in soccer and cricket. Rugby was mentioned by only two men, both from Wales, while sports such as tennis or squash were only rarely mentioned, and golf not at all.

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Notes

1. Excluding Honorary and Royal Fellows, Foreign Members, all deceased Fellows whose last employment prior to retirement was not in the UK, and all living Fellows whose most recent employment was not in the UK or who would appear to have spent substantially more of their research careers outside of rather than within the UK.
2. We here distinguish NS-SEC Class 5, while in our paper previously cited it was collapsed with NS-SEC Class 4 of 'intermediate' (i.e. mainly clerical and lower administrative) occupations.
3. Direct grant grammar schools are also counted as state schools, but they were attended by less than 5% of Fellows in any subject area. We also distinguish a category of 'other' secondary schools, mainly religious ones, which were attended by around 8% of all Fellows.
4. The subject areas within which Fellows came into the most marked contrast with chemists as regards both their class origins and schooling were ones in those biological sciences with medical and health connections: developmental biology and genetics, immunology, microbiology; anatomy, physiology, neuroscience; organismal biology, evolutionary and ecological science; and health and human sciences. However, while Fellows in these fields become somewhat less distinctive in their class origins and schooling across birth cohorts, this was not the case with chemists. See further Bukodi et al. (2022).
5. Across the biological sciences, women account for over 10% of all Fellows. Of the 12 women chemists for whom we have relevant information, three were of Class 1 origins and three of Classes 4–7 origins. None was born in the North.
6. We omit Northern Ireland, since none of the chemists included in our study was born there.
7. This particular association between geographical and social origins is not one generally found among our elite scientists, although, rather oddly, there is some suggestion of it among those in the biological sciences

previously referred to who overall contrast most sharply with the chemists in their social origins and schooling.

8. Because memoirs and obituaries are more generally available than reports of interviews etc., there is some bias among the chemists we consider towards those in earlier birth cohorts. But, as earlier mentioned (note 4), there is no tendency for the distinctiveness of chemists as regards either their class origins or schooling to diminish across cohorts. It should in this connection also be noted that the average age of election to Fellowships of the Royal Society has been steadily increasing and by 2019 had reached 58 (Royal Society, 2019).
9. Both third-person statements coming from documentary sources and first-person statements are lightly paraphrased in the interests of conciseness, and some minor details have been changed in order to reduce the possibility of personal identification. Also for this reason, we give individuals' birth cohorts rather than actual years of birth.
10. The most notable exceptions were the three leading London private schools—the City of London School, St Paul's School and Westminster School—and Winchester. Of the seven chemists of Class 1 origins for whom positive views of their school experience are reported, one went to the City of London School and three to Winchester.
11. This was the case at the Leicester grammar school attended in the 1920s by CP Snow—later famous for initiating 'the two cultures' debate. In seeking university entry, he had to turn to science, despite having had his academic interests first stimulated by a history teacher (Ortolano, 2009).
12. Technical schools and colleges were of particular importance in the development of chemistry as an academic subject from the later 19th century onwards. Of the 16 eminent chemists whose biographies appear in the collection of Findlay and Mills (1947), previously referred to, only two went to 'public schools', and only one to Cambridge and one to Oxford. Two others went to Scottish schools and universities. The remainder all had at least some substantial part of their secondary and tertiary education in technical schools and colleges, mostly in London—notably, the Central Foundation School, Finsbury Technical College, South Kensington Technical College and the Royal College of Chemistry.
13. Members of the scientific elite who came from less advantaged class origins and who went to state schools were in general less likely than those coming from more advantaged origins and who were privately schooled to have been at Oxford and Cambridge, either as undergraduates or postgraduates. However, we find no evidence of this difference being more marked in the case of chemists than of those working in other fields.

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Article

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The evolution and predicament of modern social technicalization

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Abstract
Social technicalization refers to the construction and operation of society in accordance with the principles of technology. The stage of modern social technicalization was spawned after the Industrial Revolution and has mainly been manifested in two aspects: the heavy reliance of the operation of society on technology, and the increasing rationality of social technology. Modern society has undergone four stages of development driven by natural and social technologies: the initial stage, the institutionalised stage, the era of globalisation and the era of intelligence. The standardisation of social technology into natural technology, the comprehensive shaping of the human perspective and the promotion of social technicalization to attain social modernisation highlight the rationality and progressiveness of the technicalization of modern society. However, the rise of technological rationality also poses the dilemma of the one-sided human pursuit of efficiency, which has deepened the conflict between technology and culture and has exacerbated the imbalance between the development of social technology and natural technology. This needs to be examined dialectically.

Keywords
Social technicalization, social technology, evolution, predicament

1. Introduction

The concept of 'technicalization' is not unfamiliar. Owing to rapid advances in science and technology (S&T) in recent decades, technological development has dominated political, economic, cultural and social life in contemporary society. Society has achieved 'technicalization' to some extent as a consequence. The concept of 'social technicalization' emphasises the use of S&T achievements to inform the functioning of various fields of society, and thus realise the transformation of certain structures and functions of those fields.

The rapid S&T advances that ensued after the Industrial Revolution have had an enormous impact on society and have propelled human society into the stage of modern social technicalization. On the one hand, technology has penetrated every field of society owing to its powerful influence and has become an important force that dominates social operation. On the other hand, S&T developments have led to changes in society, such as an increasingly refined social division of labour and the rise

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of social organisations with different functions. Production, medical care, education and administration are thus maturing and have spawned increasingly sophisticated management systems, models and mechanisms in the processes of production of enterprises as well as the operation of various social organisations. Those social organisations, with various functions and efficient and orderly management systems, have promoted social technology to become increasingly rational and have enhanced the degree of social technicalization.

Although the concept of social technicalization has not been explicitly mentioned in previous theories in this area, the state of social operation to which it refers has been detailed in many theories. George Rizer's 'McDonaldized society', Max Weber's 'rational society', John Kenneth Galbraith's 'new industrial society' and Jacques Ellul's 'technological society' all describe the technological construction and operation of modern society at different levels and in different ways. Modern social technicalization is the inevitable result of the social pursuit of rationalisation.

Social technicalization means that a society is constructed and operated according to technical principles. It started as a mode of social operation at the dawn of human society, which entered the stage of modern social technicalization after the Industrial Revolution. Modern social technicalization has mainly been promoted along two dimensions. First, the operation and development of society are highly dependent on technology, which occupies a dominant position in social life. Technology permeates all fields pertaining to nature and society and determines and supports the operation of modern society. Second, social technology is becoming increasingly rational as it is perfected. It is a technical form that operates with the society as its object, and abstracts significantly from the rules, institutions and organisations related to social governance. Social technology can be divided into the forms of social organisation and social processes. 'Social organization' mainly refers to the organisations and groups that assume certain social functions, and 'social processes' refers to the workflow and regulations that are formulated to maintain the normal operation of organisations and groups. The development of natural technology and the perfection of the social technology system promote the advance of modern social technicalization. Modern social technicalization 'is a rational form of social life, which is based on reasonably designed technological artefacts and institutions endowed by reasonable technical disciplines' (Feinberg, 2018).

Social technicalization is an accurate portrayal of the current world, including politics, economy, culture and the daily lives of people. Modern social technicalization is a complicated process that has undergone four stages of development: the initial stage, the stage of institutionalisation, the era of globalisation and the era of intelligence. Many problems have been encountered while promoting social development that need to be examined rationally. Investigating this process can help us understand the relationship between natural technology and social technology in order to better understand the operational basis, the evolutionary logic and the developmental predicament of modern society. It also encourages people to reflect on their own state of living. This paper provides a detailed review and description of the process of social technicalization, analyses its complex effects based on that process and identifies the difficulties faced by modern social technicalization in an attempt to show the panorama of its development.

2. Evolution of modern social technicalization

Modern social technicalization is the result of the rational application of technological planning to modern society. Technological development in modern society is occurring more quickly than ever before, with the most prominent progress being made in the economic field. Natural technological innovation has extended to social technology and has led to transformations in the two forms of social organisation and social processes. Once the social technicalization of the economy has yielded certain results, it will spread to other social fields and drive an upgrade of the entire system of social technology, thus shaping the outlook for social technicalization in different periods.

2.1 The initial stage

The steam engine constitutes a prelude to modern social technicalization. Its invention and application

introduced mechanisation to production processes. Mechanical systems are composed of working machines, transmission engines and power engines, and this gives rise to their combination in the form of the factory. 'The factory came about not because it expanded the workshop, but because it used machine power, machines and engines' (Landes, 1986). The advent of the factory enabled the specialisation of production and prompted cooperation in the overall process of development. Factories combine many machines and workers and replace dispersed activities with joint activities. The latter necessitates management, and that led to the birth of the factory system. 'The factory system involves the concentration of capital, the collective labor of a large number of workers, a clear division of labor, and production management … The advantage is the extensive use of machines and the division of labor' (Heaton, 1920).

The Industrial Revolution was not only an accelerator of economic growth but also a driver of social transformation. Steam technology led to the development of the factory for production. The resulting use of large machines and numerous workers and the requirements related to their management led to the factory system. Factories and the factory system were the representative social and technological systems in this period. That led in turn to a more professional construction of social organisations than before and caused the social system to become increasingly orderly. Modern social technicalization was in its infancy in this period.

2.2 The period of institutionalisation

The invention and application of electric-power technology promoted developments in production. The scales of manufacturing organisations and financial institutions expanded continually, and capital became increasingly concentrated in the hands of a few rich capitalists and entrepreneurs. In the 1880s, the large-scale and standardised mode of production was dominant; monopolistic organisations came into being; and joint stock companies developed rapidly on the basis of the credit system. The establishment of corporations and the separation of property rights imposed more stringent requirements on management skills.

At the beginning of the twentieth century, there was a revolution in management with the development of models for organising production by Taylor and Ford. Taylor's system emphasised accuracy, standards and quantification. It divided the operation of the factory into various tasks that were further classified into several parts. The time needed to complete each part was determined and the best scheme was designed. Taylor's idea of 'standardization' inspired the American automobile magnate Henry Ford. In 1913, Ford built the first production line for automobiles in history. 'A production organization pattern based on standardized mass production appeared' (Liu and Wang, 2015). Ford specialised and refined the division of labour in production to implement scientific and professional management.

This period is called the period of institutionalisation because it provided the basic pattern for the technicalization of modern society. The revolution ushered in by electric-power technology changed the economic geography of society, promoted the expansion of the social division of labour and led to more specialised and rational spatial forms. 'Architects rushed to build office buildings, banks, police stations, factories, train stations, department stores, prisons, fire stations, madhouses, theatres—many different forms of space. All need to be properly laid out and coordinated … The space has to be meticulously organized, like a Bach fugue' (Toffler, 1996: 159). This accurately reflects social technicalization during this period.

2.3 The age of globalisation

After the Second World War, there was an 'explosion' of knowledge followed by the technological revolution, and the industrial society reached its developmental peak in this period. The most prominent achievement of this age was the development of the internet. Information travels at an extremely fast rate on the internet, and that led to the abolition of spatiotemporal boundaries such that information could be transmitted without delay. The birth of the internet marks the era of information technology. It began with the invention of microcomputer processing, which is now used in all fields of life.

The technology in this period exhibited the characteristics of rapid development, extraordinary complexity, high penetration, and the sharing of resources and responsibility. These characteristics highlight the universality of technology that caused the world to become closely connected, and laid the foundation for global social technicalization. With further advances in information technology, the socialisation and internationalisation of production reached an unprecedented level. Satellite communication, the internet and wireless technologies led to integrated production and consumption all over the world. Production overcame the boundaries of space and time, and the pursuit of combinations of production factors and their free circulation led to the emergence of multinational corporations.

The development of information technology induced a surge in the demand for information products and network equipment. An important feature of those products was their high degree of standardisation and modularisation. The production mode advanced by 'Wintelism' emphasised modularisation and large-scale production to integrate the production advantages and resources of all countries across the world. In order to promote international trade, rules and organisations were established one after another, which promoted a global advancement in social technology. The construction of the social technology system was no longer limited to a single country; technologies needed to be designed while considering reasonableness and standardisation in a globally holistic manner. Multinational corporations and Wintelism constituted the typical social technology system in this period. Products from all over the world became readily available at any given place, and this deepened the division of labour and cooperation among countries and led to the stage of global social technicalization.

2.4 The intelligent era

The developments in information technology have prompted a technological revolution. In 2016, the World Economic Forum was hosted in Davos, Switzerland, with the theme of 'Managing the Fourth Industrial Revolution'. In the same year, Klaus Schwab noted in his book, *The Fourth Industrial Revolution*, that 'the Fourth Industrial Revolution is being developed on top of intelligent technology' (Schwab, 2016). Intelligent technology is a comprehensive form of technology based on the internet, big data, cloud computing, artificial intelligence and other technologies. It is characterised by accuracy, openness and transparency. Intelligent technology has caused the intelligent factory to emerge as the core site of production. An intelligent system is used to realise automatic production. Data reading is completed by intelligent equipment and the output is obtained by using specific devices. In traditional production, there are fixed links among the raw materials, equipment, factory, transportation and the sale of goods, and they are all necessary to the system. These five modules are rendered independent as 'activity' modules in an intelligent factory. Each module has an independent system and supporting software in order to realise personalised production. Personalised customisation has thus become the main form of the process.

Society has entered the intelligent era as driven by intelligent technology. The intelligent factory and personalised customisation are representative systems of social technology in this period. In *The Third Wave*, Toffler has pointed out that this era has led to the introduction of new norms in society. For example, the workday has become more arbitrary. It no longer spans from 9 am to 5 pm regardless of the nature of the job, but varies according to the nature of the work involved. Dates are no longer fixed, and there is no clear division between day and night in the city:

> There are deep psychological, economic and technological forces behind this rhythm … Wealthier, better educated, and with more choices than their parents, people are reluctant to be seen as homogeneous. People do different jobs, use different products, and naturally want to be seen as different individuals who are not willing to accept a routine (Toffler, 1996: 161).

In the era of intelligence, increasingly stringent demands are being imposed on intelligent products. Intelligent wearable devices, intelligent homes, intelligent transportation and intelligent medicine reflect the trend of technology towards humanisation and intelligence.

3. Dialectical review of modern social technicalization

Although the concept of social technicalization has not been explicitly mentioned in previous theories in this area, the state of social operation to which it refers has appeared in many theories. The McDonaldized society, the rational society, the new industrial society and the technological society all describe the technological construction and operation of modern society from different aspects and in different ways. The outbreak of the COVID-19 pandemic has deepened our understanding of this mode of social operation. 'Technological pandemic prevention' became a well-known phrase in this time. Big data, cloud computing and artificial intelligence played an important role in tracing the spread of the disease, resource allocation, disease prevention and treatment. Large amounts of personal data were used for pandemic prevention and control as well as the resumption of work and production-related activities but posed issues of the violation of personal privacy as a consequence. Therefore, it is important to determine the boundary of intelligent governance and balance the relationship between personal data protection and the public interest. This is the fundamental expression of the contradiction between technical singleness and individual diversity and needs to be resolved in the process of modern social technicalization.

3.1 Advantages of modern social technicalization

In the process of modern social technicalization, the construction of social technology is continuously perfected. This is important for the normative development of natural technology.

Social technology is superior to natural technology. The objects of human cognition can be divided into three fields: nature, human society and human thinking. If the purposeful activities of humans are thus classified, natural technology, social technology and thinking-related technology are correspondingly obtained. Carl Mitcham, an American philosopher of technology, divides technology into the following aspects from the perspective of technological function: technology as reflected in the human mind, manifested through human social activity, and represented in the interaction between humans and nature (Mitcham, 1999). Technology as reflected in the human mind corresponds to thinking-related technology; that expressed through human activities corresponds to social technology; and technology involved in the interaction between humans and nature corresponds to natural technology. Thinking-related technology is the most basic of the three. Social and natural technologies can function normally based on thinking-related technology. Natural technology is the intermediate between social and thinking-related technologies. On the one hand, it is reflected as the achievement of thinking-related technology and, on the other, it is the cornerstone of social technological construction. Social technology is at the apex of these technologies. It integrates natural technology and thinking-related technology, is the realistic expression of human activities, and plays a leading and regulatory role in the development of natural technology. Every major social change in history has occurred owing to natural and social technologies. On the eve of the Industrial Revolution, Watt made a significant transformation of the steam engine. The English patent law of 1623 involved a series of policies to encourage technological innovation, which increased the benefits accruing from technological innovation. Innovation in social technology is an indispensable condition and guarantor of the development of natural technology. If the main body of social technological innovation can formulate policies to encourage technological innovation, and can solve the problems of investment, cooperation, service and technological expansion in the process of technological innovation, natural technology will develop in a benign direction.

Social technicalization shapes people's comprehensive development. Modern social technicalization accelerates the development of natural technology and provides the material foundation for the comprehensive development of humans. Moreover, the perfection of social technology guarantees such comprehensiveness. Maslow (1943) placed human needs at the core of his sociological theory and established a hierarchy of the needs. From the satisfaction of material life to the pursuit of spiritual life and the yearning for cultural life, the continual progression of human needs leads to the comprehensiveness of humans,

and this needs to be supported by modern social technology. In the aspect of physiological demand, it requires the support of natural technology. When security-related needs become pressing, the state and society should formulate institutions and laws to protect personal safety and property. In the context of emotional needs, more support and options are needed for public association, assembly, and freedom of religion. Needs further up the hierarchy, such as self-esteem, self-love and self-actualisation, require that society provide an environment of fairness and justice as well as equality of opportunities. The more people's demands rise, the greater is the extent to which advances in social technology need to match those in natural technology. Comprehensive personal development is a dynamic and historical process that requires the corresponding development of the modern society as supported by natural and social technologies.

The modernisation of society is facilitated by social technicalization. Modernisation is a macroscopic and multifaceted state of social development with political, economic and cultural progress as the main content. By contrast, technicalization mainly refers to the coordinated development of natural and social technologies. The relationship between them is one of inclusion and promotion: social modernisation includes social technicalization, and social technicalization promotes social modernisation. Different researchers have provided different definitions of 'modernization', but their content and expressions are similar. Modernisation represents social changes whereby politics, the economy, society, culture and people all advance efficiently in a clear direction. That requires the promotion of social technicalization.

3.2 Negative effects of modern social technicalization

The advent of the 'risk society'. Modern social technicalization is a new civilisation in practice. It appears that people can control the development of society to the greatest extent if they have a wide range of knowledge and abide by rational laws and order. Thus, people can enter an era of safety. Unfortunately, human society has encountered increasing uncertainty with advances in knowledge as well as progress in science and technology. While society is continually developing, it is now facing unprecedented crises and risks. The advent of the 'risk society' is not only the negative consequence of modern social technology, but also a characteristic of modern social technology. This risk occurs mainly due to the high dependence of modern society on technology and the risks inherent in technology itself. First, modern technology is a complex system based on cutting-edge science, and technological operation on this basis can yield unpredictable behaviours. 'Complex technological processes and systems have made our world so vulnerable that a single unexpected change could lead to a catastrophe' (Rapp, 1986). Second, technological artefacts need to be present in the environment to interact with social factors, and that interaction places technology in uncertain relationships. 'Technology can't just be restored to its original structure; it can take on multiple, stable, complex structures as it is used' (Ihde, 2002). Technological development means that human beings recognise technological defects and hope to improve current technologies through new technological means, thus leading to a superposition of risk.

The deepening crisis of social trust. In a technological society, we are faced with a plethora of information, confusion and fragmentation, which have resulted in a crisis of confidence. If the news is not true, the public will lose trust in the media. People are more likely to be deceived by lies and to become indifferent, such that they do not pursue the truth. That 'leads to information fatigue, the paralysis of decision-making ability, or a lack of in-depth thinking about the issues they care about at the level of being informed' (Goldman, 1999). When that trust breaks down, the cost for social operation increases. On the one hand, it takes a lot of time to authenticate information, and, on the other, that reduces the effectiveness of early warning information. The resulting social harm can be catastrophic.

The technological survival of humans. The most profound change owing to social technology lies in the large number of technological artefacts that influence life and production-related activities, where this

significantly extends the scope of human activities. The performance of certain functions of human beings by using technologies is a level of human technicalization, reflecting the progress and liberation of human beings. However, the continual replacement of human labour by technologies is exactly a process of continuous 'materialization' of human beings. According to a 2017 report by McKinsey & Company, 'By 2030, between 0 and 30 percent of jobs in various industries will be replaced by AI, ushering in an era of skyrocketing technological unemployment' (McKinsey Global Institute, 2017).

4. The predicament of modern social technicalization

Modern social technicalization is an advanced form of the modern technological movement and the basic trend of social evolution. However, the excessive expansion of technological rationality has brought about a crisis of human civilisation. Modern social technicalization faces many difficulties in the pursuit of sustainable development.

4.1 The pursuit of efficiency makes people one-dimensional

The most prominent characteristic of modern social technicalization is the supremacy of efficiency. The functions of society need to be accurate and orderly in the pursuit of efficiency. Modern enterprises continue to quickly innovate, and efficiency has greatly improved because of production standardisation, as well as the adoption of high-tech tools, the assembly line and intelligent equipment. Thus, social technicalization is deepened. Social management also sets efficiency as its goal. The early idea of such management was based on the belief that 'true democracy and true efficiency are unified' (Ding, 2004).

The pursuit of technological efficiency in modern society also requires accuracy. The book *The McDonaldization of Society* (Ritzer, 2006) describes how the fast-food company McDonald's sets strict standards for production. There are stringent requirements for the weights of pastries and meat, the operational process, the production technology, the distribution of seasonings and the time taken for roasting and frying, so that hamburgers made by McDonald's have the same weight and taste, whether in Africa or Oceania. In the field of education, one's scholarly achievements can be summarised by one's grade point average. The quality of television is no longer considered important, and the success of entertainment productions is determined based solely on ratings. In the pursuit of accuracy, there is a pervasive tendency to create the illusion of quantity and to reduce production and service processes to an 'exact' number. Ritzer (2006) summarized four characteristics of the 'McDonaldized' world: efficiency, quantification, predictability and controllability. These characteristics are shared by modern social technology. They are linked: quantification makes it easier to measure effectiveness; once they have been quantified, products and processes become more predictable. A variety of controllable, non-manual techniques are designed to ensure that a task is completed on time, or that the final product has a consistent weight and specifications. Behind these demands for precision is the same drive for efficiency.

In the process of technological development, society has been moving towards precision and efficiency at the cost of the richness and diversity of human beings. Accuracy and efficiency underlie a certain set of standards and prompt people to increasingly adjust their behaviours according to the relevant norms and standards. Being allowed to live in such a society means to be disciplined, which is a kind of submission of individuals to technical rationality. Society thus becomes a disciplined body in which the richness and diversity of individuals disappear, and the trend of one-dimensional thinking becomes prominent.

4.2 Deepening conflict between technology and culture

Technology and culture are the two main themes of human civilisation, and their development creates different forms of civilisation. They have formed both opposing and reinforcing relationships over human history and are interdependent. Technology is invented and applied in a certain cultural form, and culture constitutes the environment of

technological operation. Culture cannot be separated from technology, and any representation of the former must rely on a certain form of the latter. Technology is an important carrier of cultural representation and preservation. Every technological innovation drives an upgrade in the cultural system and becomes an important part of the culture. Therefore, from the perspective of the identity of technology and culture, the former is embedded into the latter, and is dependent on it. At this time, technology, as a subsidiary of culture, is restricted to the framework of culture and life. Therefore, the same relationship between technology and culture occupies the dominant position in the context of traditional technology.

After the Industrial Revolution, technology took on an entirely new look. The invention and use of the steam engine led to innovations in production, which in turn led to a reform of the social structure such that the degree of social technicalization improved significantly. The economic benefits of modern technology are so significant that it has penetrated all fields of social life and has become the leading force of social development by virtue of its efficiency and accuracy. Its development has shaped a unique technological culture during its evolution. The relationship between technology and culture subsequently changed: culture had to submit to technology and become a part of it. That led to a split between the scientific and the humanistic cultures. The relationship between the two is a problem faced by modern society in the development of technology.

4.3 Imbalance between the development of natural and social technologies

Modern social technicalization is continually advancing under the joint impetus of natural technology and social technology. Technology is divided into natural and social technologies because of their different fields of application, but they are in fact interdependent and complementary. On the one hand, natural technology requires a suitable social environment and institutional construction to achieve rapid development. North (1994) claimed that 'institutional factors, not natural and technical factors, are decisive for economic growth'. He believed that the development of social technologies, such as institutions, led to the development of natural technologies. On the other hand, once natural technology has been formed, it requires the coordination and cooperation of all social elements to be applied. Without social technology to mobilise the people, and money and materials, natural technology cannot influence progress. Social technology acts as a leader and a servant in the development of natural technology. Benign social technicalization should involve the coordinated development of natural technology and social technology. However, the evolution of modern social technicalization shows that the development of social technology is lagging behind that of natural technology. Another problem facing modern society is the imbalance between the development of natural and social technologies.

The failure of social technology to standardise natural technology and shape the comprehensive nature of human beings has led to problems in the process of modern social technology. 'The striking progress of natural technology, the extreme backwardness of social technology, and the cause of many modern misfortunes is the imbalance between the two technologies' (Jin, 2002). In addition to the risk-related characteristics of technology itself, unsound technical norms and poor technical standards led to the failure to set a boundary for the development of natural technology.

5. Conclusion

Modern society functions in a technicalized manner and is more efficient and orderly than any other society in human history. Its development as driven by advances in natural and social technologies can be divided into four periods: the initial stage, the period of institutionalisation, the era of globalisation and the intelligent era. The current status of modern social technicalization shows that society is on the route to rational, normative and efficient progress that has had numerous material benefits but has also caused many social problems. The crisis in the process of modern social technicalization is fundamentally the result of a conflict between technology and culture. The excessive expansion of technological rationality has caused culture to become

increasingly technicalized and lose its 'cultural' character. It is thus necessary to strike a balance between technology and culture and to enable culture to help adapt technology. That can be achieved by appropriately shaping the cultural environment to improve social technology. The system of social education should be improved in this context, because education can enrich people's understanding and encourage them to reflect on their lives in the world today. That can promote the benign progress of modern social technicalization.

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Cultures Of Science

Commentary

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Creating common ground: The 17th international conference of the Public Communication of Science and Technology Network

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Founded in 1989, the two-yearly PCST (Public Communication of Science and Technology Network) conference has established itself as the most influential international conference in the field of science and technology communication. The conference serves as a platform for practitioners, educators, policymakers and scholars to explore the evolving relationship between science and society.

The 17th PCST conference took place from 11 to 14 April 2023 in Rotterdam, The Netherlands; a series of online programmes held from 3 April to 5 April preceded the onsite conference. PCST 2023 attracted more than 700 delegates from across the globe and featured 16 pre-conference workshops, seven plenary sessions and 11 parallel sessions, making it the largest conference in the history of the network. Furthermore, the event provided a valuable opportunity for attendees to engage face to face following the previous conference, PCST 2018, held in Dunedin, New Zealand.

Conference overview: Combining theory with practice

The PCST Network aims to advance both the theory and practice of science communication, and this objective was fully realized at the PCST 2023 conference.

First, the conference was organized by a Dutch consortium comprising science communication professionals from both practical and research backgrounds.

Second, the conference encompassed more than 20 formats, from individual paper presentations to round-table discussions, problem-solving workshops and performances. One of the highlights of PCST 2023 was the integration of audiovisual art with science communication. For instance, during the lunch session, viewers were engaged with an interactive animation called 'ROBIN', which presented a scientific dilemma in a narrative format.

Third, regarding content, approximately one-third of the presentations focused on the practice of science communication, as indicated in the *Book of Abstracts* (PCST, 2023). Participants shared the achievements and experiences of various innovative science communication projects through case analysis. Some notable projects discussed included 'Borrow a Researcher' (a scalable science engagement activity), 'CitizAir' (a visualization project for real-time air-quality data), and 'Glitzern & Denken' (a science variety show). Additionally, public engagement, informal science education, citizen science and the science of science communication were major topics of discussion. The interview method and content analysis were widely applied

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in exploring these subjects. Some studies also adopted a comparative approach, comparing the views and attitudes of different groups towards scientific issues to identify influential factors.

Fourth, the conference attracted attendees from various organizations, including schools, governments, non-governmental organizations, businesses, media outlets and hospitals. This diverse participation provided a panoramic perspective and a wealth of knowledge for the conference. About half of the delegates came from the United Kingdom, the Netherlands, Australia, Germany and the United States. Among developing countries, South Africa and China had a notable presence, ranking 6th and 7th, respectively. Eight Chinese delegates from three institutions in China's mainland (Soochow University, the University of Science and Technology of China, and the National Science Library of the Chinese Academy of Sciences) attended the main conference. These delegates delivered presentations and participated in round-table discussions on topics specific to science communication research in China. These topics included interactions between Chinese scientists and journalists, the construction of civil scientific literacy in China, the effects of occupational literacy on Chinese civil servants' attitudes towards genetically modified organisms, the Chinese public's engagement with climate change, the information cues influencing the perceived credibility of deepfakes, and Chinese scientists' perspectives on the mediatization of science.

Creating common ground: Values, openness, inclusiveness, collaboration and expertise

The theme of PCST 2023, 'Creating common ground', highlighted the importance of science communication in bridging gaps, fostering collaboration and promoting the co-creation of knowledge. However, achieving common ground in the real world is a challenge, as it requires stakeholders with conflicting perspectives to cultivate mutual trust and hold an open attitude towards engaging in meaningful dialogue and debate. To address this challenge, five sub-themes closely aligned with the 'Creating common ground' concept were put forward: values, openness, inclusiveness, collaboration and expertise, which form the acronym 'VOICE'.

Values. On the one hand, the emerging field of the 'science of science communication' integrated established psychological and cognitive science approaches to revamp science communication. Several proposals explored how individual factors, such as values, influenced public perceptions of science and the challenges posed to science communication by deteriorating political and media environments. For instance, an experimental study investigated the motivated distrust of abortion science, revealing that the rejection of scientific consensus often stems from goal-oriented cognition rather than mere ignorance. This highlights the importance of effectively communicating with a public that has diverse cultural backgrounds and polarized beliefs. During a plenary session, Sonya Pemberton, an Emmy-winning science filmmaker, shared her insights on communicating science to international audiences.

On the other hand, within science and technology, various stakeholders with distinct values and interests collaborate. This diversity of perspectives raises questions about achieving scientific innovation that aligns with social values and meets societal expectations. The round-table discussion titled 'Making values work for technological innovation' explored this topic, highlighting the significance of values in technological development and showcasing two relevant projects.

Openness. According to the UNESCO Recommendation on Open Science, open science is an inclusive construct that aims to make multilingual scientific knowledge available, accessible and reusable for everyone. Open science aims to enhance scientific collaborations, facilitate information sharing and involve societal actors beyond the traditional scientific community in the knowledge creation, evaluation and communication processes (UNESCO, 2021). During the conference, participants engaged in discussions to explore how to realize open science and its contributions to the public interest. Above all, the results of studies on the social cognition of open science were presented. For example, one study analysed tweets containing hashtags related to open science, aiming to examine the evolutionary dynamics in public discussion. Moreover, participants reflected on the values and principles of open science. The insight talk 'Opaque transparency: Open science and the crisis of trust' critically examined the underlying motivations, expected

outcomes and implications of such calls for transparency. Additionally, presenters proposed various strategies to promote open science. For instance, the 'Living Labs' project strived to transform classrooms into living labs, while the 'Social Makerthons' project sought to install more open and inclusive innovation ecosystems in cities and regions.

Inclusiveness. 'Diversity and inclusiveness' form one of the guiding principles for open science, meaning that we should embrace the wider public and knowledge holders beyond the traditional scientific community. Based on interviews, researchers identified ways in which public engagement will contribute to opening science to society. It was argued that interaction between academics and societal actors could better align scientific questions and societal needs, increase academic research quality, and ensure a relationship of trust between science and society. Furthermore, participants shared various innovative approaches and practices that make public participation an essential part of open science. Additionally, inclusiveness lies in reaching out to minorities or marginalized groups and engaging them. Hence, there was a round table focusing on the methodologies that enable young people's voices to be heard and counted on in a connected, collaborative society.

Collaboration. Centring on this sub-theme, participants demonstrated multiple levels of cooperation, including collaborations between scientists and journalists, artists and educators, among others, for the purpose of promoting effective communication of cutting-edge science. Collaborations between researchers and residents can focus on seeking sustainable solutions to long-term challenges such as energy transition and water-quality testing. Collaborations among research institutes, government agencies and other organizations can help develop and implement innovative science communication projects. Several workshops were designed to address practical obstacles in cooperation, providing ways to enhance relevant skills. For example, games were used to teach participants how to match motivation for interdisciplinary collaboration with their actual roles. Different ways of cooperation across boundaries were explored through experience sharing and interactive discussions.

Expertise. From public crises like the COVID-19 pandemic to controversial issues like climate change, the public is overwhelmed by the sheer amount of information and opinions. In this context, attendees discussed the challenges faced by science communicators. For example, science used to have a monopoly on interpreting nature and society; however, nowadays, expertise is confronted with a crisis of trust. The reasons behind that fact were discussed in the sessions. Some argued that the proliferation of disinformation and conspiracy theories increases uncertainty, while others believed that the differences in perception between the public and experts result in barriers to risk communication. The competition between non-scientific and scientific knowledge erodes the authority of scientists' discourse and affects the public perception of science. At the conference, indigenous knowledge, a non-scientific knowledge system, was given serious attention. Using a recent example of a public debate in New Zealand about whether Māori knowledge is science, one presentation questioned what knowledge is and who has the right to determine it. Further, participants discussed whether the parameters of what constitutes an 'expert' and 'expertise' may need to be widened.

To address these challenges and find common ground, it is essential to create opportunities for scientists to communicate with the public and establish relationships of trust. It was noted that scientists, as the 'first servers', should increase their visibility on social media and actively participate in social debates. Several sessions aimed to help scientists improve their science communication abilities through introducing ability-training courses and resource-sharing platforms. Further, scientists' experiences in leveraging new media, such as blogs, to construct expertise and engage in science communication was also covered.

Prospect: PCST 2025 and PCST 2027

The Scientific Committee is the governing body of the PCST Network and consists of 28 members. The election term is four years, and half of the members step down at each conference. The PCST President Jenny Metcalfe announced the new Scientific Committee members at the closing ceremony. PCST 2025 organizers introduced the upcoming conference, which will be held from 27 May to 29 May in Aberdeen, Scotland. The conference

theme will be 'Using science communication to effect positive change: Exploring transitions, traditions and tensions'. Additionally, the committee voted to grant Shanghai Jiao Tong University the right to host the 19th PCST conference in 2027. This will be the first time that China hosts the PCST biennial conference.

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Journal Description

Cultures of Science is a peer-reviewed international Open Access journal. The journal aims at building a community of scholars who are expecting to carry out international, inter-disciplinary and cross-cultural communication. The topics include: cultural studies, science communication, the history and philosophy of science and all intersections between culture and science. The journal values the diversity of cultures and welcomes manuscripts from around the world and especially those involving interdisciplinary topics.

Aims and Scope

Cultures of Science is an international journal that provides a platform for interdisciplinary research on all aspects of the intersections between culture and science. It is published under the auspices of the China Association for Science and Technology.

It welcomes research articles, commentaries or essays, and book reviews with innovative ideas and shedding a fresh light on significant issues. Research articles report cutting-edge research developments and innovative ideas in related fields; commentaries provide scientific perspectives on emerging topics or social issues; book reviews evaluate and analyze the contexts, styles and merits of published works related to cultures of science.

The topics explored include but are not limited to: science communication, history of science, philosophy of science, sociology of science, science education, public understanding of science, science fiction, political science, indicators of science literacy, values and beliefs of the scientific community, comparative study of cultures of science, public attitudes towards a new scientific and technological phenomena.

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