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HYPOTHESIS

The Primo Vascular System as a New Anatomical System

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Abstract
Traditional Eastern medicine has had a successful existence for a long time and has provided functional paths for curing disease. However, some scientists do not accept acupuncture, primarily because the meridian system lacks a physical anatomical basis. To date, scientific theories have not been able to explain the functional paths used by traditional Eastern medicine to cure disease. According to Western medicine, no known anatomical foundation exists for the meridians and unknown nervous, circulatory, endocrine, and immune mechanisms mediate the effects of acupuncture. In the early 1960s, only one hypothesis was proposed to explain the anatomical basis of the meridians. By using different experimental approaches during the past 10 years, the number of scientific papers that report the discovery of different anatomical and physiological evidence confirming the existence of an anatomical basis for the meridian system has increased. Morphological science is greatly challenged to offer a new biomedical theory that explains the possible existence of new bodily systems such as the primo vascular system (PVS). The PVS is a previously unknown system that integrates the features of the cardiovascular, nervous, immune, and hormonal systems. It also provides a physical substrate for the acupuncture points and meridians. Announcements of the morphological architectonics and the function of the PVS fundamentally changed the basic understanding of biology and medicine because the PVS is involved in the development and the functions

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of living organisms. We propose a new vision of the anatomical basis for the PVS and the vital energy—called "*Qi*"—as an electromagnetic wave that is involved very closely with the DNA in the PVS. DNA provides genetic information and it functions as a store of information that can be obtained from the electromagnetic fields of the environment. The PVS is the communication system between living organisms and the environment, and it lies at the lowest level of life. The theory of the PVS could be a good basis for forming a new point of view of Darwin's evolutionary theory. Discoveries in morphological theory—such as discoveries with respect to the PVS—have not been made since the 18th century. For that reason, the PVS needs more attention.

1. Introduction

A mysterious phenomenon that has attracted scientific attention for ages has been the fact that, despite acupuncture's thousands of years of success, no solid scientific explanation has been proposed for the anatomical pathways and the physiological mechanisms of the meridian system that is the basis of traditional Chinese medicine. The primary theory of acupuncture is based on specific energy that flows throughout meridian channels that are stimulated by metal needles inserted at acupoints. The medicine of ancient China described different kinds of vital energies, called "*Qi*", which are defined by five cardinal functions. However, to date, acceptable scientific theory has been proposed to explain the meridian channels and to define the vital energy *Qi*. Because of this, some scientists do not accept acupuncture as a scientific medical method because the meridian system and the acupuncture points have no fundamental physical anatomical substrate.

To explain the action of the meridian system, there have been some attempts to provide a full theory such as the opioid peptide theory and the gate theory, but these attempts have been unsuccessful. No theories that are acceptable to the scientific community can describe the anatomical basis for the meridian system and its functional aspects, which are fundamental for explaining its successful treatment of pain and different diseases through natural health processes. According to Western medicine, meridians have no known anatomical foundation, and unknown nervous, circulatory, endocrine, and immune mechanisms mediate the effects of acupuncture.

We can identify two important periods of discovery for the new morphological and functional system. The first period began with the hypothesis of Bong-Han Kim in 1963 [1—5] and the second period consists of the experimental confirmations by different authors who were primarily from Seoul National University (SNU; Seoul, South Korea). The SNU scientists have published more than 50 articles and have obtained more than 200 citations concerning this subject. (The data were obtained from the BioInfoBank Library.)

The hypothesis by Bong-Han Kim concerning a new bodily system, the primo vascular system (PVS), is a powerful candidate to serve as the basis for a new theory to explain the fundamental anatomical and physiological concept of the meridian system and acupuncture points. In our previous review papers, we provided a detailed description of the morphological and functional aspects of the PVS [6,7]. In this article, we will briefly mention the primary findings of the authors who have dedicated their research to this subject. Because every successful theory is based on previous observations that cannot be explained satisfactorily, we will present the data of various authors that can provide a scientific basis for the new anatomical bodily system and can be used to predict the new system's main characteristics and possible functions.

The main scientific experimental results of the SNU scientists confirmed the hypothesis of Bong-Han Kim. The SNU group applied all standard methods and new methods [8]. They named the new system "the primo vascular system", and the experimentally observed channels and nodes as "primo vessels" (PV) and "primo nodes" (PN), respectively. Kellner [9] denied Kim's claims, based only on histological methods. Prior to the systematic investigations of the SNU group concerning the PVS, only Fujiwara and Yu [10] had been able to confirm Bong-Han Kim's findings, but only partially. In this paper, we will use the terminology that was adopted at the International Symposium on the Primo Vascular System that was held in 2010 [11] because the terms offered by Kim do not have scientific meanings.

2. Bong-Han Kim's hypothesis

In the 1960s, Professor Bong-Han Kim described a new anatomical system that corresponded to the ancient acupuncture meridians. He presented five articles describing nodes and ducts that corresponded to acupunctural points and meridians, and he called the nodes and ducts after his own name: Bonghan corpuscles and Bonghan ducts. Kim used several experimental methods such as anatomical methods, histological methods, radioautography, histochemical methods, "mysterious" blue staining methods, and radioactive dosimetry. He claimed to have found the physical substrate of acupuncture points and meridians, including some new points that were different from the classic acupuncture points. We accept Kim's findings only as a hypothesis because of the lack of detailed descriptions of the methods and the scientific protocols that he used for his investigations. Because of that deficiency in Kim's reports, his claims only serve to present the main idea on the existence of a new anatomical system that corresponds to the meridian system.

Despite this, Kim's findings (until recently) had not attracted much attention and had been forgotten for many years. His claims can be collectively known as the "Bong-

Han Kim hypothesis." The main points of the hypothesis are as follows: (1) the PVS is an independent functional morphological system; (2) the superficial PVs and the extravascular PVs are connected by superficial nodes; (3) the deep PVs are connected by intravascular PVs, deep PNs, and organ nodes; (4) the superficial PNs have a muscular layer and various cells inside, and their structure is different from the deep PNs; and (5) the PNs have different kinds of nucleic acids, primarily DNA.

A liquid, called "the primo fluid", circulates in the PVS. Its flow is slower than blood flow and lymphatic flow. The primo fluid flows in one direction, attending blood flow. The liquid flow depends on the heart beat and on the pressures of the blood and the lymph. The PVS fluid has DNA outside the cell nucleus. The biochemical components of primo fluids are DNA, RNA, nitrogen, fats, reducing sugar, hyaluronic acid, 19 free amino acids, and 16 free mononucleotides. The routes of flow are interconnected, but relatively independent. Primo fluid circulates only in a specified region, but it can also be transmitted through interconnections with other pathways.

The subvessels of the PVs are composed of endothelial cells with rod-shaped nuclei, smooth muscle cells, and adventitia. Fiber structures and amorphous substances exist among the subvessels. A membrane surrounds the whole primo vessel. The constituents of the PN are the subvessels and various cells. The subvessels are densely distributed, enlarged, and connected to each other. Kim developed his idea for the PVS by adding interior and exterior PVs.

Primo vessels have bioelectrical activity, excitatory conductivity, and mechanical motility. The electrical activity changes in relation to stimuli to the PVs. The PVs have mechanisms to circulate the primo fluid actively. All nuclei of the tissue cells are connected to fine terminal subvessels, and these subvessels are connected to the primo vessels in a body's organs. The PNs in an organ are connected to the organ's tissue cells within a specified range. All PNs for the organs are connected to all meridians. The meridian structures start and end at the PNs for the organs.

Primo fluid circulates from superficial PNs to deep PNs and then to an organ's PNs and to the tissue cells. Changes in the primo fluid circulation affect the function of organ tissues. Stimulation of the PVs induces changes in the number of heart beats and the power of the heart, intestinal movement, and the fatigue curve of skeletal muscles. Cutting PVs causes prominent changes such as karyolysis, apoptosis in the cells and reduced excitability of nerves and muscle movement.

The development of meridians (i.e., the PVS) takes place prior to the development of other organs such as blood vessels and the nervous system. The formation of the PV blast cell occurs within 7—8 hours after fertilization; the formation of the primordial PVs occurs within 10 h after fertilization; the formation of the primitive primo lumens occurs within 15 hours after fertilization; and the completion of the primo lumens occurs within 20—28 hours after fertilization. The PVS plays an important role during the development of an organism and seems to exist throughout the biological world, including in invertebrates, vertebrates, and plants. Living organisms keep themselves alive via regeneration following the sanal-cell cycle. Sanals (i.e., microcells) grow into cells, and cells become sanals. A sanalsome is a type of chromosome that forms when cells divide. The chromosome emerges in the metaphase of cell division. Hematopoietic organs such as bone marrow, spleen, and lymphatic nodes have well-developed PVs, the structures and functions of which are similar to PNs.

2.1. Experimental confirmation of the Bong-Han Kim hypothesis

During the past 10 years, the SNU team has exerted great effort to confirm the claims of Bong-Han Kim, to add new ideas, and to develop methods to detect and identify the PVS [12].

2.2. Confirmation of organs and tissues that are supplied by the PVS and new data

The PVS has been detected in the heart chambers [13], the caudal vena cava, the hepatic vein, the hepatoportal vein, the femoral vein, the aorta [14], and the large lymph vessel along the caudal vena cava [15—19]. The PVs have been found inside blood vessels and lymphatic vessels. The PVs inside lymph vessels freely flow in the lymph [16,17]. The PVs and PNs flow in the third ventricle, fourth ventricle, cerebral aqueduct, and along the central canal of the spinal cord [8]. The PVS has also been found on the arachnoid mater, cerebellum [20], perinervium, and epinervium of the sciatic nerve [20,21]. The PVs and PNs are present on the surfaces of the liver, stomach, small and large intestines, bladder, spleen, kidneys and omentum, abdominal cavity [22—26], hypodermal layer of the skin, superficial fascia [27], fat tissue [28], and cancer fascia [29]. The PVs also enter internal organ tissues [30].

2.3. Confirmation of the structures of the PVS and the liquid in the PVS and new data

The PVS has vessels and nodes. The PVs consist of several subvessels. The hallmarks of the PVS are 10—20-μm rod-shaped endothelial nuclei [31,32]. The primo subvessels and primo nodes carry a liquid. The liquid is richly supplied with different groups of basophilic granules [33]. The primo liquid also contains different proteins [34], steam-like cells [28], or microcells [35—37] with membranes much harder than the membranes of apoptotic bodies of similar size [38], and hormones [39—41]. The liquid was found to flow at a speed of 0.3 mm/s, as measured by injecting Alcian blue dye into the surface of the liver [42]. When directly measuring the speed by using radioactive tracers, the liquid flowed in the range of 100—800 μm/s [14,43,44], which is much higher than the speed of lymph [34].

Five types of cells float in the primo liquid. Type 3 cells are in the mitosis stage. Type 4 and type 5 cells contain granules with DNA that do not exist in other body liquids [45]. The PVs are surrounded by a membrane with a high concentration of hyaluronic acid [16]. The PVS has been observed to be connected to tumor tissues growing in the internal organs and to the fascia of tumor tissue [29,46,47].

2.4. Functional aspects of the PVS

The cells of the PVS show smooth muscle-like excitability with calcium channels [20,48]. The subvessels have adventitia that contains connective tissue [12]. Collagen is the main component of the connective tissue. The data indicate that collagen interferes with photon emissions emanating from biomolecular sources. This property of collagen facilitates the possibility of tuning photon emissions throughout an organism [49]. This supports the hypothesis that the PVS acts as an optical channel of biophoton emission and that DNA may act as a photon store and coherent radiator. Biophotons may be electromagnetic signals that play a key role in cell development and differentiation. The light propagation function of the PVS may explain the instantaneous effect after needling at acupoints [16,35]. Spontaneous ultraweak photon emission from cultured cells is primarily involved in changes of the ploidy number during the proliferative process of a cancer cell line [50].

The PVS may be an endocrine organ [35] because of the presence of chromaffin cells in the acupoints [51,52], and the PVS liquid carries adrenalin and noradrenalin [39—41]. The PVS in the vitelline membrane of eggs was formed after 16—24 hours of incubation, and the putative PVS was clearly developed earlier than the extraembryonic vessels, the heart, and the intramembrane vessels [53].

All results concerning the PVS have been published in international scientific journals such as *Anatomical Record Part B: The New Anatomist*; *Microscopy Research and Technique*; *Naturwissenschaften*; *Lymphatic Research and Biology*; *Applied Physics Letters*; *Current Applied Physics*; *Journal of Biomedical Optics*; *Microcirculation*; *New Journal of Physics*; *Cardiology*; *Lymphology*; *Journal of Health Science*; *Biologia*; *PLoS One*; and *Journal of International Society of Life Information Science*. Results have also been published in specialized scientific journals on acupuncture.

2.5. New hypothesis for the primo vascular integrated system

Based on previously obtained data, we can propose a new hypothesis for the PVS and make some predictions about its role. The PVS consists of PVs and PNs. The PVs, which have double coats, contain subvessels. The first coat is adventitia that contains fibers and amorphous substances serving as supporting tissue. The second coat is a common membrane surrounding the subvessels. This kind of double-coat structure suggests stability against mechanical influences, a lower possibility of connecting with other PVs, the possibility of a two-way flow of fluid, and good isolation against mechanical, physical, and thermal influences. The diameter of the lumens of the PVs is 5—10 μm. The endothelial cells have rod-shape nuclei, as Fig. 1 shows.

The constituents of the PN are subvessels with various types of cells. The primo subvessels and primo nodes carry a liquid. The liquid is richly supplied with 1—2-μm microcells with DNA. The PNs serve to gather and to distribute the PVs and to control the fluid's flow speed, direction, and contents.

The PVS consists of a dense network of PVs and PNs that is distributed throughout the entire body. The PVS is the physical anatomical basis of the meridian system.

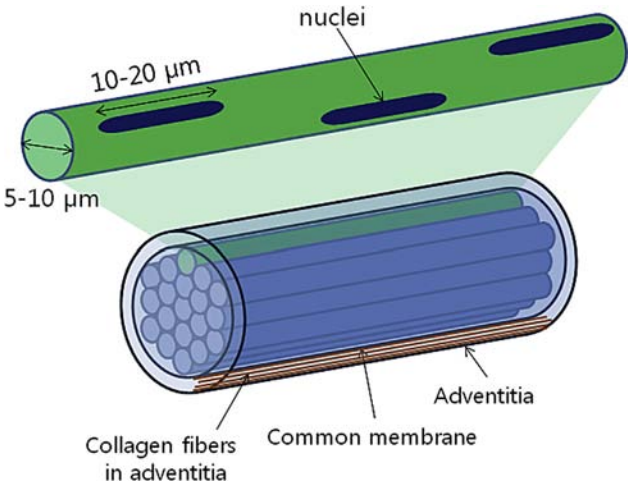

Figure 1 Illustration of one isolated subvessel (top) and a bundle of subvessels of the primo vessel.

Every anatomical system needs terms to describe it; therefore, we propose new terminology for the PVS. The PVS consists of three subsystems, which are summarized in Fig. 2. The external subsystem of the PVS (ePVS) has external PVs (ePVs) and external PNs (ePNs) and lies in the hypodermal layer of the skin and in the superficial fascia. The internal subsystem of the PVS (iPVS) includes internal PVs (iPV) that lie inside blood vessels and lymphatic vessels, inside the heart chambers, and inside and on organs. The internal primo nodes (iPNs) exist inside and on organs. The nervous subsystem of the PVS (nPVS) includes nervous primo vessels (nPVs) and nervous primo nodes (nPNs), which are distributed in the brain cavities and in the spinal cord channel. PVS are associated with epinervium and perinervium of the nerves. As a whole, the PVS is distributed throughout loose connective tissue, fat tissue, serous membranes, and in some cavities and lumens, as previously described. The external subsystem has "receiving" primo nodes (rPN) and "receiving" primo vessels (rPV). They connect with each other on the superficial layer and have a connection through "communicating" primo vessels (cPV) to deeper PNs that are named "communicating" primo nodes (cPN). The cPNs are "extraorgan" PNs (eoPN). The cPN and cPV are connecting parts of the internal PVS and

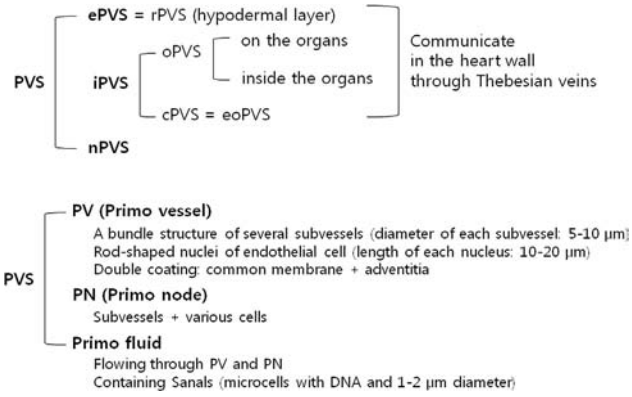

Figure 2 Schematic of the primo vascular system.

make connections between the external subsystem and the organs. The internal subsystem has a "communicating" PVS and an "organ" PVS (oPVS). The oPVS net consists of "organ" primo vessels (oPVs) and "organ" primo nodes (oPNs). The organ part of the PVS is inside organs and on the superficial serous coverings of organs. As mentioned previously, the nervous subsystem has PVs along the nerves, in the brain cavity, in the spinal cord channel, and in the nervous system covers. The PNs in the nervous subsystem are in the brain covers (meninges) and in the brain. The main organ of the external and the internal subsystems is the heart, and the two subsystems communicate in the heart wall through the thebesian veins (TVs; vv. Cordis minimae). The embryonic development of the TVs in the heart is similar to the development in thebesian definite channels that remain after birth connected to the heart wall. In the earliest stage of embryonic development, the primordial PVS is probably connected to the TVs, which establishes a connection between the PVS and the heart [6]. The main organ of the nervous subsystem is the brain. The different parts of the nPVS communicate through the sinuses and the cisterns of the dura mater. External signals are accepted from the rPN; through the rPV, the signals are distributed in the ePVS. Through the cPN and the cPV, the signals reach an organ's tissues via the oPN and oPV. Fig. 3 shows the three subsystems' communication at the tissue level.

The fascia covers the muscles and enters between them. The serous membranes cover nearly all organs. Loose connective tissue is the most distributed tissue in the body and does not exist only in the brain, the penis, and the clitoris. The PVS is associated with the vessels and the nerves and is abundant in loose connective tissue, fat tissue, serous membranes, and fascias; therefore, it is possible that it is distributed as a web among all body systems, including the tissues of organs. The ePVS is in the skin's hypodermal layer and superficial fascia. The iPVS and the nPVS follow the fascia, loose connective tissue, and serous membrane distribution, and then reaches the oPVS.

The PVS contains some relatively independent nets of circulation, and superficial, deep, and organ circulation.

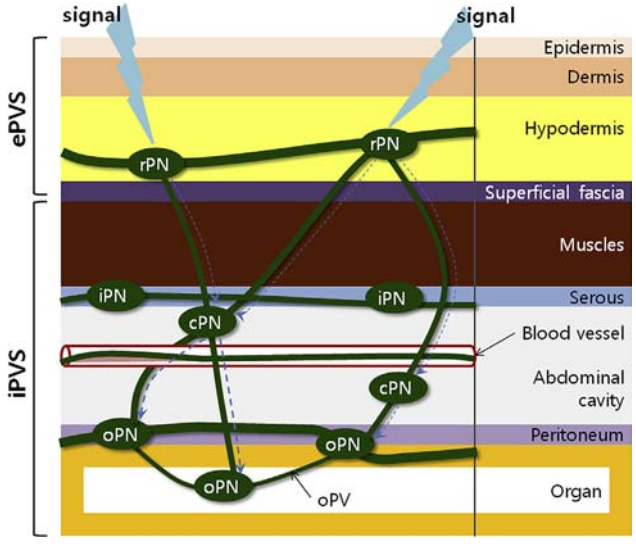

Figure 3 Topographical distribution of the primo vascular system.

The independent nets of circulation may increase, depending on the changing needs of an organ's tissue. In circumstances requiring more systemic or whole body reactions, the interconnections and "sleeping" parts of the PVS may become activated. Acupunctural needles and other acupunctural techniques may provoke mechanical or electrical stimuli. The needles may serve as antennae for externally influencing physical fields such as electromagnetic fields. In pathological situations, the damaged cells send out signals; the PVS then transmits the primo fluid to the damaged cells to supply the substances and the information needed to repair the cells. The direction of communication in this situation will be in the opposite direction from normal and will start from the organ. The PVs in a tumor's capsule may be another way for metastasis to occur, but it may also be a way to repair wrongly programmed and growing cells.

In following the vessels and the nerves, the PVS uses these structures as a type of "highway" and as a way to influence body systems and organs. In fact, supplying, draining, and innervating tissues and organs are duplicated by the PVS. This duplication may be a way of controlling these functions. The PVS controls the cardiovascular system (which provides substances and hormones to the organs) and the nervous system (which provides impulses to the organs).

Collagen is the main component of connective tissue. Collagen interferes with photon emissions emanating from biomolecular sources [6]. This property of collagen may facilitate tuning photon emissions throughout an organism, and it supports the hypothesis that metabolism is regulated by a photon field [54]. Soh [55] previously proposed a similar hypothesis. He suggested that the PVS was an optical channel of biophoton emission. Biophotons may be electromagnetic signals that play a key role in the processes of cell development and differentiation. A hypothetical light propagation function of the PVS may explain the instantaneous effect that is felt throughout the entire body on needling acupoints [12,55].

The PVS has bioelectrical activity, excitatory conductivity, and mechanical motility. The bioelectrical signals of the endothelial cells of the PVs are similar to the signals of the smooth muscle cells [20]. Changes in a bioelectrical impulse may indicate the existence of other kinds of physical influences on the PVS, other than influences by the nervous and cardiovascular systems [6]. There is a hypothesis that DNA may act as a photon store and coherent radiator [55].

We offer a new point of view concerning the type of vital energy *Qi* is. Because the PVS may be an optical channel for photon emission, an electromagnetic field that travels throughout the PVS and throughout the DNA in the PVS may be the mysterious vital energy *Qi* that can be distributed throughout the entire body. Based on a previous hypothesis [2,55], we believe the function of the PVS as an optical channel is closely related to the DNA in the PVS. We hypothesize that DNA carries genetic information and its structure is capable of storing information obtained from environmental physical fields such as electromagnetic fields. We support the previous hypothesis that *Qi* is an electromagnetic standing wave [56]. We can add that these electromagnetic waves may be transformed into information and that this information is stored in the DNA granules of the PVS.

A support for this idea is that physicists recently offered the possibility of converting information to energy; they presented their findings as a spiral-staircase [57]. Toybe et al[57] suggested a new principle for converting information into energy, which was based on Szilard's [58] idea of equivalence between energy and information. Because the bases of DNA lie horizontally between two spiraling strands, the most important model of a biological molecule of DNA is a spiral model, which needs more attention concerning the conversion of information into energy and vice versa through the participation of light. The theoretical physicist Stephen Hawking once said, "electromagnetism is the basis for life itself" [59]. To this statement, it can be added that the PVS has all the characteristics necessary to provide electromagnetic waves to every part of the body. The ancient vital energy *Qi* probably is an electromagnetic wave that is transported through the PVS, and the information obtained from that electromagnetic wave may be stored in the DNA of the PVS microcells.

DNA may produce low-frequency collective motion. Low-frequency collective motion in DNA refers to the application of statistical thermodynamics to understand low-frequency vibrations in biomolecules. To solve the perplexing free-energy deficit problem in protein binding, Chou and Chen [60] suggested the concept of low-frequency phonons in proteins. The phonons have a modified relation between wavelength and energy and are able to transfer energy. The combination of all DNA characteristics makes DNA a powerful candidate that serves as a store for transforming electromagnetic energy information.

3. Conclusions

We conclude that the PVS allows communication between living organisms and the environment. The PVS is duplicated by the vascular and the nervous systems during the very early stage of body development. For this reason, the PVS combines the features of the vascular, nervous, immune, and hormonal systems. The PVS in all its aspects is understood as a system that covers the entire body, and regulates and coordinates all biological life processes.

The PVS receives external and internal signals. The external signals come from the environment as electromagnetic waves. The internal signals are products of metabolic processes and arise as bioelectrical, bioluminous, and acoustical fields. These fields all bring information to the PVS concerning bioprocesses in the body.

The PVS is furthermore the physical substrate for the acupuncture points and meridians and is involved in the development and the functioning of living organisms. The primordial PVS is like a matrix for the vascular and the nervous systems, which are formed around the PVS. The PVS is duplicated by the vascular and the nervous systems during the very early stage of body development, which is the reason the PVS combines the features of the vascular, nervous, and hormonal systems. After all embryonic body systems have been developed, the primordial PVS subsequently remains connected with these systems, but dominates and controls them because it is the oldest morphological functional system. The PVS, which until now has been a missing body system, can explain many of the mysteries of life. The physical substrate for the meridian system is the missing point that can be used to combine the knowledge of ancient Chinese medicine and that of modern science into one successful unit.

Because the meridian system exists in the Animalia, Plantae, and Fungi kingdoms [61], an interesting subject would be to investigate the role of the PVS in the evolution of organisms. Based on the PVS, we propose a new point of view concerning Darwin's evolutionary theory. The main problem of current evolutionary theory is the lack of intermediate forms between species. We suggest that the PVS—as a primordial body system distributed throughout the entire organism—is capable of capturing and storing information from environmental electromagnetic fields, which would permit dramatic and sudden changes in an organism's DNA. Such a sudden change of an organism's DNA may explain why there is a lack of intermediate forms between species.

Disclosure statement

The author affirms there are no conflicts of interest and the author has no financial interest related to the material of this manuscript.

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References

1. Kim BH. Study on the reality of acupuncture meridian. *J Jo Sun Med*. 1962;9:5—13 [In Korean].
2. Kim BH. On the Kyungrak system. *J Acad Med Sci, DPR Korea*. 1963;90:1—41.
3. Kim BH. The Kyungrak system. *J Jo Sun Med*. 1965;108:1—38 [In Korean].
4. Kim BH. Sanal theory. *J Jo Sun Med*. 1965;108:39—62 [In Korean].
5. Kim BH. Sanals and hematopoiesis. *J Jo Sun Med*. 1965;108:1—6 [In Korean].
6. Stefanov M. Critical review and comments on BH Kim's work on the primo vascular system. *J Acupunc Meridian Stud*. 2012;5:241—247.
7. Stefanov M, Kim J. Primo vascular system as a new morpho-functional integrated system. *J Acupunc Meridian Stud*. 2012;5(5):193—200.
8. Soh KS. Current stage of research on the primo vascular system. In: Soh KS, Kang KA, Harrison D, eds. *The primo vascular system, its role in cancer and regeneration*. New York: Springer; 2011:25—40.
9. Kellner G. Bau und Funktion der Haut. *Deutsche Zeitschrift für Akupunktur*. 1966;15:1—31 [in German].
10. Fujiwara S, Yu SB. "Bonghan Theory" morphological studies. *Igaki no Ayumi*. 1967;60:567—577.
11. Soh KS, Kang KA, Harrison D. *The primo vascular system, its role in cancer and regeneration*. New York: Springer; 2011.

12. Soh KS. Bonghan circulatory system as an extension of acupuncture meridians. *J Acupunc Meridian Stud*. 2009;2: 93—106.
13. Lee BC, Kim HB, Sung B, Kim KW, Sohn J, Son B, et al. Network of endocardial vessels. *Cardiology*. 2011;118:1—7.
14. Jiang X, Kim HK, Shin HS, Lee BC, Choi ZZC, Soh KS, et al. Method for observation of intravascular Bonghan ducts. *Korean J Oriental Preventive Med*. 2002;6:162—166.
15. Lee BC, Yoo JS, Baik KY, Kim KW, Soh KS. Novel threadlike structures (Bonghan ducts) inside lymphatic vessels of rabbits visualized with Janus Green B staining method. *Anat Rec B New Anat*. 2005;286:1—7.
16. Lee C, Seol SK, Lee BC, Hong YK, Je JH, Soh KS. Alcian blue staining method tovisualize Bonghan threads inside large caliber lymphatic vessels and X-ray microtomography to reveal their microchannels. *Lymphat Res Biol*. 2006;4: 181—190.
17. Johng HM, Yoo JS, Yoon TJ, Shin HS, Lee BC, Lee C, et al. Use of magnetic nanoparticles to visualize threadlike structures inside lymphatic vessels of rats. *Evid Based Complement Alternat Med*. 2007;4:77—82.
18. Yoo TJ, Johng HM, Yoon TJ, Shin HS, Lee BC, Lee C, et al. In vivo fluorescence imaging of threadlike tissues (Bonghan ducts) inside lymphatic vessels with nanoparticles. *Curr Appl Phys*. 2007;4:342—348.
19. Lee BC, Soh KS. Contrast-enchancing optical method to observe a Bonghan duct floating inside a lymph vessel of a rabbit. *Lymphology*. 2008;41:178—185.
20. Park SH. Bioelectrical Study of Bonghan System. In: *Ph.D. dissertation*. Seoul: Seoul National University; 2009.
21. Lee BC, Kim HB, Sung B, Kim K, Sohn J, Son B, et al. Structure of the sinus in the primo vessel Inside the bovine cardiac chambers. In: Soh KS, Kang KA, Harrison D, eds. *The primo vascular system, its role in cancer and regeneration*. New York: Springer; 2011:57—62.
22. Lee BC, Kim KW, Soh KS. Visualizing the network of Bonghan ducts in the omentum and peritoneum by using trypan blue. *J Acupunct Meridian Stud*. 2009;2:66—70.
23. Shin HS, Johng H, Lee BC, Cho S, Baik KY, Yoo JS, et al. Feulgen reaction study of novel threadlike structures on the surface of rabbit livers. *Anat Rec B New Anat*. 2005;284: 35—40.
24. Lee BC, Yoo JS, Ogay V, Kim KW, Dobberstein H, Soh KS, et al. Electron microscopic study of novel threadlike structures on the surfaces of mammalian organs. *Micro Res Tech*. 2007;70: 34—43.
25. Sung B, Kim MS, Lee BC, Yoo JS, Lee SH, Kin YJ, et al. Measurement of flow speed in the channels of novel threadlike structures on the surface of mammalian organs. *Naturwissenschaften*. 2008;95:117—124.
26. Yoo JS, Kim MS, Sung B, Lee BC, Soh KS, Lee SH, et al. Cribriform structure with channels in the acupuncture meridian-like system on the organ surfaces of rabbits. *Acupuncture Elecltrotherapy Research*. 2007;32:130—132.
27. Han HJ, Sung B, Ogay V, Soh K. The flow path of Alcian blue from acupoint BL23 to the surface of abdominal organs. *J Acupunct Meridian Stud*. 2009;2:182—189.
28. Lee BC, Bae KH, Jhon GJ, Soh K. Bonghan system as mesenchymal stem cell niches and pathways of macrophages in adipose tissues. *J Acupunct Meridian Stud*. 2009;2:79—82.
29. Yoo JS, Hossein Ayati M, Kim HB, Zhang W, Soh K. Characterization of the primo vascular system in the abdominal cavity of lung cancer mouse model and its differences from the lymphatic system. *PLoS One*. 2010;5:e9940.
30. Han HJ, Ogay V, Park SJ, Lee B, Kim K, Lee Y, et al. Primo vessels as new flow paths for intratesticular injected dye in rats. *J Acupunct Meridian Stud*. 2010;3:81—88.
31. Lee BC, Baik KY, Jhong HM, Nam TJ, Lee J, Sung B, et al. Acridine orange staining method to reveal the characteristic features of an intravascular threadlike structure. *Anat Rec B New Anat*. 2004;278:27—30.
32. Baik KY, Lee J, Lee BC, Jhong HM, Nam TJ, Sung B, et al. Acupuncture meridian and intravascular Bonghan duct. *Key Eng Mater*. 2005;277:125—129.
33. Vodyanov V. Characterization of primo nodes and vessels by high resolution light microscopy. In: Soh KS, Kang KA, Harrison D, eds. *The primo vascular system, its role in cancer and regeneration*. New York: Springer; 2011:83—94.
34. Lee SJ, Lee BC, Nam CH, Lee WC, Jhang SU, Park HS, et al. Proteomic analysis for tissues and liquid from Bonghan ducts on rabbit intestinal surfaces. *J Acupunct Meridian Stud*. 2008; 1:97—109.
35. Kwon JH, Baik KY, Lee BC, Soh KS, Lee NJ, Kang CJ. Scanning probe microscopy study of microcells from the organ surface Bonghan corpuscle. *Appl Phys Lett*. 2007;90(173903):1—3.
36. Ogay V, Baik KY, Lee BC, Soh K. Characterization of DNA-containing granules flowing through the meridian-like system on the internal organs of rabbits. *Acupunct Electrother Res*. 2006;31:13—31.
37. Baik KY, Ogay V, Jeoung SC, Soh K. Visualization of Bonghan microcells by electron and atomic force microscopy. *J Acupunct Meridian Stud*. 2009;2:124—129.
38. Baik KY. Fluorescence Imaging of Bonghan Duct with Nanoparticles and Study of Sanal Membrane with Atomic Force Microscope. In: *Ph.D. dissertation*. Seoul: Seoul National University; 2008.
39. Kim JD, Ogay V, Lee BC, Kim MS, Lim I, Woo HJ, et al. Catecholamine producing novel endocrine organ: Bonghan system. *Med Acupunct*. 2008;1:83—90.
40. Ogay V, Kim KM, Seok HJ, Choi CJ, Soh KS. Catecholamine-storing cells at acupuncture points of rabbits. *J Acupunct Meridian Stud*. 2008;1:83—90.
41. Yoo JS, Choi K, Baik KY, Chung D, Soh K. Liquid-phase microextraction method in capillary electrophoresis to detect adrenaline in Bonghan lipid. *Journal of International Society of Life Information*. 2005;23:292—295.
42. Lee CH, Yoo JS, Kim HH, Kwon J, Soh KS. Flow of nanoparticles inside organs-surface Bonghan ducts. *Proceedings of the 23rd Symposium Korean Society Jungshin Science*. 2005; 23:129—134.
43. Daras JC, Albaredo P, deVernejoul P. Nuclear medicine investigations of transmission of acupuncture information. *Acupunct Med*. 1993;11:22—28.
44. Zhang WB, Tian YY, Li H, Tian JH, Luo MF, Xu FL, et al. A discovery of low hydraulic resistance channel along meridians. *J Acupunct Meridian Stud*. 2008;1:20—28.
45. Sung B, Kim MS, Lee BC, Ahn SH, Hwang SY, Soh KS. A cytological observation of the fluid in the Primo nodes and vessels on the surface of mammalian internal organs. *Biologia*. 2012; 65:914—918.
46. Yoo JS, Kim HB, Ogay V, Lee B, Ahn S, Soh K. Bonghan ducts as possible metastasis path of cancer. *J Acupunct Meridian Stud*. 2009;2:118—123.
47. Yoo JS, Kim HB, Won N, Bang J, Kim S, Ahn S, et al. Evidence for an additional metastatic route: in vivo imaging of cancer cells in the primo-vascular system around tumors and organs. *Mol Imaging Biol*. 2011;13:471—480.
48. Jia ZF, Lee BC, Eom KH, Cha J, Lee J, Su Z, et al. Fluorescent nanoparticles for observing primo vascular system along sciatic nerve. *J Acupunct Meridian Stud*. 2010;3:150—155.
49. Kim J, Kim Y, Lee YJ, Kobayashi M, Tsutsumi Y, Kondo R, et al. Spontaneous ultraweak photon emission during the cell population of culture HeLa cell line. *J Health Sci*. 2007;53(4): 481—485.

50. Ogay V, Bae KH, Jhon GJ, Soh KS. Comparison of the characteristic features of Bonghan duct, blood and lymphatic capillaries. *J Acupunct Meridian Stud*. 2009;2:107—117.
51. Lee BC, Kim SK, Soh KS. Novel Anatomic structures in the brain and spinal cord of rabbit that may belong to the Bonghan system of potential acupuncture meridians. *J Acupunct Meridian Stud*. 2008;1:29—35.
52. Lee BC, Eom KH, Soh KS. Primo vessels and primo nodes in rat brain, spine and sciatic nerve. *J Acupunct Meridian Stud*. 2010;3:111—115.
53. Lee SY, Lee BC, Soh KS, Jhon G. Development of the putative primo vascular system before the formation of vitelline vessels in chick embryos. In: Soh KS, Kang KA, Harrison D, eds. *The primo vascular system, its role in cancer and regeneration*. New York: Springer; 2001:77—82.
54. Wijk E, Groeneveld M, Greef J, Wijk R. Unusual optical properties of collagen and implication for the primo-vascular system. In: Soh KS, Kang KA, Harrison D, eds. *The primo vascular system, its role in cancer and regeneration*. New York: Springer; 2011:235—241.
55. Soh KS. Bonghan duct and acupuncture meridian as optical channel of biophoton. *Journal of the Korean Physical Society*. 2004;45:1196—1198.
56. Yung KT. A birdcage model of the Chinese meridian system: part I. A channel as a transmission line. *Am J Chin Med*. 2004; 32:815—828.
57. Toybe S, Sagava T, Ueda M, Mueyuki E, Sano M. Experimental demonstration of information-to-energy conversion and validation of the generalized Jarzynski equality. *Nature Physics*. 2010;6:988—992.
58. Szilard L. On the decrease of entropy in thermodynamic system by intervention of intelligent beings. *Zeitschrift für Physik*. 1929;53:840—856.
59. Hawking S. *A brief history of time*. New York: Bantam Books; 1988:61.
60. Chou K-C, Chen N- Y. The biological functions of low-frequency phonons. *Scientia Sinica*. 1977;20:447—457.
61. Yung KT. A birdcage model for the Chinese meridian system: Part V: applications to animals and plants. *Am J Chin Med*. 2005;33:903—912.