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The Chinese Black Box – A Scientific Model of Traditional Chinese Medicine

Matthias Theodorou [1,*], Johannes Fleckenstein [1,2]

1 University of Bern, Bern, Switzerland
2 University of Frankfurt, Frankfurt, Germany

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ABSTRACT

Models of traditional Chinese medicine (TCM) are still difficult to grasp from the view of a Western-cultural background. For proper integration into science and clinical research, it is vital to think "out of the box" of classical sciences. Modern sciences, such as quantum physics, system theory, and information theory offer new models, that reveal TCM as a method to process information. For this purpose, we apply concepts of information theory to propose a "Chinese black box model," that allows for a non-deterministic, bottom-up approach. Considering a patient as an undeterminable complex system, the process of getting information about an individual in Chinese diagnostics is compared to the input-process-output principle of information theory and quantum physics, which is further illustrated by Wheeler's "surprise 20 questions." In TCM, an observer uses a decision-making algorithm to qualify diagnostic information by the binary polarities of "yang" (latin activity) and "yin" (latin structivity) according to the so called "8 principles" (latin 8 guiding criteria). A systematic reconstruction of ancient Chinese terms and concepts illuminates a scattered scientific method, which is specified in a medical context by Latin terminology of the sinologist Porkert [definitions of the Latin terms are presented in Porkert's appendix [1] (cf. Limitations)].

Introduction

Traditional Chinese medicine (TCM) is based on empirical observations of nature, health and disease. In contrast to a "substitution," TCM is more focused on self-healing. Therapy proposes to direct, enhance, or restore this self-healing potential. Disease emerges by maladaptation of the individual's self-healing capacity in a struggle with environmental influences, the so-called agents (latin agens) [2,3]. An observer gathers information about the functional state of an individual by interrogation, pulse, and tongue diagnostics [2,4-7]. The collected data is further qualified by the polarities of activity ("yang") and structivity ("yin") to integrate it into subsystems, comprising whole functional complexes of symptoms, signs of disease, findings, somatic and mental functions. Such functional circuits (latin orbis, "viscera") are abstraction models, which evolved empirically by observation, independent of anatomical postulates [8]. They connect to the body surface by a 3-dimensional network of conduits (latin sinarteries, "meridians") [9,10], which colligate "openings of influence," known as "acupuncture points" (latin foramina, inductoria) [11,12]. According to diagnostic criteria, they are carefully selected for acupuncture and moxibustion to exert a directed influence on the complex functions of an individual. Besides lifestyle recommendations, further therapies comprise drug therapy through herbal, animal, and mineral decoctions, pills, powders, and plasters, massage (latin premoprehension, "tuina") or "conduction exercises" (daoyin) [13]. From a Western perspective, the decision process leading from symptoms to an individualized diagnosis and treatment is barely traceable. Clinical and experimental studies use (semi-)standardized paradigms that focus on classical mechanisms and effects. The actual individualization in TCM remains a red rag in the perspective of evidence-based medicine. Less restrictive concepts, such as the more holistic biopsychosocial model (BPSM), strengthen the impact of individual versus standardized prerequisites in the course of disease. However, their conceptual complexity concerning methodology is still limited compared to TCM. The controversy in thinking is well explained by the following example:

*Corresponding author.
University of Bern, Bern, Switzerland
E-mail: mat@mail.ch
ORCID: https://orcid.org/0000-0002-6839-9519

some researchers attribute the Chinese theory of health and disease according to the classics (e.g. "Classic of the Yellow Emperor," 3rd Century B.C., including "Basic Questions" and the "Divine Pivot," "Classic of Cold Damage," 2nd Century A.D.) as "philosophical or superstitious construction" without need for application [14,15]. However, according to Chapter 13 of the "Basic Questions" [16], and Chapter 1 of the "Divine Pivot" [17], TCM is a rational method of correspondence desisting from shamanism and magic [2,14]. In the case of acupuncture, representing the most popular therapy of TCM in the West, common biomedical models of acupuncture effects like the gate-control-theory, segmental models, referred pain mechanisms, trigger points, placebo-effect, etc. [18,19-27], do not close the gap by explaining specifically diagnosis, therapy, and the resulting systemic effects of acupuncture on a wide variety of diseases that exceed a simplified pain-model. Acupuncture is also used for viral infections, allergies, sleeping disorders, urticaria, tiredness, depression, and many other systemic disorders that have nothing in common with pain mechanisms [28].

This gap may be left behind by the epistemological background of the biomedical model, based on causality and determined prognosis (determinism) (Table 2) [2]. Causality is a fundamental paradigm for classical sciences and Western medicine to handle quantitative data. Etiology describes causes of diseases in a medical context. Knowledge of causes allows determinism. Analysis of an investigated system or object provides information by dissolution in its components (elements). The sum of individual parts forms the whole. In biological systems, order of higher organization is reduced to underlying levels (reductionism). Biomedical physiology is the immediate consequence of this reductionistic model of biological systems, whose development can be traced back to the Iatrophysics and Descartes (1596-1650 AD). But what if causality faces the reality of indeterminacy (where cause and effect occur at the same time) in nature? Modern sciences like quantum physics and system theory reveal causality as a concept of mind, not a fundamental law of nature. Causality is only valid for the special case of a linear system with 2 active positions, where cause and effect can be assigned locally and temporally [29]. Initial and final conditions are separate, proportional, and determinable. Three factors already end in non-linear behavior, as seen in complex systems [29-31]. Cause and effect can no longer be defined locally (non-locality). Iterative feedbacks among multiple factors increase the sensitivity of a system to its initial conditions (butterfly effect) [32,33]. In quantum systems, cause and effect coincide temporally (indeterminacy) [34]. Prominent examples that violate the paradigm of determinism are the realization of the Einstein, Podolsky, and Rosen (EPR) experiment [35-37], Heisenberg's uncertainty principle (equation 1) [34], Bell's inequality [38], or the non-linear dynamics of complex systems [31]. What are the consequences of modern physics for medicine, which is still based on causality? To give a possible answer to this question, it is necessary to review some basic concepts of quantum physics (QP), system theory (ST), and information theory (IT), which illuminate possible crosslinks to TCM.

Table 1. The Eight Guiding Criteria.

Activity (yang)	Structivity (yin)
Extima "exterior"	Intima "interior"
Calor "heat"	Algor "cold"
Repletio "excess"	Depletio "deficiency"

Non-Causality in science and open questions

Quantum Physics and Living Systems

We would like to investigate Heisenberg's uncertainty principle (equation 1) more closely to understand the concept of indeterminacy in QP. It defines the interdependency of 2 complementary observables, such as position and momentum of a particle. Both cannot be determined arbitrarily at the same time. Measurement of the position x with precision Δx disturbs the momentum p by Δp [34,39]. This bottom limit sets the constant h, introduced by Planck, when he observed black-body radiation, and interpreted the true nature of light by single portions of energy, the light quanta [40].

Heisenberg's uncertainty principle:

$$\Delta x \cdot \Delta p \geq \hbar/2 \quad \text{(equation 1)}$$

Δx: change of position; Δp: change of momentum; $\hbar$: reduced Planck constant

Such light quanta can form quantum systems, showing a non-causal, non-classical interaction among pairs or groups of photons, called entanglement. Entanglement concerns all complementary observables, such as position and momentum in Heisenberg's uncertainty principle [34]. Entangled particles interact as a whole system. Independent of their distance, their measured properties (i.e. position, momentum, spin, polarization) correlate complementarily. In 1935, EPR tried to disprove Heisenberg's uncertainty principle by a thought experiment [35], which could be realized much later by Freedman and Clauser [37] in 1972, and Aspect et al [36] in 1981. All these experiments did not lead to refutation but to confirmation of entanglement. In Aspect's realization of the EPR-experiment [36], a pair of entangled photons is emitted in contrary directions at the same time. Their polarization describes their direction in space and time, which is not measurable directly, but can be observed until both pass a filter. Each photon shows a vertical or horizontal polarization. According to the filter's angle, 50% will be absorbed and 50% will pass. If the 50% of the passing photons would pass another filter that is turned by 30°, 75% will pass and 25% will be absorbed. If it is turned by 60°, 25% will pass and 75% will be absorbed, by 90°, 0% will pass and 100% will be absorbed. If 2 entangled photons move in contrary directions and pass filters that are turned by 30°, it would be expected that at each filter, 50% will pass and 50% will be absorbed. However, this is not the case with entangled photons. Surprisingly, the second photon will pass the second filter with a probability of 75%, if the first photon passes the first filter at the same time. Both results are complementary; if one is horizontal, the other is vertically polarized, although the observation of a single photon would predict another result [41]. The entangled photons seem to interact although they are strictly separated. A classic interaction would only be possible, if it would occur faster than light over an arbitrarily large distance, which would violate the local realist view of causality required by EPR [35]. The polarization is yet not determined until it passes a filter. The measured result depends on the measurement of the first photon, which is also not possible in classical physics. Even the observer (subject) and the system (object) depend on each other like in an entangled state [41]. According to the Copenhagen Interpretation [42], entangled states collapse from a potential of probabilities (superposition) to a single measured value, which is not yet determined until its measurement [39,41]. According to Born, measured eigenvalues of light quanta are probabilistic (Born rule) [43,44]. This is not compatible with deterministic sciences, based on established laws of nature, determinable attributes, and reliable measurements. Heisenberg's uncertainty principle set the bottom

limit of causality. This contradiction was already shown by Bell's inequality in 1964 [38], long before its first experimental confirmation in 1972 by Freedman and Clauser [37]. Further refined experiments by Aspect et al [36] and others followed, which all could not disprove Bell's inequality. Until today, quantum theory is one of the most profoundly tested theories in the history of science.

Current concepts are far beyond previous assumptions that quantum-physical entanglement is limited to the subatomic level of non-living matter. Indeed, entanglement occurs also in living systems. Investigations show that a highly efficient energy transfer in photosynthesis is possible only by the entanglement of photons with the light-harvesting complexes inside [45]. The perception of the earth's magnetic field in European robins is also a good example for entanglement in biological systems [45]. A photochemical reaction creates radical pairs in spin-correlated quantum states, such as singlets or triplets. They change their polarization under the influence of the weak magnetic field and act as a chemical compass [45]. In a human system, entanglement is not yet observed. Biomedical physiology is still founded on "reliable" measurements, as far as they can be. However, Heisenberg's uncertainty principle raises uncleared issues about established concepts of physiology, which is yet based only on classical physics.

System theory and complexity

The problem of indeterminacy is not just limited to the small world of quantums. Also, large complex systems show behaviors, which are not determinable. Complexity is a common phenomenon of nature as seen in social networks and behaviors, global markets, the weather forecast, the immune system, the nervous system, the genetic system, and others. Stability (homeostasis) depends on synergetic auto-feedback (iteration) interactions, which enable adaption to spontaneous environmental changes. Complex systems are more heterogeneous in their entity. Thus, they sustain a higher stability by an increasing count of feedbacks and a redundant allocation of tasks. Upcoming entropy is dissipated to the environment to maintain order and stability by influx of matter and energy [33,46]. ST is an interdisciplinary method using mathematical models to predict the dynamic behavior of complex systems by defined control parameters over a limited period (time series analysis) [47]. Parameter sets are modeled from bottom-up in pathways (trajectories) to construct attractors that designate possible equilibria of a time-evolving complex system [29,31]. Such attractors can describe the increasing complexity of a system from fixed points, periodic, and quasi-periodic up to chaotic behavior [47].

However, this is still far from a complete description of a self-organizing, complex system that is in continuous exchange with its environment. Self-organization, self-creation (autopoiesis), iteration, synergetics, cyclic behaviors, emergence, chaos, fractality, and self-similarity are further attributes that exhibit non-linear dynamics far from thermal equilibrium [31,47]. Lorenz noted how tiny changes of initial conditions in mathematical parameters had a big effect on the calculated prognosis of the weather forecast (butterfly effect) [32,33]. The Lyapunov-exponent quantifies this disproportional effect [47]. Smallest fluctuations escalate by iterative feedbacks until they rise to non-linear behavior of a whole system [47]. This refers to the assumption of non-causal, synchronous interactions in complex systems concerning Poincaré's non-linear solution of the 3-body problem in classical mechanics [29-31]. Prognosis is limited by the increasing count of influencing factors, that may be considered as control parameters. Since even small fluctuations can induce profound changes, prognosis about the progression of a system is limited by symmetry-breaking [31,33]. It would be an impracticable effort to measure and determine all possible interactions to consider them in calculations. However, even though this may be possible, it is not possible to measure beyond Heisenberg's uncertainty (equation 1) [34,39]. Thus, fluctuations beyond this bottom limit remain unknown and make it impossible to determine a complex system in principle [31].

The contribution of ST to medicine was the introduction of the BPSM. However, the methodological consequences sine qua non of complexity on causality and determinism are still lacking. Complexity in medicine is mainly restricted to mathematical approximations or stochastics. Comprehensive medical approaches include for example neuronal cluster binding in the process of perception (binding problem) [48,49], epidemic models of the Lotka-Volterra type [50], the heart frequency analysis of pacemakers, the heart rate variability in the prognosis of heart failure, the chaotic analysis of epileptic EEG signals, and spreading and growth of tumor cells [51-53].

Information theory - a possible solution for non-causality in medicine?

Both, the tiny realm of QT and big complex systems, reveal causality as a limited epistemological method in the light of non-linearity and Heisenberg's uncertainty principle. Which method could handle non-causality in medicine, considering the human nature as an undeterminable issue? IT provides a possible solution independently of causality [54]. IT assumes a so-called black box for a system with undeterminable attributes. Only its input- and output-behavior provides information by the input-process-output (IPO) principle (Fig. 1), without the need to know its inner structure and processes [47,55]. Experimental setups and observations are conceivable as questions (input) and answers (output). The output is submitted by information units, the classical bits (cbits). They connote yes- or no-statements by the mathematical expression of a binary code with 1 and 0 [56]. The information of a cbit is determined before the experimental question (input) arises since it is based on classical physical phenomena. However, this is not the case with the entangled state of a quantum system that constitutes the smallest possible information system [41]. Entanglement depends on 2 complementary observables, which can be expressed by 2 "probabilistic" yes- or no-statements. Till measurement, the information of both states is "simultaneously" present with certain probabilities [41]. In contrast to cbits, non-classical quantum bits (qubits) confine the probability for yes- or no-statements along a given path, which depends on the initial state and the asked question (path dependency) [41]. They remain also undetermined

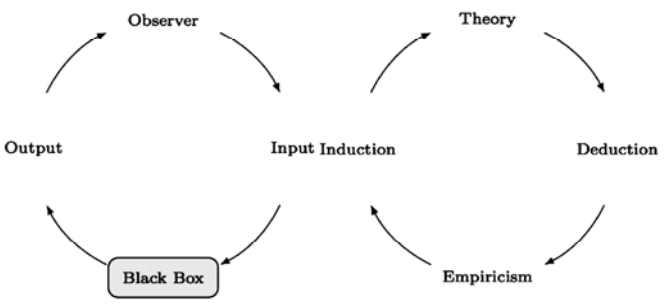


Fig. 1. The diagnostic cycle of the CBB follows the IPO principle of IT. The doctor (observer) evokes responses (output) by physical examination and questions (input) to the patient (black box), whose "inner world" is unknown.
CBB, Chinese black box; IPO, input-process-output; IT, information theory.

till the experimental question (input) arises.

Wheeler illustrated the process of getting information about a quantum-system by the game of 20 questions, known in many cultures [57]. In this game one tries to ascertain an issue another person thinks about. The answers are restricted to "yes" or "no." The better the questions are, the less are needed to characterize the issue. The issue is determined, before the person is asked, just like in the case of cbits. In Wheeler's version (surprise 20 questions), the issue remains undetermined till the question is asked, as in the case of qubits, but, proceeding answers must not contradict the prior ones (path dependency). In general, this method characterizes the information about an undeterminable system. The properties of a system "evolve" firstly along probabilistic pathways dependent on the questions of the observer. Thus, IT is a useful tool for complexity and a non-deterministic approach. Hence, IT maybe also be a useful tool for a methodological framework in medicine.

The Epistemological Encounter - Introducing Information Theory to Traditional Chinese Medicine

As a general method, IT is already indispensable for QP and ST [31]. In the case of TCM, IT seems to be the key for handling complexity in medicine, as causality might not be apt for TCM [2]. Indeed, the similarities between both methods are striking, especially in Chinese diagnostics [2]. To understand the concepts of TCM better, it is necessary to take a step back to its roots of methodology in Daoism, the "teaching of the way." Daoism uses polar abstraction of natural phenomena in terms of activity and structivity [58,59]. Beyond their medical implications as technical conventions, both terms cover abstractions of dynamic functions to gather information about an observed issue. Each effect in nature unfolds in certain directions (directionality) [2]. Activity starts from one position and spreads. Structivity ends in a position and absorbs an effect [58,59]. Together they encircle rhythms of nature. Phenomena can be qualified in directions of more or less, smaller or higher, etc. In this "way," mapping directions of natural phenomena into polar complementarities refers to a kind of binary code (Fig. 2) [14,58,60,61]. If cbits and qubits are recapitulated as units of information, the Daoist binary code lacks quantitative statements. However, it is closer to the quantum binary code than a classical binary code, as it also characterizes information about probable, undetermined states or functions [58]. For example, qubits characterize probabilistic information about the direction of an entangled photon with a certain polarization, whereas activity and structivity are 2 indivisible superimposed qualities that provide probable, complementary statements dependent on the observers view. Independent statements are impossible [58,59]. Hence, the more something is qualified active, the less it is structive.

This might reflect Heisenberg's uncertainty principle (equation 1) of complementary observables in a qualitative "way" [34]. Considering the "way" as the undifferentiated and undeterminable potential of reality, the unobtainable limit that is drawn beyond the Planck scale is quite close to this definition [58,62]. An observer applies this binary code to approximate the dynamics of nature, as it is also done in Chinese diagnostics.

ST illustrates common features of TCM and IT remarkably by Feigenbaum's map (part of Fig. 2) concerning non-linear behavior [63]. Complexity and indeterminacy increase by progression of bifurcations [33]. Up to the first bifurcation equilibrium systems are predictable. Between the first and third bifurcation, complex systems oscillate between different probabilistic states. Above the third bifurcation, systems become chaotic. They are no longer predictable according to the indeterminacy of probabilistic states, as already mentioned in the case of quantum systems or the 3-body problem in classical mechanics [29,31]. After chaotic evolution, order reestablishes and disperses again in later periods, as shown by oscillation of brighter and darker areas in Feigenbaum's map [33]. Order and chaos are both interactive parts of the unfolding living dynamic [39].

ST is not limited to qualitative statements, but its quantitative statements are limited concerning behavior and prognosis [31,39]. The progression into indeterminacy with probabilistic states after bifurcations in Feigenbaum's map is strikingly reminiscent of Daoist key points. According to Feigenbaum's map [33], a "Daoist map" (Fig. 2) can be reconstructed from the "Classic of Changes" (10^{th} to 4^{th} Century B.C.) [60,61] and the "Classic of the Way of Virtue" (4^{th} Century B.C.) [64], where qualifications of activity and structivity progress in the same way by bigrams, trigrams, and hexagrams. Both illustrations of complex phenomena show self-similarity of fractals that evolve in a 2^n period paradigm (2^0=1, 2^1=2, 2^2=4, 2^3=8) according to a binary code [60,61]. In both cases, the Daoist and Feigenbaum's map, prognosis is limited up to the third bifurcation (Fig. 2). In the "Classic of Changes," the complexity of life seems to be embedded in a dynamic balance between order and chaos. Starting from "non-polarity" or "nothingness" (wuji) the static state of the highest order is moved by disorder [65,66]. This stimulates the unfolding process of life, which enters the "ten thousand things" with the highest content of information [67]. By progression of bifurcations, freedom of movement increases in line with probabilistic evolution. Entropy rises along the edge of chaos [33]. "Eight trigrams" are mentioned in 2 sequences, the "pre-" and "post-heaven" sequence [65]. They are characterized by symmetry (pre-heaven) and symmetry-breaking (post-heaven), both common phenomena of nature, also well-known in complexity by the emergence of order and chaos [31,33,46]. Each of the 64 hexagrams in the "Classic of Changes" consist of 2 complementary trigrams. The upper is qualified by activity or "heaven," the lower by structivity or "earth." Their interaction predicts the dynamic order of time and space [66,68]. "Man" connects in the middle between both trigrams. Assuming that the 64 hexagrams illustrate an oscillation between ordered and chaotic states as it happens in time-evolving, living systems [69], the "Dao" (way) is just like a pathway or guidance for this unfolding process of life in complexity. "Heaven" according to a more chaotic state interacts with "earth" according to a less dynamic, more static, or ordered state to create "man" and the "ten thousand things" in the dynamic "ordered chaos" of living phenomena [66]. Thus, the concepts of Daoism might yield information about a "way" to describe complexity. This affects also the concepts of TCM about the development of health and disease by chaotic disruptions of the environment, the agents [3].

The Chinese "Way" of Diagnosis according to Feigenbaum's Map and Wheeler's Surprise 20 Questions

Like a mirror to macrocosm, Chinese non-linear physiology reflects a microcosm with the same dynamic balance between order and chaos in the Daoist map. Chapter 5 and 67 of "Basic Questions" indicate, that agents are not just the operative factors of disease, but also "chaotic" stimuli, needful to maintain health [70,71]. Chaotic deviation (latin heteropathy, "pathogenic qi"), and thus, disease will not develop, if such stimuli are balanced and integrated in a self-stabilizing order, defined as "straight-running function" (latin orthopathy, "healthy qi") [2]. While agents are disturbing factors, a heteropathy is a disorder that persists beyond the influence of an agent [3]. Heteropathies are deviated functions from the physiological equilibrium that stabilizes between unfolding functions and auto-feedback controls [2].

Disease develops between order and chaos as a "chaotic excess" from the maladaptation of an individual (microcosm) within its environment (macrocosm) [71]. The Chinese diagnostic cycle follows the pathway of the Daoist map backwards to discover the "roots" of disease. Starting with symptoms according to the expression of living phenomena (ten thousand things), the process follows 3 levels of abstraction [2,6]:

- First, the observer uses the 8 guiding criteria (Table 1) to judge the present qualitative deviations that are induced by chaotic "excess" (latin repletio) of heteropathies or "deficiency" (latin depletio) of the orthopathy [2,5,6]. Heteropathies manifest by a certain dynamic (latin calor, "heat," or latin algor, "cold") and location (latin extima, "exterior" or latin intima, "interior") [5,6]. According to the "eight trigrams," the 8 guiding criteria qualify different states of maladaptation of an individual in its embedded environment. They qualify 8 probable conditions of a dynamic system according to the level of the third bifurcation in the probabilistic Feigenbaum map (Fig. 2). They are a qualifying tool, not an analogy to examination findings [5,6]. They "guide" a pathway of qualitative decisions through a "complex" of examination findings in a non-causal network [4,72]. Their common property is their synthetic direction (directionality) [5,2], expressing the deflection of physiological functions [e.g., calor is an abstraction, not a sign or symptom. It is an evaluation of an observer about the direction of activity, and composes signs and symptoms like heat sensation, agitation, a fast pulse, redness of the tongue, etc. in a non-causal complex (Fig. 3)] [5,6,70]. Calor is like a "quantum binary," complementary assessment to algor, if one considers the condensation of information about probabilistic states, that manifest in individual examination findings. Therefore, all abstractions like the 8 guiding criteria, agents, orbis, and conduits, are complexes of symptoms, signs of disease, and findings, that cannot be traced back to single elements, such as anatomy, physiology, etc [2,4,70,72].
- Second, the observer identifies the agents of disease that are induced by the chaotic influence of the environment and the 4

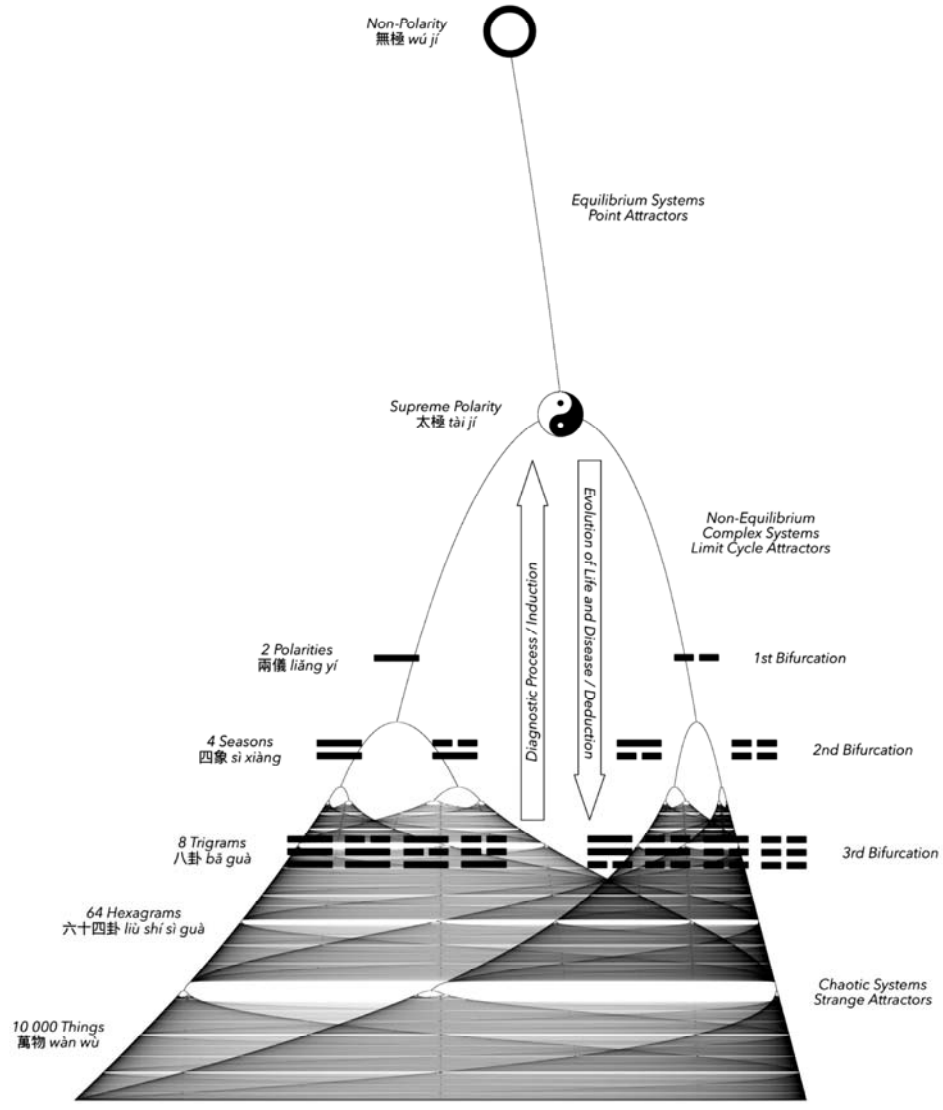


Fig. 2. Feigenbaum's logistic bifurcation-map of complex system behavior and the Daoist mapping of living phenomena in a binary code (bigrams, trigrams, hexagrams) of information show the close relation between ST, IT, and Daoism.
IT, information theory; ST, system theory.

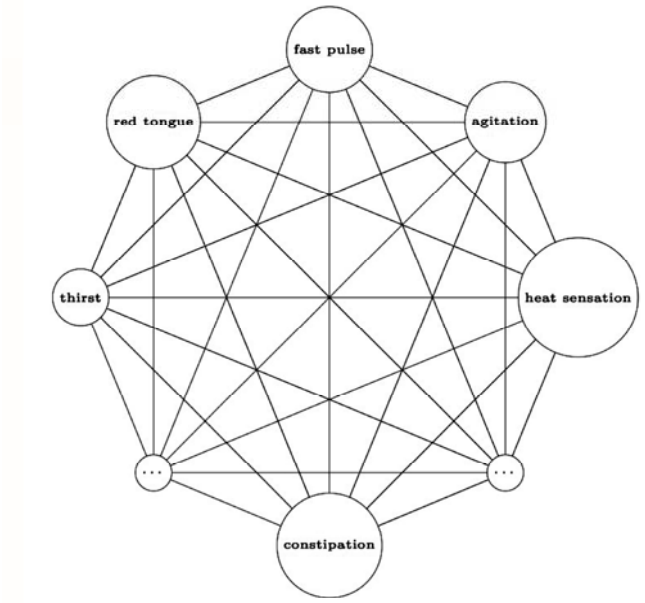


Fig. 3. This complex of calor is an example of a correspondence network like conduits, orbis, etc. Such abstract models of TCM integrate information simultaneously in a non-causal relation which is illustrated by connections between synchronous interactions between tissues, symptoms, signs, and functions.
TCM, traditional Chinese medicine.

seasons with their implication of the "4 divisions" [3,60].

• Finally, the synthesized data is integrated into corresponding models of orbis and conduits, according to the "2 polarities" and the "6 meridians" in the Classic of Cold Damage, also known as the "3 yang" and "3 yin."This final step hypothesizes the origin of disease as an imbalance of activity and structivity in the pathways of the conduits. Conduits and orbis are expressions of healthy functions, i.e. the orthopathy [6]. According to Chapter 10 of the "Divine Pivot" [73], yang- and yin-conduits are the "roots" of disease ruling life and death. Chapter 11 of the "Divine Pivot" [74] compares conduits to the "way" (Dao) mirroring macrocosm. According to Chapter 1 of the "Divine Pivot" [75], the foramina on the conduits are not skin, flesh, tendons or bones. Thus, the conduits are "pathways" of interchanging spaces, "adjacent" to anatomical structures, which integrate multiple modalities of bodily tissues and functions [12,58,76,77]. The Chinese term "jīng luò", containing the radicals "jīng" (warp thread, underground river), "mì" (silk), "gè" (each, every, different), can be translated as fabric of a weaving loom. By extension, fabric means all kinds of networks, including information networks. The conduits are "logistic" networks in 2 ways. On one hand, they distribute healthy function along networks to develop and maintain a healthy state of dynamic order (orthopathy) [2,6,76,77]. On the other hand, they guide diagnostics by evaluating body functions according to probabilistic pathways (i.e. direction) in a highly dynamic complex system, which in the given case is the patient. Like an abstract network of information within a complex system, the conduits integrate several heterogeneous types of adjacent body tissues and functions [76,77]. These tissue types and functions are also described classically, but their interplay in the wholeness of an individual is complex. Therefore, even the small stimulus of a tiny needle at the right location of influence (foramina) might have a big systemic effect (cf. butterfly effect).

The Chinese Black Box - a scientific model of information

If we now implement the Chinese diagnostic framework of gathering information into the theory of science, thinking in networks leads us back to the black box of IT. A black box is a bottom-up model to handle indeterminable information by the IPO principle (Fig. 1). If we consider this approach for TCM, examination findings, answers and questions represent input and output of information in a Chinese black box (CBB) model. Answers and behavior of the patient are evaluated by a binary code of complementarities [2,58,59], like a black box that gives information by yes- or no-statements. Doctor and patient do not know what really happens inside the patient in a deterministic sense. Only the process of exploration can be qualified by the binary polarities of activity and structivity in the 3 steps of diagnosis [2,5,58,59]; e.g. whether the skin is reddened or pale, whether the symptoms occur during the day or at night, whether the pulse is superficial or submerged (i.e. pulse qualities in the diagnostics of TCM), etc. Answers to questions such as: "do you feel too warm or too cold?" "is the pulse superficial or submerged?" etc. are qualified by an observer in the process of diagnostic abstraction. In the 8 guiding criteria (Table 1), such findings are polar abstracted in repletio or depletio, calor or algor, extima or intima. They "guide" the final synthesis [theory of disease (Fig. 1)] [5,6,70,72]. The evaluation of empirical findings condensates the obtained information (induction) [2]. Orbis, conduits, and agents are such abstractions in correspondence systems, providing an explanatory model for the collected empirical data (theory). Such "models of correspondence" propose a theory of disease about the patient and his symptoms [4-6]. From this model of disease, further statements are deduced that correspond or contradict the model (deduction). This allows conclusions to be made about further complaints and to test the initial hypothesis about the disease [78-81]. For example, in assumption of a "splendor yang disease" ("yang brightness;" this type of disease is associated with symptoms such as agitation, heat sensation, and constipation, referring to the "Classic of Cold Damage" [82], a fundamental classic of TCM), the question whether constipation is present or not might be answered with "yes," although the patient had not mentioned this during his initial examination. The hypothesis is evaluated further by success of the derived therapy and the changes of the initial findings (pulse, tongue, conduits). This constantly modifies the direction of the therapy in a proceeding diagnostic cycle (Fig. 1). This processing of information in polar abstraction equals not just Wheeler's surprise 20 questions [57], but reflects a scientific bottom-up model of information about a system with undeterminable properties (black box), as also assumed in QP and ST. For example in ST, a bottom-up approach is used in time series analyses. The construction (induction) of mathematical models (attractors) from obtained data (output) describes the collected data (deduction) [47]. In the classical scientific model of cause and effect, the process advances from empiricism through induction to a theory. From there, statements about further observations are derived (deduction), which empirically confirm (verification) or prove themselves as untrue (falsification). However, this is implicitly emanating from fixed qualities, natural laws, and a determined truth. Subject and object are separated from one another, so that general statements are attempted. Empiricism is based on experiments and quantitative measurements to extend the perception of nature. However, quantitative measurements are just expressions of past actions that are traced back in matter, underlying the limitation of causality that is drawn by Heisenberg's uncertainty principle [2,34]. Present and future are undeterminable in principle. Thus, empiricism in medicine cannot be limited to, or classified by measurements or experiments in the

classical sense. Qualitative observation of natural phenomena is information that has to be recognized (e.g., findings and questions about symptoms in TCM are a "qualitative" collection of current empirical information, independently of matter as a carrier of information [2]). The Chinese method for gaining information is based on non-causal principles. This method is based on the processing of qualitative information, complementary to the classical model of quantitative sciences [2]. TCM offers a "way" to handle the problem of indeterminacy in medicine. Embedded in a qualitative version of IT, the method of the CBB defines its place in modern science and may close the gap of conventional models. Hence, TCM might enhance conventional medicine "orthogonally," allowing a more refined diagnosis and prognosis.

Discussion

Causality remains a controversial issue in science, but IT might offer a possible solution for complexity. With the CBB, a scientific integration of TCM could be considered as a pragmatic approach to handle complexity in medicine. As the BPSM was also designated to fulfil the needs of complexity in medicine, how does TCM differ from it and is it possible to integrate both models?

The BPSM considers psychosocial dysfunctions in an integrated medical model [83]. Engel followed Bertalanffy's general ST, when he criticized the deterministic biomedical approach of classical physics, chemistry, and biology in open, living systems that are in a continuous exchange with their environment far from thermal equilibrium [84]. As an individual of psychological, biological, and social entities, a person is interwoven in a network of complex feedbacks. The advanced version of the BPSM is the mind-body-unity model, which was designated to overcome the dualism of psychosomatics [85]. In this model, health and disease interact among the different biopsychosocial entities. However, health and disease can also emerge on each separate level (psychological, social, biological) at the same time. The individual is part of subordinate biological, physical, and chemical entities that interact with the superior social and natural environment [83,85]. Each category has its own laws and language. Thus, a multilayered diagnosis and therapy are needed to consider all 3 levels [85]. Psychosocial disorders can be researched with qualitative tools like the Framework Method [86], the Grounded Theory [87], or case studies. For example, the Grounded Theory gathers key points of collected data from interviews (empiricism). A researcher then conceptualizes the key points in patterns and integrates them in interrelated categories and concepts to generate a theory (induction). The tentative theory has no demand for truth and is further refined by cases that do not confirm the initial model. The collection and abstraction of data is limited by the researcher's and the participants' view.

Despite the efforts of the BPSM and the mind-body-unity model, the dualism of body and mind, and the predominance of biomedicine are still present in the daily routine of medicine. Science is more focused on quantitative than on qualitative research. Doctor and patient have to oscillate between dualities of body and mind by "clinical experience," if they are not causally correlated. The "composite" name (bio-psycho-social) and structure of subsystems (atoms, molecules, cells, etc.) express a mind-body-split that is enrooted in the BPSM itself. Unfortunately, implicit causal-analytic assumptions distorted the structure of the BPSM, although complexity was its motif. Thus, terminology of a multi-causal BPSM is fragmented in separate disciplines, which hinders systemic communication, thinking, and acting [85]. A clear definition of health is also controversial [88]. Medicine is unable to define health by its own standards and methods, as it cannot be measured quantitatively. In 1946, the WHO defined health as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [88]. This is in contrast to the BPSM, as it only considers the subjectivity of a patient, apart in duality from quantitative measurements (scores, laboratory findings, etc.). There is no guiding method to bring these parts together, except by clinical experience. Today, according to the "Ottawa Charter for Health Promotion," health can be defined better as an expression of functionality, perceived quality of life, and wellbeing, which is based on social, personal, and physical resources [85,88]. However, this also lacks a definition in terms of ST. Although based on non-linear systems, the BPSM describes causes of disease, but not how the individual reacts to them, nor does it define the strength or deflection of the self-healing potential by diagnostic tools. Indeed, the placebo effect, resilience, and certain causal mechanisms of self-healing are known, but not why they are unhindered in one case and develop only hesitantly in the other case [25-27,70,89]. Although complications are familiar, such as stress, lack of nutrition, psychosocial stressors, and others, the BPSM does not explain, if such factors are actually strong enough to weaken the self-healing potential of an individual or in which direction they divert them. A multimodal therapy is costly and time-consuming, considering biomedical, psychological, and social support [85]. Facing the reality of limited funds, capacities, and time in modern healthcare systems, this might be a reason, why the BPSM is still not sufficiently implemented.

The BPSM is based on the assumption of complexity, but gives a solution by causality as it designates somatogenic and psychogenic dysfunctions. It is a linear approach for a non-linear human system. What TCM could add to the BPSM is the fact, that dysfunction may also emerge spontaneously by chaotic phase transitions, independently of causal incidences. This important attribute of complexity is still not recognized enough in medicine, especially concerning methods and fundamentals of medicine. This fact might reflect the extended use of complementary therapies by an increasing number of patients who feel better recognized by such models.

Looking again at TCM, this model also assumes non-linear interactions, but its subsystems are completely different from the BPSM. Functions of the body and mind flow continuously in a superimposed continuum and are never separated. There are no independent levels of functions as in the BPSM. Orbis, conduits, agents, etc., are subsystems that encompass always all classically defined systems by negating causality [2]. In contrast to the hierarchic order of inclusive subsystems in the BPSM, in TCM the immune system, the nervous system, the psyche, behavior, social interactions, etc., interact together as an interwoven network of balanced functions according to defined patterns of correspondence. Such subsystems describe different functional directions of the same human entity, differing in their qualitative aspects, colorations, and conditions under which classical networks are established synchronously [2,90]. Moreover, in TCM there is only 1 common language, which integrates abstract relations through the Chinese characters and emblems in a picture of functional complexes, expressing a non-linear physiology. Health is defined in TCM as a "straight-running function" (orthopathy) which aligns well with concepts of order in ST [2,91]. Health is assessed by diagnostic tools as the highest complexity of a directed, dynamic order, balanced simultaneously between a highly-ordered state according to structivity and a chaotic state according to activity [59]. Thus, a heteropathy is a deviation from that balanced order, and chaos, i.e. disease, can evolve. Either this separation emerges from a deficiency (depletio) of the ordered state (structivity) that is too weak to control chaos (activity), or the

chaotic state is too excessive (repletio) to be controlled. In both cases, activity prevails, which can be seen in the diagnostic signs for calor, as outlined in the example of calor (Fig. 3) in a splendor yang disease. In addition, imbalance also emerges, when there is lack of chaotic stimulus, or if the static order is predominant. Chinese pathophysiology knows these 4 imbalances between activity and structivity [5,6]. Thus, TCM reaches far beyond the assessment of well-being by scoring and measuring health and disease states. It is much closer to a non-linear description of complex functionality of a multilayered open biological system like the human being.

However, the limitation of a non-linear and non-causal qualification of open systems brings also some disadvantages. TCM emphasizes the "nourishing of life" (yangsheng) as the best prevention of diseases. Lifestyle recommendations include meditation, gymnastic exercises, diet, and rules to live in harmony with nature and the social environment. However, this lacks individual psychosocial dynamics, which can be the predominant factor of disease. TCM is bound to the potential of the individual, promoting self-healing and self-efficacy. In some cases, this approach is not enough, as resources and psychosocial support are lacking in difficult conditions of life. An individualized approach of self-regulation is also insufficient, if surgery is needed, or if there are emergencies, traumas, or epidemics that cause diseases of large populations [2].

In the rush of Mao's steering to the West, China itself was misled by the implicit agreement to causality, when they thought that "single" measured parameters could be matched with Chinese diagnostics or models [2]. Methodology of TCM is still not recognized enough in clinical trials, but the bottom-up approach of qualitative research is quite promising. The CBB uses also a bottom-up approach in diagnosis and treatment, but judges empiric data in polarities, based on physical examination and interview. Thus, the CBB may be regarded as a more specialized tool for medical application whereas the Framework Method or Grounded Theory remain to be independent of the concerned topic. As both ST and TCM characterize directions of non-linear systems [2,33], chaotic attractors of ST that consider huge sets of human data [91] might offer not a solution, but a bridge between the quantitative, mathematical abstractions of physiologic, psychological, and social data with the qualitative observations in Chinese diagnostics. To handle this effort, it would be necessary to master an overwhelming amount of data, which keeps an almost insoluble endeavor.

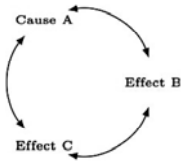
Systemic integrated medicine

So, how to bring together the best of 2 worlds? Considering IT and ST, TCM brings some new insights to the BPSM. Like activity and structivity, the BPSM and TCM are synergistic models like 2 sides of the "same" coin with no demand for truth [2,92]. This characterizes a more credible "systemic integrated medicine", which considers causality and non-causality in the nature of health and disease. As function is most important to maintain autonomy of an individual as a self-regulating complex system, systemic integrated medicine defines functions within a 3-polar model, uniting the biomedical, Chinese, and psychosocial approach. In the BPSM it is common sense to declare disturbed functions by biomedical or psychosocial diseases in a cause-effect relationship [83,85]. Between biomedical and psychosocial dysfunctions is a vacuum of spontaneous, non-linear dysfunctions, induced by chaotic phase transitions, which defines the main field of TCM [2,90]. This leads to the principle questions: how homogeneous or heterogeneous is the true nature of a disease [2]? How can a disease be characterized epistemologically as a causal or non-causal interaction [2]? The scientific integration of TCM draws this line very clearly. The more complex, heterogeneous the true nature of a system or disease, the bigger the information content of the system and its disease, the less accurately is the homogeneous, causal approach, which is directed to a single specific mechanism [2]. Conversely, this defines the strength and weakness of TCM. Homogeneous diseases, such as a bone fractures or severe epidemics affecting large collectives are better treated with homogeneous remedies than with the individualized therapies of TCM [2]. Statistical validity rises and falls by the correlated homogeneity of diseases. The patient's inner world of experience finds less correspondence in the quantitative assessment scale of EBM, since a median collective case draws conclusions on an individual. An information-theoretical based model, which considers the tools of Chinese diagnostics, has not yet been considered in randomized, placebo-controlled trials. Instead, classical biomedical models [18-24] or psychological effects (placebo, nocebo [25-27]) are discussed among the BPSM-filter and its implicit causality. However, they do not explain the "specific" or non-local effects of acupuncture. Thus, this debate should not proceed within conventional standards, but rather "about" conventional standards of medicine. As the BPSM was introduced by Engel in 1977, there was an important part of medicine that could not be defined by the biomedical model [83]. Thus, it was necessary to broaden this model by psychosocial dysfunctions that have also indirectly influenced somatic diseases. Since then, the understanding of health in society has changed remarkably. Today, the same situation recurs and the next step forward is needed with TCM, defining functional disorders as chaotic deviations. Instead of falling apart, medicine could regain unity and broaden its therapeutic horizon by considering this more seriously in science, education, and patient care.

Limitations

Limitations are mainly present due to the terminology in TCM which is based on polar abstraction. This is no surprise as Chinese concepts and characters (pictograms) themselves are abstract images of complex phenomena (cf. Fig. 3). E.g., the Chinese character "qi" integrates over a hundred facets of meanings in a complex of activity, that refer to the context of specific conditions. Qi is a synthetic judgment about all of them. Like Chinese language, mathematics is a language of symbols. Symbols can be used in a broad sense by its relationship to a context, but, with precise definitions, symbols turn into conventional standards for complex phenomena of nature. However, the Western reader lacks the nuances of the Chinese-cultural background, using such signs and concepts for thousands of years. Instead, Westerners are often confounded by their own philosophy and history. This might explain the difficulties in translating Chinese concepts into Western, more analytical-elementary, less abstractly structured language, and the necessity of a defined scientific terminology, differentiating clearly its abstract concepts and examination findings. Porkert's terminology offers new insights in the integration of TCM into Western sciences (Table 2). It is an attempt of a systematic reconstruction about a "scattered" scientific method throughout the history of TCM to handle complexity [92]. Porkert attempted to meet the requirements of a standardized terminology by substituting and defining certain abstract concepts of TCM into abstract "complexes of meanings" with Latin termini technici according to a Western background [2]. An abstract Chinese term is therefore translated in a more context-related way by another abstract concept, and not by a single specific expression. However, some criticize this methodological approach and prefer a more "unrelated" translation in the more historical, less medical, or epistemological context [93]. This is also not invulnerable to

Table 2. Complementarity of Scientific Models, Concepts, and Terminology.

Non-Classical Science	Classical Science
	
indeterminacy	determinism
non-causality	causality
non-locality	locality
synchronic related events	metachronic related events
potential	manifestation
present effects	past effects
cyclic progress	infinite regress
non-linearity	linearity
interdependence of subject and object	independence of subject and object
synthetic method	analytic method
induction	deduction
evaluation	measurement
qualitative data and conventions	quantitative data and conventions
directions of activity and structivity	international system of units (SI)
pictograms	analytical-elementary writing system
multiple factors	2 factors
complex systems	linear systems
dynamics	statics
information	matter
function	structure
form follows function	function follows form
prospection	retrospection
correspondence	analogy
complementarity	duality
heterogeneity	homogeneity
unity	elements
background	foreground
environment	object
network	isolation
connection	separation
decentralism	centralism
synergism	mechanism
small dosis/stimulus, big effect	linear dose-response relation
agents of disease	etiology of disease
orbisiconography and sinarteriology	anatomy and physiology

misinterpretations of historical views in the author's opinion. This debate has to be clarified by clinical trials that are more focused on methodology and Chinese diagnostics.

Conclusion

Nondeterministic and non-linear models of science might offer additional insights into the nature of health and disease. In this article, rudimentary fragments of an information-based ST of nature, life, health, and disease become visible with the reconstruction of Chinese classics in a CBB model. TCM offers a way to handle indeterminacy in medicine as a complement to the BPSM and illuminates a non-linear physiology, focusing on the embedding of its environment. The CBB provides a structured algorithm as a possible solution to an "evidence-based method," guiding the pathway of decisions in Chinese diagnostics as a standardized method in treatment protocols. Thus, systemic integrated medicine synergizing the BPSM and TCM by considering, diagnosing, and defining the heterogeneous or homogeneous nature of a disease, balanced by the qualification of the individual self-healing potential, might bring us a step closer to understanding health and disease better, and fill the vacuum between body and mind in medicine.

Conflicts of Interest

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Appendix 1.

Latin	WHO	Pinyin
activity	yang	陽 yáng
acu-moxi-therapy	acupuncture and moxibustion	針灸 zhēn jiǔ
agens	“cause” of disease	因 yīn, 病因 bìng yīn
algor	cold	寒 hán
calor	heat	熱 rè
decoction	decoction	湯 tang
depletio	deficiency	虛 xū
eight guiding criteria	eight principles	八綱 bā gang
extima	exterior	表 biǎo
foramina	acupuncture point	穴 xué, 空 kōng, 空穴 kōng xué, 氣穴 qì xué
heteropathy	pathogenic qi	邪氣 xié qì
sinartery	meridian, collateral, vessel	脈 mài, 經 jīng, 經脈 jīng mài, 經絡 jīng lùo
splendor yang	yang brightness	陽明病 yáng míng
structivity	yin	陰 yīn
inductoria	acupuncture point	腧/俞 shù
intima	interior	裏lǐ
repletio	excess	實shí
orbis	viscera	藏 zàng
orthopathy	healthy qi	正氣 zhèng qì
pilula	pill	丸 wán
premoprehension	tuina	推拿 tuī ná
pulvis	powder	散 sǎn
n/a	acquired essence, post-heaven	後天 hòu tiān
n/a	Basic Questions	素問 sù wèn
n/a	Classic of Changes	易經 yì jīng
n/a	Classic of Cold Damage	傷寒雜病論 shāng hán zá bìng lùn
n/a	Classic of the Way of Virtue	道德經 dào dé jīng
n/a	Classic of the Yellow Emperor	黃帝內經 huáng dì nèi jīng
n/a	conduction exercise	導引 dǎo yǐn
n/a	Daoism	道教 dào jiào
n/a	Divine Pivot	靈樞 líng shū
n/a	each, every, different	各 gè
n/a	earth	地 dì
n/a	eight trigrams	八卦 bā guà
n/a	four divisions	四象 sì xiàng
n/a	heaven	天 tiān
n/a	hexagrams, 64	六十四卦 liù shí sì guà
n/a	innate essence, pre-heaven	先天 xiān tiān
n/a	life nurturing	養生 yǎng sheng
n/a	man	人 rén
n/a	non-polarity, nothingness	無極 wú jí
n/a	plaster	膏藥 gāo yào
n/a	qi	氣 qì
n/a	root	本 běn
n/a	silk	糸 mì
n/a	six meridians	六經 liù jīng
n/a	ten thousand things	萬物 wàn wù
n/a	the way	道 dào
n/a	three yang	三陽 sān yáng
n/a	three yin	三陰 sān yīn
n/a	two polarities	兩儀 liǎng yí
n/a	warp, thread, underground river	巠 jīng