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The Acupuncture System and The Liquid Crystalline Collagen Fibres of the Connective Tissues

Liquid Crystalline Meridians

Mae-Wan Ho (Ph.D.)Bioelectrodynamics Laboratory,
Open University, Walton Hall, Milton Keynes, MK7 6AA, U.K.
David P. Knight (Ph.D.) Dept. of Biological Sciences,
King Alfred's College, Winchester SO22 4NR, U.K.

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Abstract:

We propose that the acupuncture system and the DC body field detected by Western scientists both inhere in the continuum of liquid crystalline collagen fibres that make up the bulk of the connective tissues. Bound water layers on the collagen fibres provide proton conduction pathways for rapid intercommunication throughout the body, enabling the organism to function as a coherent whole. This liquid crystalline continuum mediates hyperreactivity to allergens and the body's responsiveness to different forms of subtle energy medicine. It constitutes a "body consciousness" working in tandem with the "brain consciousness" of the nervous system. We review supporting evidence from biochemistry, cell biology, biophysics and neurophysiology, and suggest experiments to test our hypothesis.

Meridians and fields

The meridian theory is a prominent component of traditional Chinese medicine. It was formulated in ancient China with the practice of acupuncture, moxibustion, massage and *qigong* - an integrated mind-body exercise for controlling and mobilizaing *qi* (energy) for physical fitness and well-being. The meridians are a complicated system of pathways in which "qi and blood" are said to circulate in the body, thus interconnecting the viscera and limbs, the deeper and superficial layers of the body in a fine meshwork (Yin, 1992). The meridians have effectively guided diagnosis and treatment of diseases by drugs, acupuncture, moxibustion, and massage for thousands of years. Acupuncture is also widely used for pain relief, anaesthesia, and in some cases, for treating psychiatric disturbances (Esser et al, 1976).

Yet, the meridians and their acunpuncture points have no known, straightforward anatomical correlates recognized in western medicine, such as the circulatory system or the nervous system. Attempts continue to be made to establish anatomical and functional connections between acupuncture points and a variety of structures. These include receptors supplied by sensory nerves (Wang and Liu, 1989), tendon organs, encapsulated nerve-endings, extensive neural terminals, vascular network or superficial blood vessels (Gunn, 1976; Pan et al, 1988), veins perforating fascia (Plummer, 1980), and mast cells (Zhai, 1988).

Since the 1970s, there has been growing interest in the electrical characteristics of acupuncture points and in developing instruments for diagnostic and therapeutic purposes, as reviewed by Tiller (1982). Such instruments all measure skin conductances and how they change on being stimulated by direct current (DC) or alternating current (AC). Measurements of DC skin conductances have provided evidence that acupuncture points and meridians have distinctive electrical properties compared with the surrounding skin. Acupuncture points typically represent local maxima in conductance, elevated by a factor of 10 to 100, compared with the surrounding skin, while acupuncture meridians have the chracteristics of electrical transmission lines (Tiller, 1973; Reichmannis et al, 1976; Becker, 1990).Tiller (1982, 1987)has presented several models to account for the electrical properties of acupuncture points based on charge movements and selective permeability of ions through different layers of the skin.

In the kind of measurement offered by Motoyama (1980), multiple fixed electrodes are positioned over 28 acupuncture points on the hands and feet, while the large reference electrode is attached to the wrist. A direct current is passed through the circuit by a 3V battery. The conductance typically shows a fast decay in microseconds, overlying a slow baseline conductance with a relaxation time of some tens of seconds. Motoyama attributes the fast component to semi-conduction in the dermis, while the slow component is attributed to ion movements and storage across the basal membrane separating the dermis from the epidermis. Tiller (1987) represents the epidermal and dermal layers as two domains in series, each with its capacitance and resistance with very different response (relaxation) times. The fast component is associated with the dermis, the low frequency component, the epidermis. Tiller has further suggested that the fast conductance might be due to H^+, as the DC voltage supplied (3V) was sufficient to ionize water. This model identifies the differing electrical properties of the dermis and epidermis, which could account for some, though not all, of the responses of the acupuncture system to electrical stimulation. These responses are often found to correlate with states of disease and health (Becker et al, 1976; Kobayashi, 1985).

According to traditional theory, the acupuncture system is an *active* circulatory system for mobilizing energy and for intercommunication throughout the body. So, it is unlikely to be completely understood in terms of the *passive* responses of skin conductances to electrodermal stimulation. The most promising functional correlate of the acupuncture system, as Becker (1990) suggests, is the direct current (DC) electrodynamical field that he and others have detected in the body of all organisms. This DC body field is involved in morphogenesis during development, in wound-healing and regeneration subsequent to injury. The direct currents making up the body field are not due to charged ions but instead depend on a mode of semi-conduction characteristic of solid state systems (Becker, 1961). The acupuncture points, moreover, may act as "booster amplifiers" of the very weak currents that typically flow along the meridians.

According to Becker (1990), the DC body field is not located in the nervous sytem itself, but in "perineural" tissues such as the glial cells in the brain and spinal cord, and the schwann cells encasing the peripheral nerves. This hypothesis would seem to conflict with the suggestion that the DC body field is correlated with the acupuncture system. The acupuncture system is clearly not directly associated with the perineural tissues, although it may have functional interconnections with the central and peripheral nervous system (Gunn, 1976; Wang and Liu, 1989; Pan et al, 1988). Also, an electrodynamical field can be detected in all early embryos and in plants and animals which do not have neural or perineural tissues (Burr and Northrup, 1935). It is likely that the DC field is functionally interconnected with the nervous system, and yet exists, to a large degree, outside the nervous system. In fact, it is widely recognized that under a variety of conditions, the speed of communication in our body is much faster than can be accounted for by the known speed of nerve conduction (see Ho, 1997a), and nerves simply do not reach all parts of our body.

We propose that both the DC electrodynamical field and the acupuncture system have a common anatomical basis. *It is the aligned, collagen liquid crystalline continuum in the connective tissues of the body with its layers of structured water molecules supporting rapid semi-conduction of protons.* This enables all parts of the body to intercommunicate readily, so the organism can function as a coherent whole. This liquid crystalline continuum may mediate hyperreactivity to allergens and the body's responsiveness to different forms of subtle energy medicine. Furthermore, it constitutes a "body consciousness" that is functionally interconnected with the "brain consciousness" of the nervous system (Ho, 1997a). We review supporting evidence from biochemistry, cell biology, biophysics and neurophysiology, and suggest experiments to test our hypothesis.

The organism is a liquid crystalline continuum

One requirement for an intercommunication system is a continuum which can carry the signals for intercommunication. For example, a continuum of air, liquid or solid, can all serve as medium for sound and mechanical waves. If the medium is electrically polarizable, it will also transmit polarization waves. Electromagnetic waves are thought to be an exception, as they can travel through empty space. But to this day, physicists are still debating the nature of the vacuum, which carries not only electromagnetic waves but also gravity waves (see Laszlo, 1995). The living organism is a continuum. Not only is the entire cell now known to be mechanically and electrically interconnected in a "solid state" (Clegg and Drost-Hansen, 1991) or "tensegrity system" (Ingber, 1993, 1998); *all* the cells in the body are in turn interconnected to one another via the connective tissues (Oschman, 1984, 1996).More accurately, perhaps, we recently discovered that the living continuum is liquid crystalline, with all the properties that make liquid crystals ideal for intercommunication (Ho et al, 1996; Ho, 1997a).

Liquid crystals are states or phases of matter in between solid crystals and liquids, hence the term, *meso*phases. Unlike liquids which have little or no molecular order, liquid crystals have orientational order, and varying degrees of translational order. But unlike solid crystals, liquid crystals are flexible, malleable, and responsive (De Gennes, 1974; Collings, 1990). There are many kinds of liquid crystals, from those which are most like liquids, to ones that most resemble solid crystals. Those that are like liquids can flow in the way water does, and even though all molecules tend to be aligned in one direction, individual molecules can move quite freely and change places with one another while maintaining their common orientation. The ones that resemble solid crystals will have order in all three dimensions, and molecules may even be extensively covalently cross-linked together, but they will remain flexible and responsive.

Liquid crystals typically undergo rapid changes in orientation or phase transitions when exposed to electric (and magnetic) fields - which is why they are widely used in display screens. They also respond to changes in temperature, hydration, shear forces and pressure. Biological liquid crystals carry static electric charges and are therefore also influenced by pH, salt concentration and dielectric constant of the solvent (Collings, 1990; Knight and Feng, 1993).George Gray (1993), who has studied liquid crystals for many years, refers to liquid crystals as "tunable responsive systems", and as such, ideal for making organisms.

It is already widely recognized that all the major constituents of living organisms may be liquid crystalline (Collings, 1990) - lipids of cellular membranes, DNA, possibly all proteins, especially cytoskeletal proteins, muscle proteins, and proteins in the connective tissues such as collagens and proteoglycans (Bouligand, 1972; Giraud-Guille, 1992; Knight and Feng, 1993). Recent nuclear magnetic resonance (nmr) studies of muscles in living human subjects provide evidence of their "liquid-crystalline-like" structure (Kreis and Boesch, 1994). However, very few workers have yet come to grips with the idea that *organisms* may be essentially liquid crystalline.

The importance of liquid crystals for living organization was actually recognized a long time ago, as pointed out by Joseph Needham (1935).Hardy suggested in 1927 that molecular orientation may be important for living protoplasm, and Peters, two years later, made the explicit link between molecular orientation and liquid crystals. Needham, indeed, proposed that organisms actually *are* liquid crystalline. But direct evidence for that has only recently been provided by Ho and coworkers (Ho and Lawrence, 1993; Ho and Saunders, 1994; Ho et al, 1996). who successfully imaged live organisms using an interference colour technique that amplifies weak birefringences typical of biological liquid crystals. They further discover that all organisms so far examined are polarized along the anterior-posterior or oral-adoral axis, so that when that axis is properly aligned, all the tissues in the body are maximally coloured; the colours changing in concert as the organism is rotated from that position. Not only live organisms, but also fresh-frozen or well-fixed sections of the skin, cartilage and tendons, all exhibit the same brilliant interference colours typical of living organisms.

The connective tissues are still regarded by most workers in purely mechanical terms - their functions are to keep the body in shape, to act as packing between the major organs and tissues, to strengthen the wall of arteries, veins, intestines and air passages, and to provide the rigid elements (bony skeleton) for the attachment of muscles. A more enlightened view is that of a global tensegrity system, in which compression elements (bones) are interconnected with tension elements (muscles, tendons and ligaments), and local stimuli invariably lead to global reorganization of the whole (Ingber, 1998).

Actually, connective tissues may also be largely responsible for the rapid intercommunication that enables our body to function effectively as a *coherent* whole, and are therefore central to our health and well-being.

Collagens and Intercommunication

The clue to the intercommunication function of connective tissues lies in the properties of *collagen*, which makes up 70% or more of all the protein of the connective tissues. Connective tissues, in turn form the bulk of the body of most multicellular animals. Collagen is therefore the most abundant protein in the animal kingdom (Knight and Feng, 1993).

There are many kinds of collagens, all sharing a general repeating sequence of the tripeptide, (gly-X-Y) - where X and Y are usually proline or hydroxyproline. They also share a molecular structure in which three polypeptide chains are wound around one another in a triple-helix, with the compact amino acid glycine in the central axis of the helix, while the bulky amino-acids proline and hydroxyproline are near the surface (Van der Rest and Garrone, 1991).In the fibrous forms, the triple-helical molecules aggregate head to tail and side-by side into long *fibrils*, and bundles of fibrils in turn assemble into thicker fibres, and other more complex three-dimensional liquid crystalline structures. Some collagens assemble into sheets constructed from an open, liquid crystalline meshwork of molecules. All these structures are formed by *self-assembly*, in the sense that they need no specific "instructions" other than certain conditions of pH, ionic strength, temperature and hydration. The process seems to be predominantly driven by hydrophilic interactions due to hydrogen-bonding between water molecules and charged amino-acid side-chains (Leikin et al, 1995).However, the precise mesophase structures resulting from different conditions of self-assembly show endless variations (Zhou et al, 1996; Haffegee et al, 1998). The different kinds of collagen assemblies in different connective tissues are generally well-suited to the mechanical tasks performed by the connective tissue concerned, because they were shaped by the prevailing conditions and the relevant mechanical forces.

Recent studies reveal that collagens are not just materials with mechanical properties. Instead, they have dielectric and electrical conductive properties that make them very sensitive to mechanical pressures, pH, and ionic composition (Leikin et al, 1993, 1995),and to electromagnetic fields. The electrical properties depend, to a large extent, on the bound water molecules in and around the collagen triple-helix. X-ray diffraction studies reveal a cylinder of water surrounding the triple-helix which is hydrogen-bonded to the hydroxyproline side-chains (Bella et al, 1994). Nuclear magnetic resonance studies have provided evidence of *three* populations of water molecules associated with collagen. These are *interstitial* water, very tightly bound within the triple helix of the collagen molecule, and strongly interacting with the peptide bonds of the polypeptide chains; *bound* water, corresponding to the more loosely structured water-cylinder on the surface of the triple helix; and *free* water filling the spaces between the fibrils and between fibres (Peto and Gillis, 1990).Evidence for bound water in collagen also comes from studies using another popular physical measurement technique, Fourier Transform Infra Red (FTIR) spectroscopy (Renugopalakrishnan et al, 1989).

Bound water, or vicinal water is a very general phenomenon involving the structuring of water on solid surfaces. It is already known that up to 50 or 60% of the cell water is structured in the enormous "microtrabecular lattice" that fills the entire cell (Clegg and Drost-Hansen, 1991), which gives the cell its "solid-state" like characteristic (see above).

The existence of the ordered network of water molecules, connected by hydrogen bonds, and interspersed within the protein fibrillar matrix of the collagens is especially signicant, as it is expected to support rapid jump conduction of protons - positive electric charges - and this has been confirmed by dielectric measurements (Sasaki, 1984). The conductivity of collagen increases strongly with the amount of water absorbed (from 0.1 to 0.3g/g of dry collagen), in accordance with the power-law relation,

$$\square(\square) = X\square Y$$

where □ is the water content, and *X* and *Y* are constants. The value of *Y* is found to be 5.1 to 5.4, and is a function of the collagen fibrillar structure. These results suggest that continuous chains of ordered water molecules join neighbouring ion-generating sites enabling proton jumps to occur. The high value of the exponential suggests that up to 5 or 6 neighbours may be involved in the jump conduction. Based on these findings, it is estimated that conductivity along the collagen fibres is at least one-hundred time that across the fibre (Pethig, 1996). Measurements have yet to be made to reveal the true extent of anisotropy in conductivity. The increase in conductivity is most marked around 310 K (Jaroszyk and Marzec, 1993), which interestingly, is close to the normal temperature of our body . It is to be noted that the triple-helix of collagens in dilute solutions "melt" at around the same temperature - 40oC (Leikin et al, 1995). Melting may enable the collagen fibres to better realign, and hence increase conductivity. Collagen melting and realignment may be one of contributing factors to the now well-documented health-promoting effects of physical exercise (see Bortz, 1996).

The collagenous liquid crystalline mesophases in the connective tissues, with their associated structured water, therefore, constitutes a semi-conducting, highly responsive network that extends throughout the organism. This network is directly linked to the intracellular matrices of individual cells via proteins that go through the cell membrane. The connective tissues and intracellular matrices, together, form a global tensegrity system (Oschman, 1984; Ingber, 1998), as well as an excitable electrical continuum for rapid intercommunication throughout the body (Ho, 1997a).

Collagen fibre orientation and the acupuncture system

A major factor contributing to the efficiency of intercommunication is the structured, oriented nature of collagen liquid crystalline mesophases in all connective tissues. Each connective tissue has its characteristic orientation of fibrous structures which are clearly related to the mechanical stresses and strains to which the tissue is subject. This same orientation may also be crucial for intercommunication. Collagen alignment has long been recognized to be important in the structure of bone and cartilage. Less well known are the "Langer lines" (Langer, 1978) in the skin, corresponding to predominant orientations of collagen fibres, which are determined, at least in part, by stresses during development and growth (Reihsner et al, 1995).

Collagen fibre alignments in connective tissues providing channels for electrical intercommunication may thus be correlated with the acupuncture system of meridians and points in traditional Chinese medicine, which, as mentioned above, is also related to the DC body field identified by scientists in the West.

As collagen fibres are expected to conduct (positive) electricity preferentially *along* the fibres due to the bound water, which are predominantly oriented along the fibre axis; it follows that these conduction paths may correspond to acupuncture meridians. By contrast, acupuncture points typically exibit low electrical resistances compared with the surrounding skin, and may therefore correspond to singularities or gaps *between* collagen fibres, or, where collagen fibres are oriented at right angles to the dermal layer. A number of structures mentioned earlier, which are at or near acupuncture points, have a common feature in that they are located in local gaps in the fascia or collagen fibres (see Meridians and Fields). Actual conducting channels may bear a more subtle relationship to the orientation of the collagen fibres, as conductivity depends predominantly on the layer(s) of bound water on the surface of the collagen molecules rather than the collagens themselves. So-called free water may also take part in proton conduction as the result of induced polarization, particularly as water molecules naturally form hydrogen-bonded networks (Luzar and Chandler, 1996). This would be consistent with the observed increase in conductivity of collagen as hydration increases to a level well beyond the bound water fraction, around 0.15g/g dry weight; and also with the fact that the normal hydration level of tendon is about 65%.

That conductive pathways actually link the entire body is demonstrated by Han Wan and Robert Balaban of the Canadian National Heart, Lung and Blood Institute (see Ehrenstein, 1997), who are taking advantage of the variation in conductivity of different layers of tissues in the body to develop a new, non-destructive imaging technique to aid clinical diagnosis.

The correlation between collagen alignment and the acupuncture system could be tested by examining the alignment in skin biopsies at acupuncture points and meridians - with corroborative skin conductance measurements - compared with non-acupuncture, non-merdian areas. In this connection, we have developed a quantitative imaging package based on our interference colour polarizing microscopy that readily plots molecular alignment in sections of the skin and other connective tissues (Knight et al, 1996; Ross et al, 1997).

Collagen alignment in health and injury

If our hypothesis is correct, and patterns of collagen fibre alignment are indeed important for intercommunication, then they would be expected to affect the health of the individuals concerned, and also to be involved in the processes of healing and regeneration.

Electrical injury currents typically flow from skin wounds and sites of amputation, which are found to be involved in healing and regeneration (Becker, 1990). Injury currents themselves constitute evidence that conductive circuits link the entire body, so that cuts result in leakage currents. The leakage currents mobilize cells to migrate to the site of injury to initiate the healing and regenerative processes. It is significant that the immediate injury currents are all positive, as suggestive of proton currents. Only later on, after the regenerating blastema is formed, do the currents reverse to negative (see Becker, 1990).

Since these observations were made, electromagnetic interventions have been widely used for stimulating regeneration or healing, with conflicting results. Part of the problem may have been that the strengths of electromagnetic fields used were far stronger than the endogenous fields. Another important factor which has received little attention may be the orientation of the applied electromagnetic field with respect to the alignment of collagen fibres at the site of injury. If the field orientation is inappropriate, then application of the external field is likely to be ineffective, and may even delay recovery (Watkins et al, 1985).On the basis of the estimated 100-fold difference in electrical conductivity along the fibre compared to that across the fibre, it would be expected that collagens fibres will align in the direction of the applied electric field. Again these experiments should be done to ascertain the optimum conditions for collagen alignments, which may have important implications for healing and regeneration.

Oriented Collagens and Body consciousness

Proteins in liquid crystals have coherent motions, in the first place, because the molecules are aligned, so that not all the degrees of freedom of movement that individual molecules have will be available in the liquid crystal mesophase (Searle and Williams, 1992). Protein motions involve vibrational deformations of peptide bonds, which will generate polarization waves along the proteins, accompanied by proton conduction in the structured water shell. Fröhlich (1980) has predicted that coherent vibrations (or excitations) will result from metabolic pumping in dielectric systems such as organisms, where electromagnetic and electromechanical forces are expected to interact. Liquid crystallinity will make coherent excitations even more likely to happen. Weak signals of mechanical pressure, heat or electricity, may therefore be readily amplified and propagated by a modulation of the proton currents or coherent polarization waves (Mikhailov and Ert, 1996)

The hydrogen-bonded water network of the connective tissues is actually linked to ordered water dipoles in the ion-channels of the cell membrane that allow inorganic ions to pass in and out of the cell (Williams, 1993). There is thus a direct electrical link between distant signals and the intracellular matrix, leading to physiological changes inside the cells, including neurons and glial cells. This electrical channel of intercommunication is in addition to, and coupled with, the mechanical tensegrity interactions of the connective tissue-intracellular matrix continuum mentioned above. Any mechanical deformations of the protein-bound water network will automatically result in electrical disturbances and conversely, electrical disturbances will result in mechanical effects. The new imaging technique that Han and Balaban are developing (see above) depends specifically on detecting ultrasound emissions from mechanoelastic vibrations caused by electrical pulses applied to the tissues.

Proton jump-conduction is a form of semi-conduction in condensed matter, and is much faster than conduction of electrical signals by the nerves. Thus the 'ground substance' of the entire body may provide a much better intercom-munication system than the nervous system. Indeed, it is possible that one of the functions of the nervous system is to slow down intercommunication through the ground substance. Lower animals which do not have a nervous system are nonetheless sensitive. At the other end of the evolutionary scale, note the alarming speed with which a hypersensitive response occurs in human beings. There is no doubt that a body consciousness exists prior to the "brain" consciousness associated with the nervous system. This body consciousness also has a memory, as argued in the Section following.

Crystal Memory

Many studies on the conformation (three-dimensional shape) of the collagen triple-helix have shown that subtle changes are correlated with specific biological activities (Fields, 1995). Cells are guided in their growth and movement by contact with collagens, and specific sites are recognized by a host of cell membrane proteins. Mutations altering collagen amino-acid sequences give subtle changes in the conformation (Bella et al, 1994) which are associated with hereditary diseases, such as osteogenesis imperfecta, chondrodysplasias and Ehler-Danlos syndrome. Changes in collagen conformation should alter the bound water. Conformations of proteins are by no means static. All proteins undergo a hierarchy of conformational changes on a range of timescales, and collagens are unlikely to be exceptions. The conformations are clustered in groups of nearly identical energy content, with very low energy barriers between individual members of the group, but separated from other groups by higher energy barriers (see Welch, 1985). Collective changes in conformation (or phase transitions) can readily be triggered, in turn altering the liquid crystalline structure and the bound water network, as dielectric studies on synthetic liquid crystals have documented (Leikin et al, 1993; Wrobel et al, 1988).

As the collagens and bound water form a global network, there will be a certain degree of stability, or resistance to change. This constitutes a memory, which may be further stabilized by cross-linking and other chemical modifications of the collagens. The network will retain tissue memory of previous experiences, but it will also have the capacity to register new experiences, as all connective tissues, including bones, are not only constantly intercommunicating and responsive, but also undergo metabolic turnover like the rest of our body. Memory is thus dynamically distributed in the structured network and the associated, self-reinforcing circuits of proton currents, the sum total of which will be expected to make up the DC body field itself.

Coupled Body and Brain Consciousness

We have argued that a body consciousness possessing *all* the hallmarks of consciousness - sentience, intercommunication and memory - is distributed throughout the entire body. Brain consciousness associated with the nervous system is embedded in body consciousness and is coupled to it (see also Ho, 1997a,b; 1998). That bound water plays a crucial role in conscious experience is supported by recent evidence that anaesthetics act by replacing and releasing bound water from proteins and membrane interfaces, thus destroying the hydrogen-bonded network that can support proton jump-conduction (Tsukamoto and Oglie, 1995).Significantly, Becker (1990) found that general anaesthesia also leads to the complete attenuation of the DC body field. It would be of interest to study the conductivities of collagen equilibrated with different solvents and anaesthetics. We would predict that collagens equilibrated with anaethetics will show a decrease in conductivity compared to an equivalently hydrated sample.

Although brain and body consciousness are normally coupled to each other, they may decouple under certain circumstances. Surgical patients under general anaesthesia have been known to regain (brain) consciousness of pain, but not the ability to move or to express their distress. In contrast, acupuncture has been successfully used to anaesthesize patients who are fully awake. Further evidence that brain and body consciousness are to some extent independent is Becker's (1990) observation that during a perceptive event, local changes in the DC field can be measured half a second before sensory signals arrive in the brain. Similarly, Libet et al (1979) produced evidence suggesting that a "readiness potential" precedes the decision of a subject to move an arm or a leg. It appears that the activities in the brain may be preconditioned by the local DC field.

If it is true that brain and body consciousness can decouple from one another, it would be important to develop monitoring systems specific to either of them. For example, acupuncture points may show changes independently of the EEG, and hence, surgical patients whose EEG, or better yet, whose magnetoencephalogram (MEG) measured with the ultrasenstive SQUID magnetometer show wakefulness may yet have acupuncture point(s) electrodermal readings typical of the anaesthetized state. Similarly, patients anaethetized by acupunture should have the appropriate "anaethetized" electrodermal readings even though their EEG or MEG is fully "awake".

Conclusion

We have proposed that the acupuncture (meridian) system and the DC body field detected by Western scientists both inhere in the continuum of liquid crystalline collagen fibres and the associated layers of bound water that make up the bulk of the connective tissues of the body. Acupunture merdians may be associated with the bound water layers *along* oriented collagen fibres, which provide proton conduction pathways for rapid intercommunication throughout the body; while acupuncture points may correspond to gaps in the fibres or fibres oriented at right angles to the surface of the skin. The sum total of the electrical and electromechanical activities of the liquid crystalline continuum constitutes a "body consciousness" that works in tandem with the "brain consciousness" of the nervous system. We have reviewed supporting evidence from biochemistry, cell biology, biophysics and neurophysiology, and have suggested the following experiments to test our hypothesis.

1. Dielectric measurements on oriented samples of collagen fibres, to ascertain the anisotropy of conductivity along and across the fibres (see p. 8).

2. Dielectric measurements on the conductivities of oriented samples of collagen fibres equilibrated with different anaesthetics, to ascertain the decrease in conductivity compared with samples equilibrated with water (see p. 13).

3. Examination of collagen fibre alignments in skin biopsies at acupuncture points and meridians - with corroborative skin conductance measurements - compared with non-acupuncture, non-meridian areas. This is to ascertain the association of meridians with oriented fibres and acupoints with gaps or with fibres oriented at right angles to the surface of the skin (pp. 9-10).

4. Alignment of collagen fibres in the direction of an applied electric field, predicted from the anisotropy in electrical conductivity along and across the fibre (p. 10).

5. Simultaneous measurements of EEG/MEG and skin conductances of acupuncture points of patients under chemical anaesthesia to detect correlated and uncorrelated activities between brain and body consciousness (p. 13).

6. Simultaneous measurements of EEG/MEG and skin conductances of acupuncture points of

patients under acupuncture anaesthesia to detect possible uncorrelated activities between brain and body consciousness (p.13).

It is reasonable to conclude that under normal, healthy conditions, body and brain consciousness mutually inform and condition each other, and that the unity of our conscious experience and our state of health depends on the complete coherence of brain and body. Traditional Chinese medicine based on the acupuncture meridian system places the emphasis of health on the coherence of body functions which harmonizes brain *to* body, which makes perfect sense if one recognizes the brain as part of the body. Western medicine, by contrast, has yet no concept of the whole, and is based, at the very outset, on a Cartesian divide between mind and brain, and brain and body.

References : Please refer to the following website: http://www.i-sis.org.uk/lcm.php