

SCIENTIFIC HOLISM: CHINA MEETS WEST

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Abstract: This paper begins with an attempt to dissolve the issue of whether traditional China had science. It clarifies the issue as a philosophical problem about whether Chinese culture embraces a natural philosophy—a rational and abstract conceptual system that offers a higher order of understanding and explanation of Nature than do empirical sciences. It dissolves the issue by articulating Chinese natural philosophy characterized as scientific holism consisting of law-like Dao, paraconsistent properties of Yin and Yang, and interdisciplinary domains of Heaven, Earth and humans and by arguing that Chinese Science, the scientific spirit that is culturally distinctly Chinese, and Western Science, the scientific spirit that is culturally distinctly Western, will merge at the point of scientific holism, despite of their historical differences and contraries.

SOME YEARS ago, one of my colleagues, who was the dean of School of Natural Sciences, asked me if I could offer science-majored students a “Chinese Science” course. That struck me as a fascinating proposal. Though the course did not work out, the proposal inspired me to undertake a research project concerning the following questions. Is there such a thing as Chinese Science? Can any science be legitimately described as distinctly Chinese? How can a science be culture-specific? These questions converge on a problem that I am here attempting to dissolve.

I. The Problem of Chinese Science

IS THERE a meaningful way to speak of Chinese Science? This question was raised at the time when Needham started out on his monumental work, *Science and Civilization in China*. His sinological friends “doubted whether Chinese culture had ever had any science, technology, or medicine significant for the world” (Needham 1981, 3-4). Of course, this is not a novel doubt. Early in the twentieth century Dr. Youlan Feng, a distinguished Chinese philosophy of the 20th century, even presumed that China did not have science (Fung, 1922, 237). The cloud of suspicion dispersed, however, when Needham demonstrated that “before the river of Chinese Science flowed ... into the sea of modern science, China had seen remarkable achievements in many directions” (1981, 9). The influence of Chinese achievements in science and technology, especially the four great inventions, on the world history is so profound that, according to Francis Bacon, no religious movement, political operation, or military maneuver is comparable to it (1620, vol. 4, 114). Sivin, in his earlier thought, once argues that humanity has evolved *more than one* tradition of science. To think of science this way is not to think of “science as a world phenomenon with many

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local variants”; it is, rather, to think about science as a local and cultural phenomenon that contributes to the formation of the river of world science (1973, xi).¹

However, it has been argued that science and technology in China, which once occupied an advanced position in the world for a long period of time, failed to culminate in such a scientific revolution as the European one in the modern time. Toby Huff, for example, indicates that in such fields as astronomy, physics, optics and mathematics, which form the core of modern science, “the Chinese legged behind not only the West but also the Arabs from about the eleventh century” (Huff 1993, 239). Huff further indicates that unlike Arabic-Islamic science, which paved the path leading to the scientific revolution in Europe, Chinese Science was not even on the path. According to Huff, then, there is something internal to Chinese Science that explains its “great inertia,” that is, that the superiority of China to the West in ancient and medieval times “was wholly of a practical and technological nature, not one of *theoretical understanding*” of nature (1993, 238, italics added). Following Nathan Sivin (1982), Huff claims that this simply technological and not scientific advantage indicates that in ancient China “there was no overall, *coherent natural philosophy* such as one finds among the Greeks, Arabs, or medieval Europeans” (1993, 244, italics added). Once again Chinese Science is clouded with doubts.

Is there such a thing as Chinese Science? This is not an empirical question. It is not to be answered by simply pointing out, for example, that Chinese medicine is a paradigm of Chinese Science. The problem that Huff, following Sivin (1982), poses is that China “had sciences but no science, no *single conception ... for the overarching sum of them all*” (Huff 1993, 533; italics added). Sivin explains this problem as follows: “There is no obvious order in which to survey the Chinese sciences. There were no fixed relations between them. Thinkers before, during and for centuries after Han did not agree on, or even argue about, what those relations should be” (2002, 226-227). So, the problem about Chinese Science is not going to be solved no matter how many sciences one finds in Chinese tradition. Indeed, if we look for sciences in Chinese history from the point of view of modern science, in particular, if we look for those theories, methods, discoveries, and inventions that directly played a role in the emergence and development of modern science, we won’t find many if any. The Sivin-Huff requirement for a cultural tradition to embrace science is that it must have fostered “*abstract systems of thought and explanation* that give higher order to our thinking about the natural realm” (Huff 1993, 238, italics added) or a “*single structure of rational knowledge* that incorporated all the sciences” (Sivin 1995a, 169, italics added). Over one and a half century, the intellectual history has moved forward in some interesting manners. It took Chinese intellectuals about half a century to discover that China did not have sciences. It is generally believed that one of the two most significant outcomes of the May 4th Movement of 1919 was that so-called Mr. Science was invited to China. It took about half a century for this new belief to take root and flourish. The basic system of modern sciences in China was established between 1920s and 1950s. And then, it took another half century for intellectuals,

¹Note that this earlier idea of Sivin’s does not deny that a science can be international or trans-cultural. Modern natural science, for example, is the common property of all mankind.

domestic and overseas, to rediscover that China actually had sciences and that what she actually lacked was science—an approach to Nature. But is this belief really true?

II. Chinese Approach to “Nature”

The reasoning behind the Sivin-Huff position runs as follows:

- (1) If there is Chinese Science, then it must be a theoretical framework that fosters a general approach to nature and that framework must be distinctively Chinese.
- (2) Traditional China did not have such an approach to Nature.
- (3) Therefore, there has not been Chinese Science.

Needham does not agree with premise (2) and hence he does not agree with the conclusion. His monumental work is precisely motivated by the convictions that Chinese civilization fostered a sophisticated philosophy of Nature giving rise to theoretical understanding of nature and that “Chinese civilization had been much effective than the European in finding out about Nature and using natural knowledge for the benefit of mankind for fourteen centuries or so before the scientific revolution” (1981, 3). However, Sivin and Huff have a point and their position is fascinating. It entails that Chinese Science is possible if Chinese approach to nature is possible. This is exactly where Needham starts his investigation into scientific culture of traditional China. Needham’s observation is that though “modern science had arisen only in European culture and not in Chinese or Indian ... Chinese civilization had been much effective than the European in finding out about Nature and using natural knowledge for the benefit of mankind for fourteen centuries or so before the scientific revolution” (1981, 3). Thus, Needham argues that the existence of Chinese Science is a concrete fact and not merely an abstract possibility, and it is evidenced by Chinese approach to nature.

The claim about Chinese approach to nature is a claim about the general framework as the common basis of discourse and activities among Chinese sciences. This is not to deny that there existed diverse approaches to nature in Chinese culture. Derk Bodde (1991) identifies seven of them. They are the antagonistic/indifferent approach, the exploitative/utilitarian approach, the theistic/anthropocentric approach, the naturalistic/analytical approach, the animistic/moralistic approach, the semi-receptive approach, and the wholly receptive approach. But none of these approaches served as the general framework for common discourse and activities in Chinese sciences; and in fact, none exerted significant influence on Chinese sciences. What is missing on Bodde’s list is a *scientific holism*. According to Dusek (1999), Chinese tradition is one of the three traditions that foster a spirit of scientific holism.² Scientific holism “is radically different from the mainstream mechanistic image of science” (Dusek, 1999, 1). It seems to me that this scientific holism is at heart of Chinese scientific spirit. It is this scientific holism that provides a general framework for Chinese sciences. It is in this scientific holism that one sees the legitimacy of Chinese Science.

²The other two are Western Renaissance occultist and German Romantic.

In what follows I shall offer an outline of the scientific holism that, I think, characterizes Chinese Science. Before I proceed, I would like to make some important notes on how I would approach to the outline. First of all, I assume, as Sivin used to believe, that humanity has evolved more than one tradition of science. Hence, my outline of Chinese Science characterized as a scientific holism will not start off a particular concept of science or a set of criteria for sciences. The concept of Chinese Science would not have made much issue had a trans-history, cross-culture definition of science existed. Second, the problem with which this paper is meant to deal is whether Chinese culture embraces a rational and abstract conceptual system that offers a higher order of understanding and explanation of Nature than do empirical sciences. For this purpose I will look into Chinese scientific *spirit* rather than disciplinary sciences so as to recapture the critical dynamics that characterize the holistic framework of Chinese Science. Hence, examining disciplinary sciences to determine which of them qualify as Chinese Science is not relevant here. Chinese Science—the scientific spirit that is distinctly Chinese—may exist without any disciplinary science that instantiates it. Third, I take it to be the task of this paper to put forth a novel perspective for viewing and understanding Chinese Science. Hence, I shall concentrate my zeal on general characteristics of Chinese scientific holism and will not go in great details. In fact, the components of the outline that I will offer are all familiar to us; but their structure, relationships and significances have been interpreted differently in different contexts. The perspective I am suggesting is that Chinese natural philosophy may be characterized as a scientific holism consisting of law-like Dao, paraconsistent properties of Yin and Yang, and interdisciplinary domains of Heaven, Earth and humans. Finally, my interest is not merely in reinterpretation of the past. Scientific holism, as opposed to scientific reductionism that has dominated modern science for over three hundred years, has become increasingly popular since the middle of 20th century. Though it is still premature, its scientific spirit, namely, the holisticity (paraconsistence, nonlinearity, synergicity, interdisciplinarity, intersystematicity, and parallelism) holds great promise for next scientific revolution. I wish to show, again in an outline form, that Chinese Science, which missed the modern train, has the ticket to the next one. This claim about the future of Chinese Science is not as radical as Needham's claim that the Chinese anticipate the second scientific revolution or that the Chinese attempted to leap from a primitive approach to nature to a postmodern science without going through modern scientific revolution (Ronan, 1978, vol. 1, 165-166).

III. One Nomological Relation: Dao

The first component of Chinese Science as a scientific holism is the Dao or the “Great Way” as it is usually understood in the English-speaking world. If there is anything central to Chinese scientific thinking, then it is the pursuit of the one Dao. For Chinese Science, to do science is to pursue the Dao.³ Insofar as the goal of science is

³Beginning with Song Dynasty pursuit of Dao became a pursuit of Li. I shall explain this in later part of this paper.

concerned, Chinese Science isn't essentially different from western science for which to do science is to discover (or to describe) laws of nature or to formulate lawful explanations. Such a pursuit is the perennial problem and the persistent effort of Chinese scientific thinking. Needham understands this characteristic of Chinese Science as being grounded on "the assumption of a permanent, uniform, abstract order and laws by means of which the regular changes in the world could be explained" (1993, 40). That is to say, Needham takes Chinese pursuit of the Dao to be comparable to a pursuit of law of nature. Bodde, however, takes exception, arguing that there is no clear sense of "laws of nature" evidenced in Chinese classics (1991, 332-344). I appreciate Needham's insight; and I am also sympathetic with Bodde's position. Bodde is right in saying that the notions of "the mandate of heaven," "the Supreme Oneness," "the ultimate Rule," "the Regularity" and "the Constancy" found in Chinese classics are not sufficient to capture the essential idea of laws of nature. What Bodde observes is the distinctiveness of Chinese pursuit of the Dao. I wish to reconcile Needham and Bodde by arguing that Chinese pursuit of the Dao is both distinct from and comparable to western pursuit of laws of nature. Interestingly, it will turn out that the distinctiveness substantiates the comparability.

In pursuing Dao in the context of scientific activities,⁴ Chinese Science went in quite different a direction than western pursuit of laws of nature; and running in that direction Chinese Science eventually reached the point that while still indulged in a dark meal she was amazed to see that western science was enjoying a candle-lit dinner on the modern train passing by. Needham describes the dark meal in quite positive a way: in contrast to merely mechanistic and analytical view of nature, Chinese Science is an *organic* view (1981, 14). The organic feature is essential to all versions of scientific holism; and in the context of pursuing the Dao, it exhibits in three interrelated modes of thinking: generationism—thinking of Dao as the single generator of myriad things, connectionism—thinking of Dao as the central radiator of universally connecting, and unificationism—thinking of Dao as the ultimate force of cosmic unifying. These modes of thinking are already evident in Chinese classics as early as in *Do De Jing* (e.g., chapters 25, 39, 40, and 62) and they can be construed as follows.

In contrast to ancient Greek science that focuses on the search for ultimate constituents of the cosmic structure, ancient Chinese Science focuses on the search for the ultimate source of cosmic generation. Hence it is a cosmic generating theory and not a cosmoplastic element theory. *Generationism* is concerned about growth and production. As growth and production always refer one to network of relations, the thinking in the mode of generationism leads to the mode of *connectionism*, the view that it is the relatedness that determines the attributes of individual things and not the other way around. As Needham frequently argues, Chinese Science envisions a universal, dynamic connectedness such that every phenomenon is generated through connecting with every other. "On the Greek worldview, if a particle of matter occupied a particular place ... it was because another particle has pushed it there";

⁴Here I confine my discussion to scientific context and exclude the discourse on the Dao as moral laws.

whereas on the Chinese view “the particle’s behavior was governed by the fact that it was taking its place in a ‘field of force’” (Ronan, 1978, vol.1, 165-166). Since it is through Dao that myriad things are generated and connected, Dao unifies, and continues to unify, every system in the universe including the universe itself; and this leads to *unificationism*. Needham argues forcefully and with textual evidence that this organic philosophy of nature, consisting of generationism, connectionism and unificationism, “was universal among Chinese thinkers” and it “helped the development of Chinese scientific thinking” (1981, 14). One exception is Moism, the only one among all schools of thought in the pre-Qin period that adopted analytical, reductionistic, and experimental approaches. Moism failed to become the main stream of Chinese Science just as Heraclitus of Ephesus, a holistic scientist, failed to become the main stream of western science. It is not difficult to see that what Chinese Science pursues in the name of pursuing the Dao is akin to universal and necessary truths that operate regularly and that explains, predict and justify relevant events in the world, the latter being considered as an essential feature of laws of nature in modern science.

While both search for universal modality that affords justificatory, explanatory and predicative power, western science concentrates her zeal on quantitative dimension of laws of nature, Chinese Science seems satisfied with qualitative dimension of the Dao. Thus, much of the development of western science consist in the discovery of necessary relationship among magnitudes (e.g., the law of gravitation); but much of the energy of Chinese scientific spirit is spent on the investigation into relationships between Dao and Li and between Li and Qi. Here is how Chinese thinking roughly goes. Dao is instantiated by multiple Li’s. “Myriad things are made by and subject to different Li’s and the totality of these different Li’s exhaust the Dao” (*Hanfeizi*, “Jie Lao”). These different Li’s are, roughly, the causal mechanisms metaphorically imagined as the “reasons” and “grammars” of worldly “words” (objects, events, and states of affairs). Zhuxi put the same point in more dynamic term. These multiple Li’s are principles according to which heaven, earth and myriad things are generated (*Zhuzi Yulei*, Vol. 95). From what are myriad things generated in accordance with their Li’s? The answer is: From Qi. “What [physically rather than metaphysically] exists under the heaven is nothing but Qi” (*Zhuangzi*, “Zhi Bei You”) and “myriad things spontaneously emerge in the meeting of the Qi from the heaven and the Qi from the earth” (Wang Chong’s *Lunheng*, “ziran”). Thus, Li’s are in turn embodied in the movement of Qi (of multiple kinds). Needham remarks that the pursuit of physical Li through experimenting on Qi is very much wave-oriented rather than particle-oriented (Needham, 1981, 11). This is because there are different scientific images involved in western science and in Chinese Science. Qi is a fine, continuous, and dynamic flow that fills, penetrates, and pervades through the universe and that can be pictorially imagined as air or imaginarily visualized as vapor. It has the characteristics of matter, force and energy all together conceptualized in western science. It is the idea of Qi rather than that of matter that permeates in the Chinese physical thoughts. Discovering Li through experimenting on Qi characterizes Chinese Science in practice.

Chinese Li-Qi relation is parallel to the Greek form-matter relation, though they are not identical and cannot be reduced to one another. There is some degree of dualistic and analytical flavor in the Li-Qi conception. Li is universal, multiply realizable, and indivisible in a relevant domain, whereas Qi is particular, unique, and divisible in the domain defined by the relevant Li. However, the Li-Qi conception is an integral part of the generationism of Dao. It is more plausible to think of Li as something very close to that of nomological mechanism and Qi to that which combines the notions of wave, field, energy, and particle. Though discovering Li through experimenting on Qi sounds familiar to and even translatable into western science, one may argue that the notion of the Dao is still too vague and fuzzy to be scientific. What is Li, the so-called instantiations of the Dao? It looks nothing like $F = ma$ or $E = mc^2$, each being an instantiation of Law of Nature. The reason why Li's do not look like instantiations of laws of nature is simple; they are not quantified.

Still, notion of Dao is, in an important and significant way, comparable to the notion of laws of nature. The comparability may be approached by dissolving a long-standing puzzle about the Dao. It has been a puzzle how the Dao produces myriad things and gets them all connected and unified. To this question there has not been a philosophical answer that would make sense in scientific context. Indeed, the notion of Dao can be as mystical as Newton's notion of the First Mover. However, mysticism is not the only cause of this puzzle. The following notion associated with popular understanding of the Dao has also made significant contribution to it: The Dao is a relationship between objects or events. On this notion the myriad things are holding direct relation to the Dao; their coming into being, enduring changes, and ceasing to be are all due to the manipulation of the Dao. It is hard to demystify the Dao if we think of it as an extensional relationship between objects or events. For, then, the Dao simply does not explain why each thing becomes what it is and why each event happens as what it is.

Now, the puzzle about the Dao may be a puzzle about laws of nature as well. Like the Dao, a law of nature is a universal and necessary truth. However, if we think of it as an extensional relationship holding between objects or between events, then it invites a similar puzzle as does the notion of Dao. It is puzzling how a universal generalization with a strong modality would explain a particular instance if it were an extensional relationship between objects or events. It may serve to categorize an instance that falls in its domain; but it does not explain why the instance is what it is. Just how would the fact that all hearts circulate blood together with the fact this thing is a heart explain why this thing circulates blood? No, they wouldn't! It is the relationship between the property of heart and the property of circulating blood that explains. A law of nature as a universal truth is essentially a necessary relationship between properties; and in the case of these properties are quantified, it is a necessary relationship between magnitudes—e.g., mass, force, energy, acceleration, etc. $F = ma$ or $E = mc^2$ are good examples, where F , m , a , E , c are magnitudes or quantified properties. Because the property F -ness necessarily relates to the property G -ness, this thing must be G if it is F . The notion of necessary relationship between properties has

the explanatory power, whereas the notion of extensional relationship between objects doesn't.⁵

Likewise, much of the mystical appearance of the Dao would come off if in the context of science it is understood as universal truth whose essential feature is necessary relationship between properties (rather than between objects or between events). Thus, our understanding of the relationship between myriad things and the Dao becomes scientifically more transparent, that is, myriad things are subject to the Dao by virtue of possessing the properties the Dao subsumes. The analysis of the Dao in comparison with laws of nature is applicable to Li's as Li's are instantiations of the Dao. In modern science whatever object or event or change that instantiates properties subsumed by a law of nature is subject to that law; likewise in Chinese Science whatever object or event or change that instantiates properties subsumed by a Li is subject to that Li. This common pattern builds a sort of bridge between Chinese and western sciences and we are thereby compelled to admit that the Dao in the context of Chinese Science is law-like or nomological of some sort.

What are the properties that the Dao subsumes? Between what properties is Li a necessary relationship holding? The answer is: They are Yin and Yang. The Dao in Chinese Science is a nomological relationship between these two fundamental properties of Qi. Myriad things are subject to the Dao by virtue of possessing the Yin-Yang properties, and each is subject to a different Li by virtue of possessing a particular instantiations (a special pairs) of Yin and Yang.⁶ Are Yin and Yang properties? Is the Dao in the context of Chinese science a relationship between Yin and Yang? Can laws of nature and the Dao be translatable into one another? Next section, which outlines the second component of Chinese scientific holism, will answer these questions.

IV. Two Paraconsistent Properties: *Yin and Yang*

E Jing (*I-Ching* or the *Book of Changes*—a classic source of Chinese Science) provides the conceptual framework for Chinese Science (Needham, v.2, 334-335) and plays a pivotal role in Chinese technological innovation (Graham, 1989, 368-370). The Yin-Yang conception is the key concept in the *E Jing* and it is the second component of Chinese scientific holism.

In all instantiations of Chinese Science, *Yin* and *Yang* appear as the common properties that Qi possesses, and hence they are the common properties that myriad

⁵For detailed discussion on this topic, especially on laws of nature as intensional relationship between properties or magnitudes, see Dretske 1977.

⁶These two properties are sometime understood as two states of Qi (Ho 1985, 11). I am not sure about this interpretation. But this state-based notion is consistent with the property-based notion I just described. Just as we wouldn't have a radically different understanding of $F=ma$ if the relata involved in the law (F , m and a) are construed as different states rather than properties, so wouldn't we run into a radically different understanding of the Dao as law-like if Yin and Yang are construed as different states rather than properties. Next section offers more discussions on Yin and Yang as properties.

things possess. In other words, each of myriad things embraces both *Yin* property and *Yang* property (*Dao De Jing*, 42). Why should we understand *Yin* and *Yang* as *properties* rather than objects or events? First of all, it had been the maneuver of Chinese Science over a long history to generalize and synthesize physical (and mental) properties in *Yin* and *Yang* terms. Such a maneuver commenced as early as with the time of *E Zhuan*, wherein it says “a female, a *Yin* thing and a male, a *Yang* thing.” It was developed by the Huang-Lao School during the period of Qin and Han dynasties and popularized by the Xuan School (roughly, dark learning) during the period of Wei and Jin dynasties. Collecting and examining all the concepts that have been incorporated in the *Yin-Yang* conception at both metaphysical and physical (including psychological) levels, one will find that *Yin* and *Yang* invariably refer to properties—e.g., being existent/nonexistent, being covert/overt, being strong/weak, etc., just to list a few, and they are conceived as the fundamental properties of *Qi*.⁷

Moreover, understanding *Yin* and *Yang* as properties makes significant difference in our understanding of Chinese Science as a pursuit of the *Dao*. It is evidenced in Chinese classics that the *Dao* and each of its instantiation (*Li*) is characterized as some relationship between *Yin* and *Yang* properties. The connection between *Dao* and *Yin-Yang* appears as early as in the *E Zhuan*; the most popular quote is: “Once *Yin*, once *Yang*; and that is the *Dao*”, meaning that *Dao* is both *Yin* and *Yang*, and it is now *Yin*, now *Yang*. The Huang-Lao School, especially the *Huai Nan Zi* (a famous classic) is responsible for the initial interpretation of *Dao* in terms of the interaction and transformation between *Yin* and *Yang*. “The *Dao*, claimed as a rule, begins with one; but one does not give birth to things and hence it divides into *Yin* and *Yang*. The harmonization of *Yin* and *Yang* give birth to myriad things” (*Tian Wen Xun* or *the Teachings of the Heaven*). This is the conceptual foundation on which the author of this classic work formulates explanations for physical, chemical, biological, social, and mental phenomena as well as regularities of those phenomena. Although these explanations are not consistent in treating the *Yin-Yang* as the most abstract concept and sometime *Yin-Yang* is only listed as one of the pairs of properties that the *Dao* subsumes (*Dao Ying Xun* or *the Teachings of Dao Response*), that the *Dao* is a relationship between properties is clear.

I have argued that if we think of the *Dao* as nomological relationship between properties rather than objects, then we can think of the *Dao* in such scientific terms that particular bodies are subject to the *Dao* by virtue of instantiating the *Yin-Yang* properties under a certain description. This argument suggests a way of making Chinese and western sciences comparable. However, it does not advocate the view that Chinese science and western science can be translated one into another. The translatability problem is not that Chinese Science fails to grasp the idea of laws of nature. The problem is rather caused by its internal logic to be explained as follows.

What we observe in Chinese scientific thinking is that self-deployment and mutual transmutation of *Yin-Yang* is imaginarily visualized as wave-like behavior as

⁷I don't mean that Chinese Science *reduce* all properties to the *Yin-Yang*. Unlike western sciences, the philosophical foundation of Chinese Sciences isn't an analytical reductionism. It is rather a *reason holism*, which I will explain shortly.

it is described in the *Tai Ji* Diagram where *Yin* and *Yang* appear to be opposite properties that also exist in one another. Here “opposite” refers to either contraries or contradictories, depending on what instantiates *Yin-Yang*. Thus, in the holistic rationality of scientific thinking, for example, *Qi* is either *Yin* or *Yang* and each is both; it is, as the metaphor “*Qi*” suggests, neither substantial nor void but both; it is both a body and a wave but neither, and so on. These dialectic theses afford only a holistic interpretation, which follows paraconsistent logic. Both modern science and Chinese Science have faith in reason; but the former has faith in consistent reason and the latter in paraconsistent reason. Perception of opposites can be found in all cultures (Dusek, 1999, 48); however, the western tend to emphasize on the opposition of the opposites whereas the Chinese on the unity of them. In view of this fact, an attempt to translate Chinese Science, for example, the science in the *E Jing* into the consistent logic may be an interesting logic exercise but will not capture its scientific spirit. This is because *Yin* and *Yang* are paraconsistent properties and they are only consistent in the cases of their being instantiated as contraries). Thus, unlike laws of nature in modern science, which subsume consistent properties, the Dao subsumes paraconsistent properties. Hence, it is difficult to translate the concept of Dao into that of Laws of Nature. The latter would look awkward in the consistent logic if it had included the nomological relation that *Yin*-ness universally necessitates *Yang*-ness and vice versa such that if something were *Yin* then it would be *Yang* and vice versa.⁸

It is worth noting that as paraconsistent properties *Yin* and *Yang* are not like color and shape, which can be static possessions of objects and events. Rather *Yin* and *Yang* are dynamic properties, ranging over opposite *activities* and opposite *processes*. Dao as a nomological relationship between paraconsistent *Yin* and *Yang* dictates a dynamic approach to Nature. As I indicated earlier, ancient Chinese Science focuses on the search for the ultimate source of cosmic generation. It is therefore not entangled by the problem of infinite divisibility and propositional derivability; rather it is puzzled by conceivability of generating existence from nonexistence. Dao is understood as both a paraconsistent source of existence and nonexistence and a dynamic source such that mutual transformation of *Yin* and *Yang*, once embodied in *Qi*, manifests in five distinct and yet inter-locked modes of motion known as *Wuxing*—i.e., water, fire, wood, metal and earth. The doctrine of *Wuxing* was once construed as a theory of elements out of which the world is made of; however, scholars of Chinese studies have later realized that the reductionist interpretation or any interpretation that views *Wuxing* as physically distinct substances misses the primary concern or an emphasis of the theory used in scientific and philosophical studies in Chinese tradition (Schwartz, 1996, 81-97). Fashionable interpretations are now diverse, ranging from five agents (*Fung*) to five processes or five phases of a process (Sivin, 1987, 73, 75), etc. The fact is that in all Chinese sciences what

⁸I am not arguing that the reason holism, together with its paraconsistent logic, only exists in Chinese culture. Though it has existed in western cultures since ancient Greek as Lloyd demonstrates (1996, chapter 6), it failed to catch the modern train of science just as did Chinese Science. However, in contemporary world, paraconsistent logic is as odd and popular as non-linear sciences.

Wuxing refers to are five dynamic properties rather than elements, instantiating the paraconsistent *Yin* and *Yang*. In the doctrine of Wuxing “water,” “fire,” “wood,” “metal,” and “earth” are metaphors for dynamic properties or modes of motion. These properties or modes are mechanical descending (water), mechanical ascending (fire), physical reshaping (wood), chemical modifying (metal), and biological growing (earth).

Yin-Yang is the conceptual apparatus by means of which Chinese Science aggregates properties, physical and mental; and the Wuxing is the conceptual apparatus by means of which Chinese sciences aggregates modes of motion, change, and event, whether they are physical or mental. Thus, they constitute a conceptual schema and a common vocabulary of Chinese sciences and technological studies. However, the entire conception consisting of Dao, *Yin-Yang*, *Li-Qi*, and *Wuxing* is so vague and fuzzy that a methodological transformation of the conception becomes extremely difficult. It is even difficult for the philosophers who accept the holistic conception. The methodological guideline recommended by Daoism is *Xunlan*, i.e., roughly, transcendent observation from Dao’s point of view, which requires merging of the object and the subject. No matter what the transcendent observation means, pursuing Dao from Dao’s point of view is as paraconsistent as the concept of Dao itself.

The methodological guideline recommended by Chinese Buddhism is *Liaowu*, i.e., roughly, understanding in transcendent intuition, which requires understanding of the object with reference to understanding of the subject—i.e., understanding the object’s answer to the way of the subject inquiry. Transcendently intuitive understanding may go in two forms: (1) *Jiewu*, i.e., roughly, understanding through dissolving puzzles (and hence recognizing truth) in transcendent intuition during meditation, and (2) *Zhengwu*, i.e., roughly, transcendently intuitive understanding through embodied cognition of truth (during physical practice). Both *Xunlan* and *Liaowu* blur the distinction between internal (subjective) world and external (objective world) and both exclude empirical observation and experiment on the one hand and rational calculation on the other. Thus, they are both as vague and fuzzy as the conception of which they are the methodological transformations. To put this point in a positive way, the spirit of Chinese Science indulges itself too much in thought experiment.

The methodological guideline recommended by Confucianism is *Gezhi*, shorthand for *Gewu Zhizhi*. It roughly means exhaustively inquiring into (*Li* of) things to pursue the highest knowledge. This, though relatively articulate, is open to various interpretations and hence it has historically undergone enormous evolution. The problem lies in the method of *Gewu*. It may be either cognitive or perceptual, either rational or empirical, either theoretical or experimental, either analytic or synthetic. *Gezhi* was a methodology of the thought-experiment kind at the time when it was advanced in the 11th century, using initially as an epistemological method for self-cultivation. It was then gradually extended to include intellectual inquiry into physical existences of various kinds and transformed into various methods including empirical ones. *Gezhi* began to incorporate more and more natural studies in Yuan Dynasty. Zhu Zhenheng (1282-1358), for example, titled his celebrate medical book *Gezhi*

Yulun and insisted that medicine be part of *Gezhi*. Ming dynasty (1368-1644) was perhaps the best time Chinese Science should have caught. A part of *gezhi* was known as *ziran zhi xue* (natural studies) and knowledge of natural studies was tested in civil examinations. A good portion of *Gezhi Congshu* (Collection of *Gezhi* Works) published in Ming Dynasty devoted to scientific and Technological works. The *Gezhi* of Fang Yizhi (1611-71) style was even more radical; his work *Wuli Xiaoshi* was exclusively a study of physical world. When history reached late Qing dynasty *Gezhi* already officially embraced such disciplinary studies as geography, mathematics, survey and mapping, mechanics, acoustics, optics, electricity, and chemistry.

Virtually, “Learning of *Gezhi*” had occupied the conceptual place of science before the concept of the science was introduced (via Japan) into China in early 20th century. Even long after the introduction of the western concept of science, Chinese sciences continued to be understood as studies of *Li* (of some *Gezhi* sort). In other words, the emergence of *Gezhi* Learning, especially in its later evolution, makes a significant methodological turn. It indicates, though suggestively, a way to transcend the transcendent intuition that occupies the spirit of Chinese Science for over a thousand years. Unfortunately, traditional political and ideological systems together with Manchu invasion make the process of methodological evolution painfully slow. Had the methodological turn completed at due time, that is, had it so evolved as to include analytical, rational, and experimental approaches at both theoretical and practical levels at due time, which was certainly possible if it was let go naturally, Chinese Science could have culminated in modern science.

Another source of the translatability problem is that in pursuing the Dao Chinese science has emphasized on the qualitative dimension of the Dao at the cost of losing the sight of the quantitative dimension. Li’s, the instantiation of the Dao, are elaborated but not quantified. The same problem occurs in the study of *Yin-Yang*, the supposed properties that the Dao subsumes.⁹ Needham makes it very clear that the quantitative contemplation of Dao in Chinese Science is invariably algebraic rather than geometric. Of course, from the viewpoint of modern mathematics, which integrated algebra and geometry through Descartes’ work, Chinese mathematical thought was handicapped, but so was ancient Greek. While geometry remains an essential element of mathematics, an algebraic system has infinite capacity of multi-dimensional representation of shapes. The quantitative contemplation of Chinese Science tends to remain in a continuous and infinite mode. The specific mathematical issues about quantitative study in Chinese Science need not concern us here. As the qualitative dimension of Dao is emphasized, and in fact overemphasized, in Chinese Science, it is plausible to claim that the problem with Chinese Science is that it fails to produce quantitative sciences (Schwartz, 1985, 328). However, this problem helps Chinese Science maintain her holistic position on another aspect of Chinese approach to nature, which in turn generates a different issue.

⁹There are some interesting studies on the quantitative dimension of Yin-Yang properties. Hetu (The River Diagram) and Luoshu (Writing from the Luo River) present them in a decimal system; and the *Book of Changes* presents them in a binary system. Scholars have found a conversion between the two.

V. Three Interdisciplinary Domains: Heavens, Humans, and Earth

The third component of Chinese scientific holism is a triad of three domains of scientific inquiry: Heavens, humans, and earth. Sivin (1973, 1980, 1995a) once proposed the following list of disciplines that might be called Chinese sciences: medicine, alchemy, astrology, geomancy, physical studies, mathematics, mathematic harmonics, and mathematical astronomy. These disciplines can be described as Chinese Science because they are circumscribed by and confined to the general conception described above, namely, the conception consisting of the monadic Dao and the dyadic properties of *Yin-Yang*. Without this conception, they would lose their cultural identity. However, once these disciplines are put in the context of the scientific holism, they should be more appropriately understood as endeavors and activities of following three kinds of science: heaven science, human science, and earth science. These three sciences are essentially *interdisciplinary* domains. What I am suggesting is that whether we accept the holistic interpretation of Chinese Science changes our view of its history. From a disciplinary point of view, the history of Chinese Science exhibits many disciplinary studies, which may or may not be scientific in their own right; however, from the viewpoint of scientific holism, Chinese Science throughout its history has cultivated interdisciplinarity, which is an essential characteristics of scientific holism and which is one of the three main features of today's intellectual movement (the other two being interculturality defining cross-cultural and transcultural studies and internationality defining globalization). One may argue that interdisciplinary study without disciplinary studies is impossible! Yes, but then we have yet another explanation why Chinese Science failed to culminate in modern science.

Ever since Needham it has become a popular view in the studies of Chinese Science that Daoist thought is the root of science and technology in China. Indeed, the permanent theme of Chinese Science is to pursue Dao; but, Dao is not a private property of Daoism (Graham, 1989, Hansen 1992). Majority of scientists during the Song, Ming, and Qing dynasties associated themselves with Confucianism. Confucianism is very much responsible for developing a natural humanism, as opposed to the anthropocentric humanism, that Chinese Science fosters in its holistic spirit. An important feature of Chinese worldview is that it treats the world or nature as, metaphorically, a family rather than an individual. It is an image of heaven-man-earth. It places man between heaven and earth, and only in that sense it places man in the center of universe. However, it envisions heaven and earth as a home for man and not as rivals of man. Here the ancient familial model comes into play, which bestows Chinese Science with a familial attitude—i.e., treating nature (heaven and earth) as the home. Heaven science and earth science are developed to deal with nature as our home, that is to say, they are developed to cooperate with nature rather than compete and conquer it, to establish relationships with nature rather than exploit it, to value nature rather than merely use it, and to come home to build a family rather than merely tap resources. Tu Wei-ming (1993a, 1993b) describes this worldview as an “anthropocosmic vision.” I would describe it as a natural humanism. A natural-

humanistic approach to nature culminates in a humanistic science for which today's world is hoping. Here is another point at which the holistic interpretation of Chinese Science changes our view of its history. A science with humanistic characters does not make much analytical sense; however, it makes perfect holistic sense in addition to the human sense it makes. A scientific spirit doesn't have to be analytical in character just as a philosophy doesn't have to be Socratic in style and logic doesn't have to be Aristotelian.

Under the influence of the natural humanism, the three interdisciplinary domains of scientific studies flourished with the tendency to concentrating on human science. Confucianism and Legalism, for example, make obvious contributions to social studies. Even the Daoist's contributions to medicine, chemistry and biology, and the Moist's contributions to logic, mechanics and optics are more human studies. Thus, the history of Chinese Science exhibits a "life-oriented feature" (cf. Wang, 2001, 56). As this life-oriented feature is materialized, we see the three most mature technologies are ceramic, textile, and architecture; the four great inventions are paper, gun power, compass, and printing; and the four most developed disciplines are agriculture, medicine, astronomy, and mathematics. This historical phenomenon leads scholars to characterize Chinese Science as empirical, practical and technological and deny that there are "abstract systems of thought and explanation that give higher order to our thinking about the natural realm" in Chinese Science (Huff, 1993, 238). This is a salient example of failure to understand Chinese scientific holism. The failure causes one to observe only "*ge wu cheng qi*" (experimenting with things to make a device) but not "*ji jin yu dao*" (extending technology for an understanding of Dao) that I explored above. Insofar as technological transformation of sciences is concerned, life-oriented science is not unique to Chinese Science. Wasn't ancient western science a life-oriented science in the same sense? Wasn't modern science a life-oriented science in the same sense? Isn't contemporary science a Life-oriented science in the same sense? Technological and practical culmination of freely pursuing truth and knowledge is always dictated by the orientation of human Life. It is a normal historical pattern of science that "abstract systems of thought and explanation that give higher order to our thinking about the natural realm" develops through and parallel to the flourishing of life-oriented disciplines. Ming-Qing scientist Fang Yizhi's distinction between the learning of "*zhi ce*" (quality measure—i.e., empirical sciences) and that of "*tong ji*" (universalization—i.e., theoretical sciences) is an example of the self-awareness and theoretical expression of the historical pattern in the spirit of Chinese Science (cf. Zheng 2001). However, the natural humanism in its historical context did have negative effect on the realization of Chinese Science. The overemphasized value orientation and its prioritization on inappropriate level suppressed and limited the spirit of freely pursuing truth and knowledge. The historical phenomenon that Moism could not manage to continue in the main stream of Chinese intellectual movement and was pushed to the peripheral is a good example. But Moism didn't die as people usually assume (Bai, 1996). It continued at the level of scientific and technological activities.

Conclusion

I have painted a simple picture of Chinese Science—i.e., as our philosophers of science wish, a simple picture of Chinese theoretical understanding of, or approach to, nature. It is a simple picture with a triadic structure: the monad of nomological Dao manifested in multiple Li's embodied in various forms of qi, the duet of Yin and Yang properties manifested in the five basic modes of motion, and the triad of the interdisciplinary and natural-humanistic dimensions of heaven science, human science and earth science. The simplicity of the picture is like the simplicity of Chinese painting. It affords a simple view of the cultural specificity and the holistic model of Chinese Science. Yet it suggests rather complex a worldview, a view consisting of connectionism, unificationism, reason holism, interdisciplinarity, and natural humanism. It enables us to understand why “Chinese Science got along without dichotomies between mind and body, objective and subjective, even wave and particle” (Huff, 1993, 537-538) and I add, between value and fact, even between materiality and spirituality. Was it because this scientific holism that Chinese Science missed the modern train? Does this scientific holism suggest a different scientific revolution?

“Chinese Science is perhaps the major alternative to Western science” (Dusek 1996, 73), but it should not insist on its cultural identity. If it does, it will miss next train of scientific revolution. However, when Chinese Science finally got on the modern train and obtain analyticity (in the early twentieth century), it should not abandon its holisticity (as much as it did up to today) because that is its admission ticket to next train. In today's scientific world, traditional property-dualism is being replaced by holism through interdisciplinary, intercultural and international movements, which blur more and more traditional dichotomies in the intellectual mind. We are in the process of aggregating properties that we used to think irreducibly distinct. Analyticity and holisticity will eventually merge. 250 years ago Denis Diderot, commenting on the future course of natural science, wrote: “Just as in mathematics, all the properties of a curve turn out upon examination to be all the same property, but seen from different aspects, so in nature, when experimental science is more advanced, we shall come to see that all phenomena, whether of weight, elasticity, attraction, magnetism or electricity, are all merely aspects of a single state (Diderot, 1754, XLV, 68). That was the time of modern scientific revolution when Diderot wrote this. It has been argued that western culture does not lack a tradition of scientific holism (e.g., Dusek, 1999). So, Chinese Science isn't Chinese, and it will be recognized as Chinese Science when it is no longer Chinese.

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