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Investigation into the acupuncture and meridian system

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ABSTRACT

INVESTIGATION INTO THE ACUPUNCTURE AND MERIDIAN SYSTEM

By

Jingong Pan

The Meridian system conceived by the ancient Chinese has been described and referenced for more than a thousand years. The Meridians meaning paths are the main trunks that run longitudinally within the body. The Meridian system consists of about 400 acupuncture nodes and 20 Meridian channels connecting most of these points. It deals with the routing and distribution of certain signals that may affect physiological functions. It integrates meridiàns, tissues and organs into a complex system.

Initially, modeling of the acupuncture system is investigated. The physical effect of injecting an acupuncture needle at a node is suggested by an equivalent model of a current (voltage) source based on a simple Faraday disk generator concept. The motion of the needle due to hand manipulation in the presence of Earth's magnetic fields acts as a Faraday's dynamo and causes accumulation of positive (negative) charges at the tip of the needle. Due to clockwise (counter clockwise) rotation, further increase of accumulated charges at the tip results in their release in the form of an equivalent current (voltage) source. This effect has been enhanced by connecting a variable frequency source on a needle inserted into one of the nodes of the meridian system. Voltage variations at the adjacent nodes along the same meridian are measured and the relative connectivity has been observed to verify the concept of a network. It is observed that the induced voltages are proportional to the corresponding path lengths, and further more, the existence paths

are found to be frequency dependent. An equivalent transmission line model is suggested. The presence of minute electrical currents also suggests that there is magnetic field along the meridian and therefore the inclusion of series inductance is appropriate. This has already been confirmed by SQUID measurements carried out and reported by [Lo 2003]. The presence of the inductive (resistive) path suggests that capacitive effects due to accompanying electric fields have to be included as shunt capacitance in the equivalent model. It shows that distributed resistance and inductance plus the shunt capacitance perfectly simulate the equivalent transmission line that is essential for signal propagation along the meridians of the acupuncture system. Measurements carried out indicate the presence of lossy resistive paths along the meridian consisting of three nodes. This has been carried out in an acupuncture clinic and two human subjects are subjected to testing on three different occasions. Sinusoidal signals in the frequency range between 20 to 80 Hz are used with different amplitudes, and strengths of propagated signals are measured to verify the existence of the electrical transmission path along that meridian.

Additional hypothesis is made suggesting that the cluster water wire can be used to model the pathways of the acupuncture system. One of the reasons for this approach is that cluster water wires are ideal to model tiny nano-size capillaries. They may be present but their presences have not been verified yet physically, even through the SQUID measurements confirm the flow of minute currents along the acupuncture meridians.

Petri net formulation has been developed as an attractive alternative to model bio-network consisting of acupuncture nodes and meridians. However, validating this assumption requires an extensive measurement to be carried out, which is beyond the currently available capabilities and resources.

Future work includes much more accurate modeling of pathways and nodes on each meridian, their coupling with each other. Further frequency dependent system identification in terms of equivalent parameters and their coupling behavior in the complex network, i.e., Petri net formation is required to solve the unexplained acupuncture meridian system. The presence of 20 meridians involving more than 400 nodes suggests that the acupuncture system is ideal to model a biological network.

INVESTIGATION INTO THE ACUPUNCTURE AND MERIDIAN SYSTEM

by
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To my wonderful parents and beloved wife.
For they allow me to travel over the Pacific Ocean after my dream

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CHAPTER 1

BIO-SIGNAL SYSTEM MODELING

1.1 Introduction

The Meridian system conceived by the ancient Chinese has been described and referenced for more than a thousand years. The Meridian meaning paths are the main trunks that run longitudinally in a human body. For thousands of years the meridian system has been postulated to exist even though no one has verified this system morphologically. On the other hand, its existence is closer and closer to verify due to the popular use of acupuncture in curing various medical disorders. Acupuncture was standardized through the effort of World Health Organization (WHO). It has also been accepted by the Western world as an alternative method dealing with many popular and rare diseases, some of which have no cure based on the state-of-art of Western medicine.

The Chinese ancient philosophy has proposed that meridians are "channel", and twelve main meridians compose an independent network. They together control all the "Qi", "blood" and consciousness. Modern science also indicates that the Meridian system seems to be a distinct signal transduction system that can be measured by instruments such as Superconducting Quantum Interference Devices [Lo, 2004]. It overlaps and interacts with other systems but is not simply part of a nervous system or circulatory system. It seems that there are invisible "soft wires" that possess high electrical conductance, responsive to non-specific stimuli and polarity of electric stimulation. The

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high skin conductance of the Meridian system is further supported by the finding of high density of gap junctions at the epithelia of the acupuncture nodes [Cohen *et al*, 1980; Shang, 2001; Shang, 1993; Zheng, 1996]. However, so far no one has a clear idea about what kind of "wire" forms the Meridian signaling transduction network.

A recent simulation study of biophysical features along Meridians on a gel model suggests that the specific biophysical feature along Meridians may be caused by a continuous rich distribution of interstitial fluid, therefore exploring inclusion of the "interstitial fluid" concept will be natural. Water constitutes a larger fraction (over 60%) of the human body, especially the brain and neural system. It is significant to analyze and find out why and how the bio-signal information is transferred through the Meridian system.

1.2 Brief History of Acupuncture

Alternative medicine is a very broad term that encompasses an array of holistic techniques for preventing and treating medical disorder. The most famous of these therapies is acupuncture treatment that has long tradition in Asian cultures. It is given more credibility by Western doctors than others. Even though still a controversial area, more and more medical schools have courses on alternative medicine, and health maintenance organizations cover certain alternative therapies. In fact, some practitioners prefer the term "complementary medicine," accentuating a partnership between Western and Eastern-based options.

Acupuncture is the insertion of hair-thin surgical steel needles into specific point on the body along the Meridians to prevent or treat medical disorders. It is an integrated

system that has been used in China and other Asian countries for more than several thousands of years. Inserting hair-thin surgical steel needles into selected acupuncture nodes in the body is just the mechanics of the technique. For a better understanding of this technique, one needs to explore some background in traditional Chinese medicine.

According to traditional ancient Chinese theory, health is achieved through the harmonious balance between the opposing forces of *yin* (spirit) and *yang* (blood). The attraction between them creates an energy-*Qi* (pronounced chee). *Qi* flows to all parts of the body through twenty Meridians that run along the surface of the body and branch into the body's interior. The movement of *Qi* in the Meridians can become deficient, excessive, or stagnant. Any mentioned situation is believed to cause certain illness. Some of those conditions can be corrected by inserting hair-thin surgical steel needles into related acupuncture nodes along the Meridians. Therefore, a proper choice of the related acupuncture nodes depending on the ailment becomes very important. The pattern of movement (clockwise or counterclockwise) and depth of the needle's insertion are very crucial during the treatment session. Therefore, one can speculate that the acupuncture works by restoring the balance of energy-*Qi* inside human body. When needles are inserted at prescribed spots (acupuncture nodes) along the Meridians, the balance, i.e., health is believed to be restored via the needles and their movement patterns. Different styles of acupuncture forms in terms of hand pressure, electrical pulse, ultrasound, or wavelengths of light are used in practice.

Acupuncture was first discussed in the ancient Chinese medical text "Huang Di Nei Jing" (The Yellow Emperor's Classic of Internal Medicine), originated more than

2000 years ago. During the 6th century, improved transportation and communications within the Asian continent led to the introduction of Chinese medicine to Japan, and along with Buddhism became the standard in the form of religious medicine. In the 17th century, one of Japanese famous acupuncturists --Waichi Sugiyama, he developed the insertion tube, an accurate, painless and speedy insertion method-- a small cylindrical tube through which the needle is inserted. This insertion method is still used today by practitioners worldwide and by over 90% of the acupuncturists in Japan.

Japanese acupuncture has been well established as the primary form of health care for over a thousand years. An acupuncturist's role was comparable to that of a modern physician. When Dutch and German medicine was introduced in the 19th century, the Western modality of medicine quickly became the dominant medical practice.

Acupuncture was recognized in Western medical texts more than a hundred years ago. The 1901 edition of Gray's Anatomy states that "the sciatica nerve…has been acupunctured for the relief of sciatica." Sir William Osler is often considered being the father of modern medicine. His book "Principles and Practice of Medicine" was first published in 1892. It recommends acupuncture for both sciatica and lumbago, "For lumbago, acupuncture is, in acute cases, the most efficient treatment" [Adriane Fugh-Berman, 1997].

After 1949, there was a large push towards the modernization of medicine in China. Some leaders proposed to replace TCM (Traditional Chinese Medicine) with modern Western medicine, while others supported TCM. To resolve this difficult issue, many studies were conducted in the 1950s. Since these studies found TCM to be effective

to cure many medical problems, the Chinese government decided to give it equal status with Western medicine in 1958. It established more than 45 TCM medical schools in 28 provinces.

Although acupuncture has always been practiced within Asian communities in the United States, it was not considered to be the efficient treatment until 1972, when *New York Times* correspondent James Reston covered Nixon's historic trip to China, and made acupuncture widespread noticed. While in China, Reston needed an emergency appendectomy and was treated with acupuncture for his postoperative pain. The report of his experience attracted the interest of dozens of American doctors who wanted to see for themselves how the Chinese operated using acupuncture as an anesthetic. Additionally, many non-physicians started to receive training overseas or work with acupuncturists who had been quietly practicing in the Asian communities of many large American cities. Some of these new converts established schools and fought for laws to allow the practice of acupuncture in many states. Since then, the practice has grown to significant levels in the United States. There are now over 50 schools of acupuncture nationwide, 21 of which are accredited by the U.S. Department of Education, and over 40 states have laws or regulations governing the practice of acupuncture. The World Health Organization, the medical branch of the United Nations, issued a provisional list of 41 diseases amenable to an acupuncture treatment. These include respiratory ailments, pain and chronic pain conditions, and other gynecological disorders, gastrointestinal disorders and many other health problems. According to a 1993 Food and Drug Administration (FDA) report, between nine and 12 million visits to acupuncturists are made every year-a number that has no doubt increased since then.

Today in China and Japan, acupuncture remains an integral part of their health care system, offered in conjunction with Western medicine. In the United States, acupuncture has grown into what is now a common form of pain management therapy in many clinics and hospitals. The Washington Post reported in 1994 that an estimated 15 million Americans, or roughly 6% of the American population visited an acupuncturist and tried acupuncture for a variety of symptoms including chronic pain, fatigue, nausea, arthritis, and digestive problems.

In 1995, the U.S. Food and Drug Administration (FDA) classified acupuncture needles as medical instruments and assured their safety and effectiveness. The medical community for the most part now accepts acupuncture and a growing number of medical schools, such as University of California, Los Angeles, include acupuncture training in their curriculum. In 1996, the FDA took the needles used in acupuncture off its "experimental" instrument list. In 1997, the US National Institute of Health issued a report titled: "Acupuncture: The NIH Consensus Statement". It states that acupuncture is a very useful method for treating many conditions. It acknowledges that the side effects of acupuncture are considerably less adverse than other medical procedures such as surgery or pharmaceuticals. In addition, the NIH made the recommendation to U.S. insurance companies to provide full coverage of acupuncture treatment for certain conditions. This momentous advancement in the status of acupuncture in the United States has certainly influenced its status elsewhere in the world, including Canada and Europe.

In the same year, the Ontario Medical Association officially recognized acupuncture as a 'complimentary medicine', acknowledging its broad success in treatment.

As acupuncture becomes increasingly accessible to more Canadians, doctors recommend it more and more as an effective relief for many medical conditions. Acupuncture treatments are included in many insurance plans. It is a sure sign of acupuncture's acceptance into the mainstream. It is also an indicator of its success.

Acupuncture received approval from two important federal health agencies FDA and National Institutes of Health (NIH) in 1997. NIH Consensus Panel was convened to examine all available research on the ancient Chinese therapy. The mere fact that the panel was convened by the central pillar of the U.S. research establishment, demonstrated how much respectability acupuncture gained among Western scientists and medical practitioners, and wiped acupuncture off people's "quackery" list. The consensus statement concludes that acupuncture [NIH, 1997]:

- Clearly works to treat a number of conditions, including nausea from chemotherapy, surgery and pregnancy, and pain after surgery (including dental surgery).
- May also be an effective adjunct therapy for a number of other conditions, including stroke rehabilitation, relieving addictions, headaches, menstrual cramps, a variety of muscle pains, carpal tunnel syndrome, tennis elbow, low back pain, osteoarthritis, and asthma.

Acupuncture has substantially lowered incidence of adverse side effects than that of many drugs or other accepted medical procedures used for treatment of same conditions. It should be integrated into standard medical practice and be covered by

Medicare, Medicaid and private insurance companies when one considers economical cost compared to standard treatments.

In China, acupuncture is used for a wide variety of medical conditions, but in the United States it is accepted by conventional doctors—if at all –solely for the treatment of pain. Many chronic pain patients seem to be helped by acupuncture. This is fortunate since several common prescription and non-prescription painkillers, for example, aspirin, ibuprofen, and naproxen, can cause liver and kidney problems, ulcers and gastrointestinal bleeding compared to almost non-existent side effects of the acupuncture.

1.3 Motivation and Contribution

This dissertation research is aimed to investigate the physical origin of the Meridian system inside our human body, and to extend it into a Petri net model as a part of bio-signal network. Further clarification of how acupuncture works may help industries develop the modern technology or devices for more applications.

The objectives of this research are divided into two parts. They are as follows.

(1)   Development of an experiment-based physical model of an acupuncture Meridian.

As suggested before, an acupuncture Meridian consists of a fixed number of nodes placed along that Meridian. Experimental evidence obtained in this thesis research verifies the existence of a conducting path between the nodes of a particular Meridian.

This aspect of research is aimed to develop a method for modeling an acupuncture node, which forms the fundamental part of the Meridian system. The precise modeling can help scientists understand better why acupuncture can work for certain medical disorder.

(2)   Based on experimental evidence obtained in this thesis, a possible model of an acupuncture Meridian is suggested in terms of equivalent clustered water wire in a network.

A further attempt is made to express this network in terms of Petri net framework. It can also help scientists develop better technology or devices to improve and maintain human health, and to correct certain medical disorders with the lower cost accessible to a large segment of population.

This dissertation is organized as follows. Chapter 2 discusses the Meridian system. Chapter 3 presents experiments that have designed and completed. A simple mathematical model is derived in this phase of the research work. Chapter 4 introduces water memory concept and experiments. Chapter 5 discusses the Petri net concept and theory. Chapter 6 concludes this dissertation by summarizing the contributions, indicating the limitation of this research and discussing the future work.

CHAPTER 2

INTRODUCTION TO MERIDIAN SYSTEMS

2.1 Meridian: An Ancient and Novel Signaling Transduction System

According to the Standard Acupuncture Nomenclature proposed by the World Health Organization (WHO) [United Nations, 1993], the Meridian system in acupuncture consists of about 400 acupuncture nodes and 20 Meridians connecting most of the body organs. Since the 1950s, it has been discovered and confirmed by researchers in several countries with refined techniques that most acupuncture nodes correspond to the high electrical conductance points on the body surface [Helms, 1995; Manaka, 1972]. The high skin conductance of the Meridian system is further supported by finding of high density of gap junctions at the epithelia of the acupuncture nodes [Zheng *et al,* 1996; Meyer, 1992]. Gap junctions are hexagonal protein complexes that form channels between adjacent cells. It is well established in cell biology that gap junctions facilitate intercellular communication and increase electric conductivity. Acupuncture and Meridian points have also been found to have higher temperature, higher metabolic rate and carbon dioxide release [Zhang, 1998].

There are two major theories related to the biological signal transduction pathways in humans:

A. The conventional theory: the nervous system or ligand-receptor model

B. The oriental theory: the Meridian system.

It is common knowledge that the human body is covered by a nervous system. The human body has this capacity in the autonomic nervous system as a signal carrier,

via both the sympathetic and parasympathetic branches. The system influences secretion, smooth muscle response, blood vessel response, electrocardiogram, heart rate variability, etc. It functions also as a signal conductor in a detection mode of operation.

According to ancient Chinese medicine, there is also a Meridian system. It is more fundamental than the nervous and blood circulatory systems. The elements of the Meridian system are thought of as the acupuncture nodes of the body. As there are hundreds of such points, they provide an array or network system with the capacity to generate and transfer the signals complimentary to the nervous system. It is believed that a fine needle in certain locations of human body generates and transmits certain kinds of bio-signal traveling along the Meridians system to certain organs to balance the "*Qi*" in whole body.

The Meridian system is different from a nervous system. For example, if people nail their finger by accident, their nervous system carries a signal from their finger to their brain. They feel pain but do not feel anything traveling along their arm. In other words people do not feel electrical signals that move through the nervous system.

However, it is a quite common reaction of acupuncture patients to feel sensation traveling along Meridians when a needle is inserted into an acupuncture node, and the sensation does not propagate randomly in any direction. It propagates only along the Meridian along which the acupuncture nodes are located. Hence this propagation of sensation is unlikely to be electrical signal moving via the nervous system. It seems that the path of the Meridian system has the property of high conductivity along that Meridian.

In oriental medicine, the Meridian system is considered as an underlying interconnected system, governing all the major systems of the body, including the

immune, reproductive, nervous, gastrointestinal, and urinary systems. The acupuncture system and acupuncture nodes are supported and verified through at least two thousand years and by millions of patients in clinical practice. But the acupuncture system and its related treatment methods are not taught in classical medical texts. Perhaps the main reason is that in anatomy we have found nerves and blood vessels, but we have not found any such signs in acupuncture Meridians until Dr. Lo demonstrated the existence of Meridian in 1999 [Lo, 2004].

What is *Qi*? Dr. Tiller has explained speculatively in his book. *Qi* (or Chee) stands for subtle energy while *gong* stands for power and, during the meditation, the focus of attention is on the "Den Tien" or "hrara" point in the abdomen about two or three finger widths below the "belly button". *Qi* plays an important role in oriental medicine. An essential aspect concerning the notion of *Qi* involves the human interaction with one's environment. The body is thought to contain a supply of *Qi* that flows throughout the Meridian system and is exchanged with *Qi* in one's surroundings. Thus the good health relates to a balance and unobstructed flow of *Qi* in both inter-body and intra-body. But so far it lacks a modern scientific explanation.

2.2 Description of Meridian System

2.2.1 Twenty Meridians

The Meridian system consists of two sections: twelve principal Meridians, and eight extra Meridians. The twelve principal Meridians are classified into: three *yang* Meridians of the hand, three *yang* Meridians of the foot, three *yin* Meridians of the hand and three *yin* Meridians of the foot. Why are they called "twelve principal Meridians"? It is because these Meridians are the chief pathways of "*qi* and blood." "*Qi*" means vital energy

supporting life in traditional Chinese medicine theory. The twelve principal Meridians start and terminate at given parts, running along regular routes and meet in a specified sequence. They are associated with the *"zang-fu"* organs that are referred to heart, liver, lung, and kidney. There are also eight extra Meridians. These eight extra Meridians interlace in the twelve principal Meridians, helping reinforce the exchange of *Qi* between these eight extra and the twelve principal Meridians. The eight extra Meridians are not directly related to any of the internal organs.

Meridians start from the limbs, run deeper into the body and emerge from the body at the back of the neck. These Meridians have counterparts in both the left and right sides of the body. They are divided into *yang* and *yin* divergent Meridians. What is *yang Meridian* and *yin Meridian*? From Meridian view, the *yang* Meridian means that divergent Meridian traveling along the outside of limbs. The *yin Meridian* means divergent Meridian traveling along the inside of limbs. However, *yang* and *yin* Meridians, after traveling through the body join each other with which they are externally and internally interconnected.

The Channel of Shou-Taiyang

The Channel of Shou-Shaoyang

The Channel of Shou-Yangming

The Channel of Zhu-Shaoyang
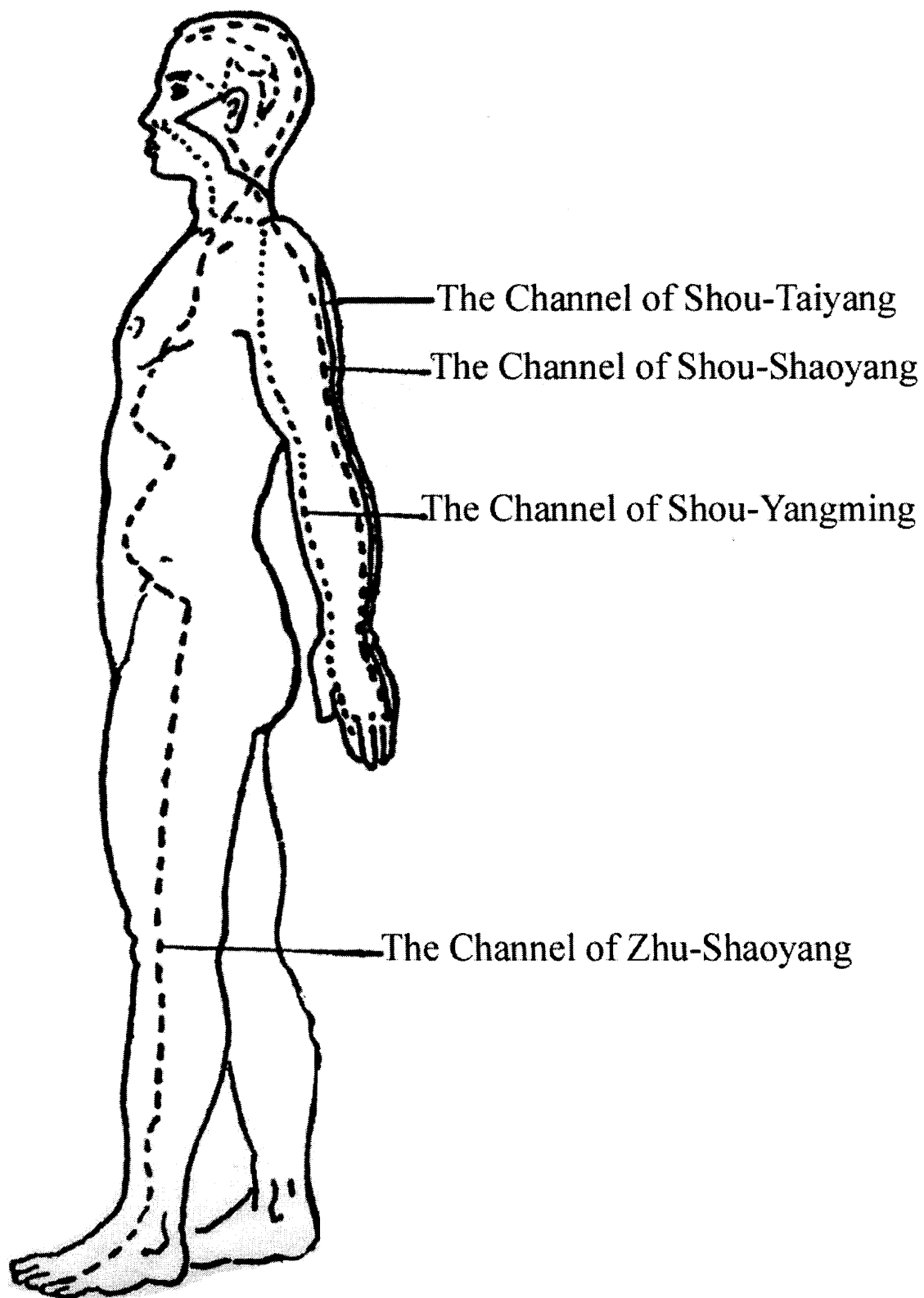
Figure 2. 1 Demonstration of *yang* Meridian of human body [Zhang 1996]

2.2.2 Four Hundred Acupuncture Nodes

World Health Organization finalized the Standard Acupuncture Nomenclature in 1990. The Meridian system consists of about 400 acupuncture nodes [United Nations, 1993]. These four hundred acupuncture nodes along with 20 Meridians consist of a rich array or bio-network inside a human body. It is well known that an electrical resistance of about 50,000 ohms exists between any two acupuncture nodes, while over the same length of normal skin. The equivalent resistance is a factor of about 20 times higher. Most of this resistance is in the outer surface layer of the skin. This resistance changes strongly with the hypnologic state, increasing by a factor of 2-3 during sleep. It is very interesting that only slight histological difference appears to exist between an acupuncture node and its surrounding skin even through the local resistance is reduced by a factor of 10. Acupuncture nodes are situated in surface depressions located along the cleavage planes between two or more muscles [Helms, 1995]. They are not good conductors. Placing small electrodes of different materials on two acupuncture nodes, a voltage difference is developed. For a nickel/silver electrode pair, the potential difference is about 50 mill volts while the current developed is about 1 to 10 microamperes. This current shrinks to almost zero between two skin points that are not acupuncture nodes. Using a ganged-electrode technique, Becker provides conductance maps around several acupuncture nodes and has observed small electrical potential variations along the Meridian channel [Reichmanis, 1975]. This observation provides us with evidences that electrodes at an acupuncture node can generate signals, provided that needles are manipulated (rotated) manually at same speed [Niver, 2008]. Hence, the acupuncture needles in acupuncture nodes can generate signals that are injected into the Meridian.

Meridians have low impedance paths. On normal skin, the impedance is lower at acupuncture node than the neighboring points. Normal skin has impedance of 600 KΩ, and at acupuncture node, it does not exceed 100 KΩ. These are validated by researchers in China, Japan, Korea, and Germany. These low impedance points are mostly located along the Meridian system or within 5mm distance from the Meridians. It is even more interesting to study the effect of electrical signals transmitted through the needle in acupuncture nodes. If one uses ac voltage of a few volts on the needles, observable effects result from signals in frequencies from 1 Hz to 100 Hz. Currently, acupuncturists seldom use frequencies that are much higher than 100 Hz. A normal human impulse might suggest to use a higher frequency, with the idea that the higher frequency may have more enhanced effect, as in the case of transmission of radio signals where one goes from kilo Hertz in the long wave band to mega Hertz in the short wave band. In the transmission of TV signals, the frequency goes even higher. However, for acupuncture to have an effect, one prefers to stay in the low frequency region if effective electrical stimulation is desired. However, this may change if one will go into IR (Infrared) region, using optical laser, or further into microwave millimeter wave region using HF (High Frequency) sources [Sitko, 1992].

In Tiller's book, it was indicated that one can also measure the electrical resistance between symmetrical points on the left and right sides of the body. These points are in the same Meridian channel. The resistance shows variations in the forward direction (R), i.e., from head to feet, and that in the reverse direction (R'). i.e. from feet to head. When a person is healthy with respect to the organs associated with that Meridian, these two resistances are the same (R=R'). However, if pathology is developing in one or

more of these particular organs, R is different from R', i.e. $\Delta R = R - R' \neq 0$. As the degree of pathological advancement increases, $|\Delta R|$ increases. This difference has been termed as the semiconductor effect. It is the electrical correlation of the well-known heat response time difference between acupuncture nodes when pathology is present.

It has also been noticed that, when a serious imbalance exists in the Meridian circuitry, and as an acupuncture needle is placed in the appropriate point, a suction-like force holds the needle in place so that, if one tries to withdraw it, the skin pulls up around the needle and it can not be easily withdrawn. However after the needle has remained in place for a proper length of time so as to bring about a temporary balance to the circuit, the needle can be withdrawn with no effort and skin does not pull up around the needle. This sanction force is due to an osmotic pressure difference, ΔP between the points. It is proportional to ΔR. For the pathological condition, an electrostatic potential difference, $\Delta \emptyset$, is also noticed among the points. Because the connective tissues are thermoelectric [Motoyama, 1977], the application of heat leads to electric current flow and associated electrical potential changes.

Oriental medicine is a systems science in which it looks at the relationships among all different parts of the body. The body is evaluated as being in harmony or not. Meridians are the fundamental system of the body, governing the whole system. The channels and collaterals of Meridians connect the entirety of the body, such that a needle insertion at one acupuncture node can affect an area distant from the needle.

So far we have a brief idea of the Meridian system. Actually, there are collaterals that are smaller and subsidiary to the main Meridian system. There are capillaries that are even smaller than collaterals. This is similar to the blood circulatory system, which has

main arteries, ordinary blood vessels, and capillaries. This network of Meridian systems covers the whole body, and is able to transmit signals from any acupuncture node to internal organs or tissues that are coupled with such signals.

2.3 *Qi* and Meridian System

The word *Qi* means vitality, energy, and life force. Chinese and many oriental people believe that the primary function of *Qi* is a spontaneous balancing and enhancing of the natural healing resources in a human system. Over thousands of years, millions of people have benefited from these practices believing that improving the function of *Qi* maintains good health and heals disease.

One can assume that *Qi* is the equivalent electromagnetic (EM) wave propagating along the Meridian systems. At the acupuncture node, if the injected current assumed to propagate along the Meridian, then the equivalent electric circuit could be modeled as a transmission line [Yung, 2004].
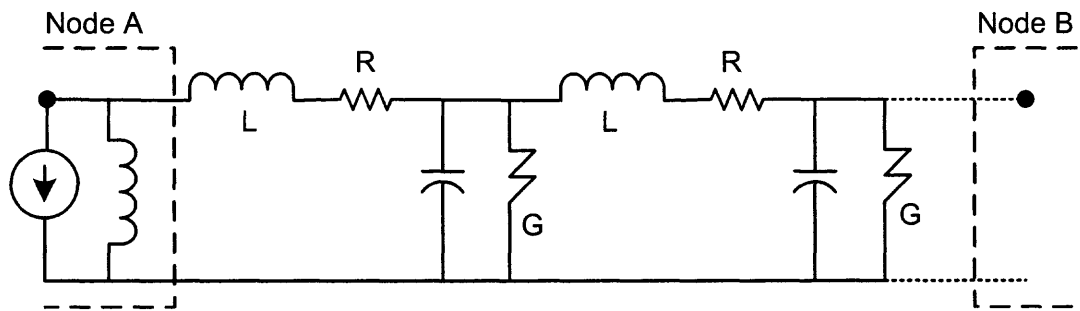
Figure 2.2   The equivalent lossy transmission line model for a path along the
Acupuncture Meridian, i.e. between nodes A and B.

R is the resistive loss per unit length along the path, L is the inductance per unit length due to flow of the current which stores magnetic energy along the path,   C is the

capacitance per unit length to indicate the storage of the electric energy and G is the conductance per unit length to incorporate leakage However, experimental evidence [Tiller, 2003] suggests that this line approach is not reciprocal, which can be attributed to presence of nonlinearity of the environment, which complicates modeling further. This will necessitate a model where all mentioned components will be nonlinear. The mechanism of *bu* (gaining *Qi*), and *xie* (distributing *Qi*) are equivalent charging or discharging the capacitor (or inductor) to bring the capacitive (or inductive) behavior of the segment back to that of the original state.

This research presents that the Meridian system is a good carrier to transfer low frequency signals. The function of the Meridian system is to maintain the free channels so that the signals, *Qi* and blood can travel all over the body freely. In general the acupuncture treatment is by inserting hair-thin needles into certain acupuncture nodes in the Meridian system to generate, or inject certain signals. The generated or injected signals are passed to the blocked channels, restore or regulate the functions of the target organs.

One possible mechanism of injecting signals due to acupuncture needle is suggested as outlined below [Niver, 2008].

Acupuncture needle subjected to manual manipulation can be viewed as an equivalent Faraday disk generator [Cheng, 1992] placed in the presence of the Earth magnetic field.

It is assumed that a needle is subject to angular rotation due to the hand manipulation of an acupuncturist. As shown in Figure 2.3,

$$\overline{\omega} = \omega_0 \, \hat{z}$$
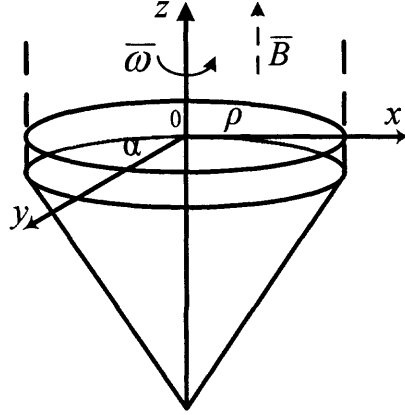
Figure 2.3   Geometry of the acupuncture needle in the
Earth's magnetic field $\overline{B} = B_0\hat{z}$.

where ω_0 is number of angular rotations per minute of an acupuncture needle.

z is vertical coordinate along the axis of the needle. Then any point ρ within the

needle can be expressed with a position vector $\overline{r}$ from the axis as:

$$\overline{r} = \rho\,\hat{\rho}$$

where ρ is the radial variable. The linear velocity at any point can then be

described as:

$$\overline{v} = \overline{\omega} \times \overline{r} = \omega_0\hat{z} \times \rho\,\hat{\rho} = \omega_0\rho\hat{\phi}$$

When an electron of charge (q_e) =-1.602x10^{-19} [C], moves with a velocity $\overline{v}$

in the presence of the magnetic fields $\overline{B}$, it experiences the Lorentz force.

$$\overline{F} = q_e\,\overline{v} \times \overline{b} = q_e\,\omega_0\rho\hat{\phi} \times \hat{z}b_0$$
$$= q_e\,\omega_0\rho B_0\hat{\rho}$$

where B_0 is the strength of earth magnetic field. The induced voltage between the axis and the perimeter of the needle can then be expressed as

$$v_{0a} = -\int_a^0 \overline{E} \cdot d\overline{l} = -\int_a^0 \omega_0 \rho b_0 d\rho = \omega_0 b_0 \frac{\rho^2}{2}$$

Considering relatively slow manual manipulation of the needle, i.e., ω_0 is 5 revolutions per minutes: $\omega_0 = 5/60$ rev/sec, we have the induced potential for a needle of a diameter of 0.28mm as follows:

$$v_0 = +\frac{5}{60} \cdot 10^{-4} \cdot \left(\frac{0.28 \times 10^{-3}}{2}\right)^2 = 0.16 \quad [\text{pV}]$$

Since the sharp edge of the needle causes accumulation of negative charges, the work function of the electron is very low and as a result electrons tend to migrate from the tip of the needle in the form of an electrical current. Reverse manipulation is also valid, resulting in the injection of the electric current with reverse polarity.

In clinical practice, selecting acupuncture nodes along the route of channels is important. In addition, we find that many traditional Chinese medicine doctors prefer to select acupuncture nodes distant from disorder organs. This is because longer distance between an acupuncture node and the disorder area can reduce the effect of distortion in the neighboring nodes.

In order to model this Meridian system, let us take a close look at the Meridian system. The acupuncture nodes of the Meridian system can be classified into two categories:
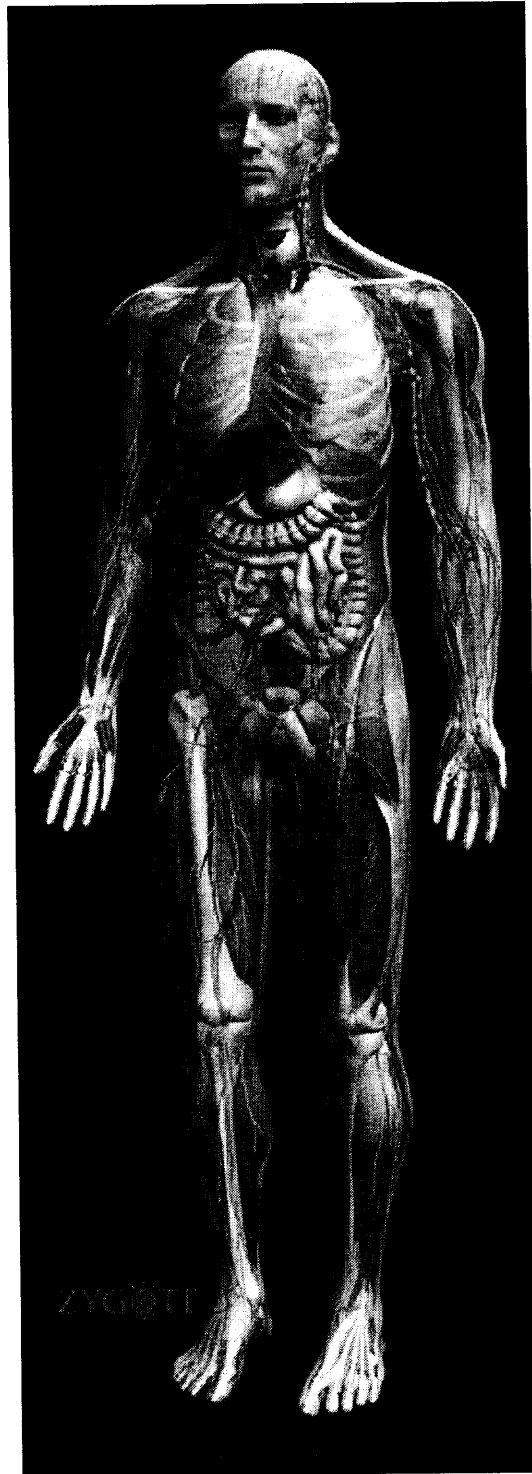
Figure 2.4 Demonstration of a nerve system of human body [ZYG 2003]

Category 1:

12 regular channels are the major trunks of the Meridian system.

- *Shoutaiyin* (手太阴)

- *Shouyangming* (手阳明)

- *Zuyangming* (足阳明)

- *Zutaiyin* (足太阴)

- *Shoushaoyin* (手少阴)

- *Shoutaiyang* (手太阳)

- *Zushaoyin* (足少阴)

- *Zutaiyang* (足太阳)

- *Shoujueyin* (手蕨阴)

- *Shoushaoyang* (手少阳)

- *Zushaoyang* (足少阳)

- *Zujueyin* (足蕨阴)

Note that the original Chinese names in Chinese are given in parentheses.

Each of these Meridians forms a path in a macro network. It has its own route and different number of acupuncture nodes.
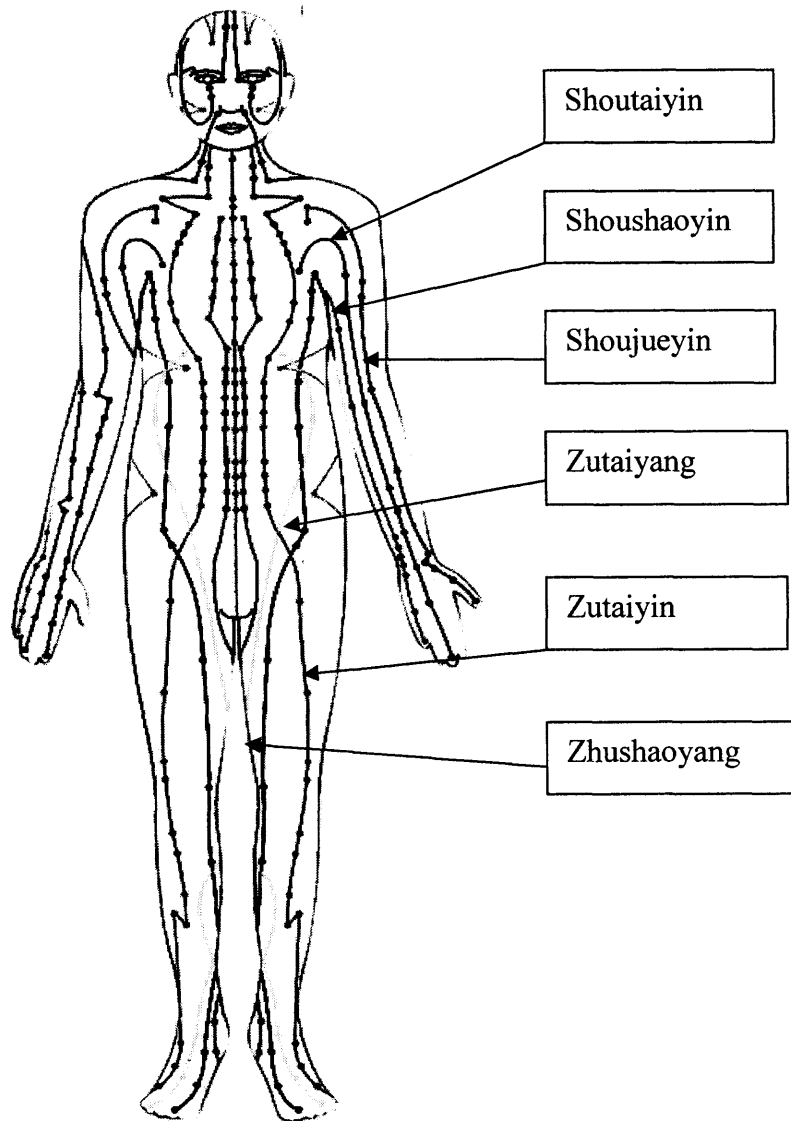
Figure 2.5 The demonstration of a human Meridian system
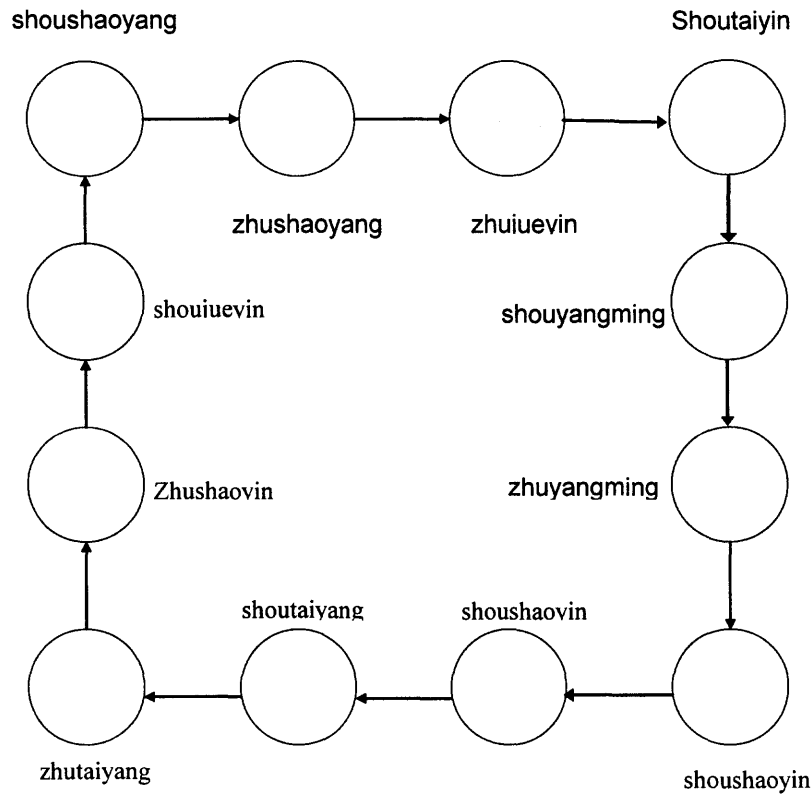
Figure 2.6 Basic model of 12 Meridians connected in a loop network.

Based on each Meridian's starting point, termination points, connecting point with other Meridians, one can lay out a basic network model as shown in Figure 2.6. Each node represents a macro network.

Category 2:

The 8 extra Meridians are:

- *Dumai* (督脉)

- *Renmai* (任脉)

- *Chongmai* (冲脉)

- *Daimai* (带脉)

- *Yinqiaomai* (阴跷脉)

- *Yangqiaomai* (阳跷脉)

- *Yinweimai* (阴维脉)

- *Yangweimai* (阳维脉)

Those eight extra Meridians have their unique courses. The function of these Meridians is to help reinforce the linkage between them and the twelve principal Meridians, strengthening the association among the twelve regular channels. *Dumai* and *Renmai* are most important two among extra eight Meridians. *Renmai* travels at the front side of the human body, and *Dumai* travels along the back side of human body.

Among all 400 acupuncture nodes, they are divided into three degrees of priority:

1. Acupuncture nodes of the 14 Meridians. Also known as the regular points, they are along the twelve Meridians, *Dumai* and *Renmai*. As the major part acupuncture nodes, they have their unique names, locations and pertaining channels.

2. Extraordinary points. Those are points with regular names and regular locations. But they are not along the 14 Meridians. These points are especially effective in the treatment of certain diseases.

3. Ashi points. They are also known as tender spots. These points have no specific names and definite locations. These points and other sensitive points are used for needling.

CHAPTER 3

EXPERIMENTAL INVESTIGATION OF ACUPUNCTURE NODES

3.1   Introduction

Acupuncture nodes have played very important role in acupuncture therapy. Electrical properties of acupuncture nodes have been studied since 1950s [Jeh, 1958, Rosendal, 1943, Nakatani, 1956, Noordergraaf, 1973]. Studies show that acupuncture nodes have lower electrical resistance than their surrounding tissues [Reichmanis *et al*, 1975; McCarrrol and Rowley, 1979; Spinelli, *et al*, 2006; Degen and Loeliger, 2007; Park *et al*, 2007; Kim *et al*, 2007]. People have developed many methods to measure the electrical properties of acupuncture nodes. The measurements are performed by using direct current measurements or polarized electrodes [Chen, 1996; Johng *et al* 2002; Fukumoto *et al*, 2001]. Measurements of skin impedance are necessary for detailed analysis of electrical properties of the skin.

Many researchers who work on acupuncture nodes conclude that an acupuncture node behaves as a resistor. Some of them think that these points can been simply treated as electrical conductance [Tiller, 2003]. However, the most important concern is that all those researches have investigated only skin around the acupuncture nodes on the surface, but not acupuncture nodes within the specific depth. The significance and detail of the singular electrical properties of acupuncture nodes are unknown at present. More careful consideration of electrical properties of the acupuncture nodes and reliable measurement are needed. In order to improve the reliability of measurements and to reveal the electrical properties of acupuncture nodes and Meridian system comprehensively, a new experimental protocol is formulated in this thesis.

One goal of this experiment is to clarify the electrical properties of acupuncture nodes themselves, but not the skin around them, considering that a needle is inserted to a certain depth. A new measurement method and conditions to collect reliable data are presented. This experiment for the first time presents the voltage response of acupuncture nodes at different frequencies from 10 to 80 Hz.

3.2 Experimental Method

The experiments are guided by a clinical medical doctor, and an acupuncturist. The six measurement locations are chosen at corresponding six points. Three of them are acupuncture nodes, i.e., *Quchi* (L11), *Hegu* (L14), and *Shoushanli* (L10), and they are located on *Shoushaoyang* Meridian at the right arm, as shown in Figure 3.1. The other three points are non-acupuncture nodes, which are about 20mm away from their respective acupuncture nodes. Six normal steel stainless acupuncture needles with a diameter of 0.15 mm, as used by most acupuncturists are used at these six points. Three tests (Test #1, Test #2 and Test #3) are designed based on Figure 3.1. These three acupuncture nodes compose a simple network. The input and output response of electrical properties of each acupuncture node is studied.

The schematic of Test #1 is shown in Figure 3.2. In this test, the input signal from *Quchi* (L11) and *Hague* (L14) is applied. Then the voltage and frequency responses of two acupuncture nodes are measured. The input source is a frequency generator (LFG-1300 made by Leader Electronics), which can generate 0-200 Hz, 0-5V sine wave signal; the detector is a multi-meter (Triplett M90151). Three acupuncture needles are inserted into Quchi (L11), Shousanli (L10), Hegu (L14), respectively as shown in Figure 3.2. The input signals are added on Quchi (L11) and Hegu (L14), and the voltage amplitude is set

as 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, and 1000 mV, and for

each voltage the frequency is set as 10, 20, 30, 40, 50, 60, and 80 Hz.
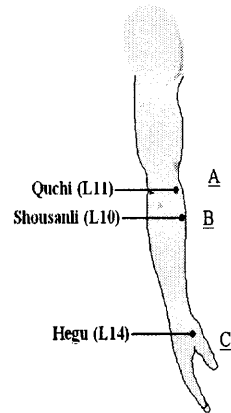
Figure 3.1 Three acupuncture nodes in right arm. Quchi (L11), Shoushanli (L10) and
Hegu (L14).
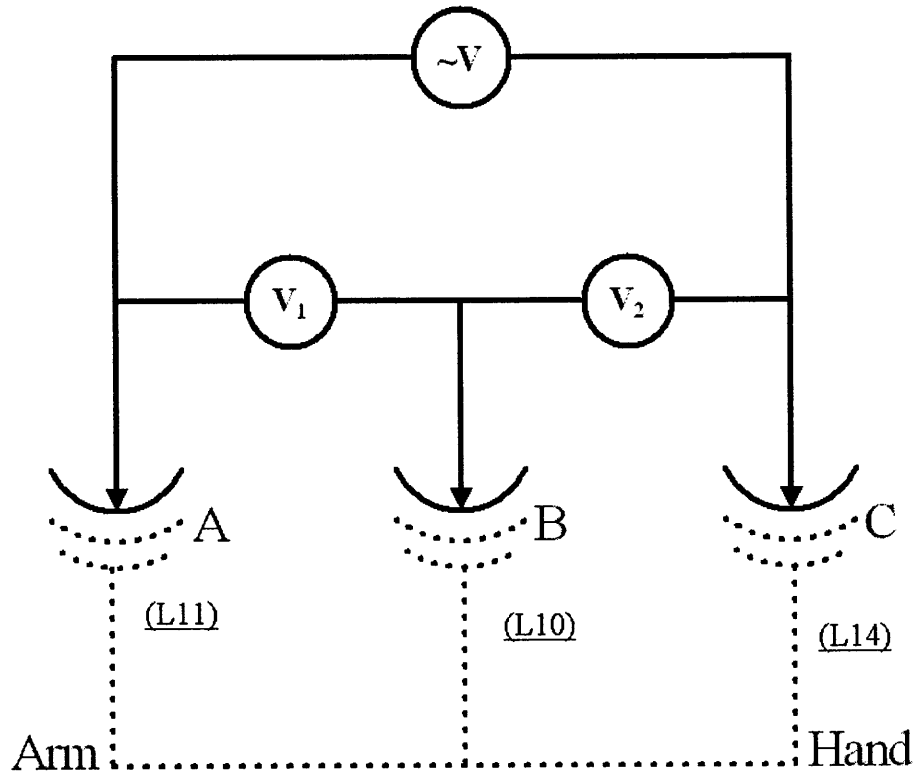
Figure 3.2 Tests #1. V_1 is voltages between Quchi (L11) and Shousanli (L10), and V_2 is
voltage between Shousanli (L10) and Hegu (L14).

Output voltages V_1 between Quchi (L11) and Shousanli (L10), and V_2 between Hegu (L14) and Shousanli (L10) are measured versus variations in frequency and input voltage amplitude.

The schematic of test #2 is shown in Figure 3.4(a). Input voltage V is added between Quchi (L11) and Shousanli (L10). The output voltage V_3 is measured between Shousanli (L10) and Hegu (L14). The input voltage is set as 200mV, 300mV, 400mV, 500mV, 600mV, 700mV, 800mV, 900mV and 1000mV, and for each voltage the frequency is set as 20Hz, 30Hz, 40Hz, 50Hz, 60Hz, 70Hz and 80Hz. Test #3 has the same voltage setting as that of test #2, and the schematic is presented in Figure 3.3(b). Input voltage V is added between Shousanli (L10) and Hegu (L14). The output voltage V_4 is measured between Quchi (L11) and Shousanli (L10).
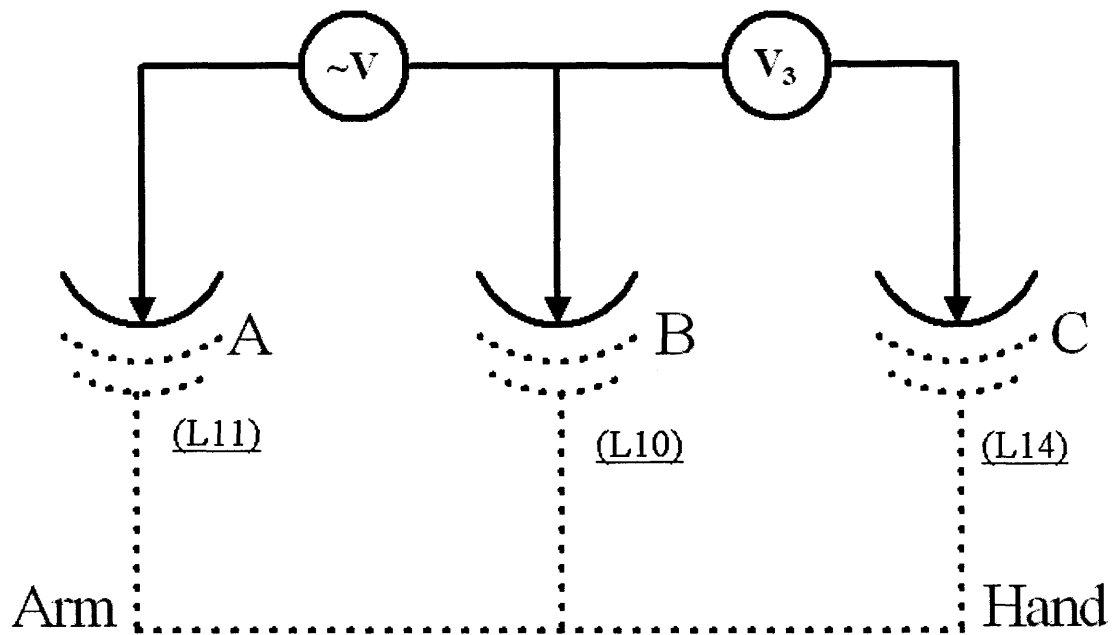
(a)
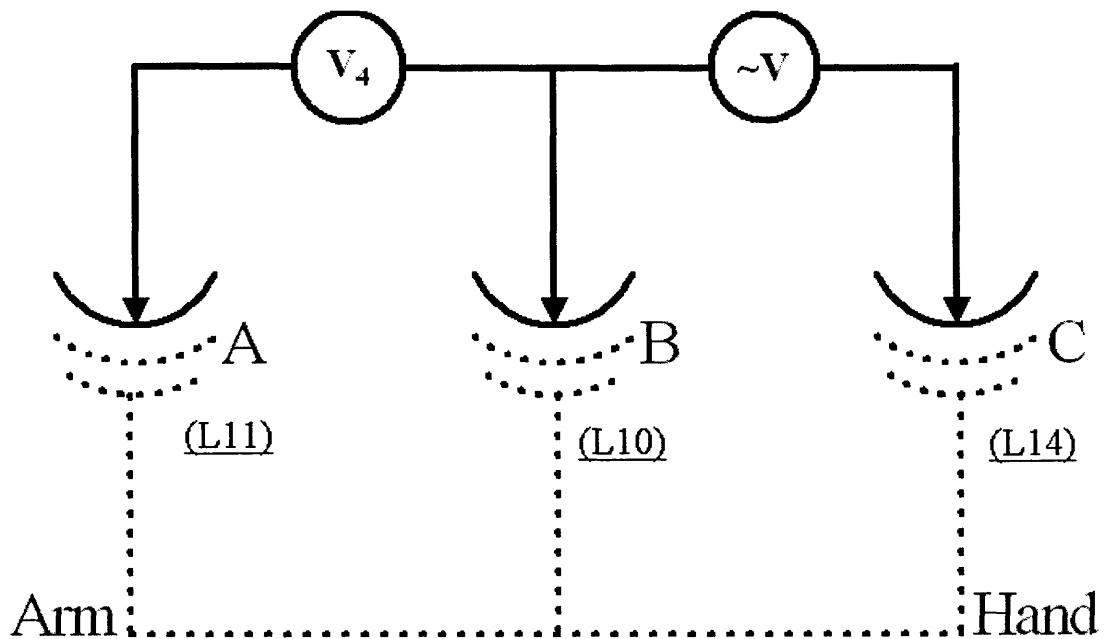
(b)

Figure 3.3 The schematics of (a) test #2 and (b) test #3. A is Quchi (L11), B is Shousanli (L10), and C is Hegu (L14). V_3 is voltage between Hegu (L14) and Shousanli (L10), and V_4 is voltage between Quchi (L11) and Shousanli (L10).

3.3   Experimental Results

Figure 3.4 presents the output voltage V_1 that is higher than output voltage V_2, and the output voltage changes linearly with the input voltage at a fixed frequency. But the summation of V_1 and V_2 is equal to input voltage. From results it is evident that $V_2 > V_1$ due to the relative lossy path lengths L2>L1.

Figure 3.5 presents results of test #2 and test #3. That the output voltages V_3 and V_4 are linear with input voltage V at the same frequency. But the output voltage between Quchi (L11) and Shousanli (L10) is higher than output voltage between Shousanli (L10) and Hegu (L14) in all measured frequencies between 20-80 Hz. Similar conclusion that the voltage is directly proportional to the path length holds for all these measurements.
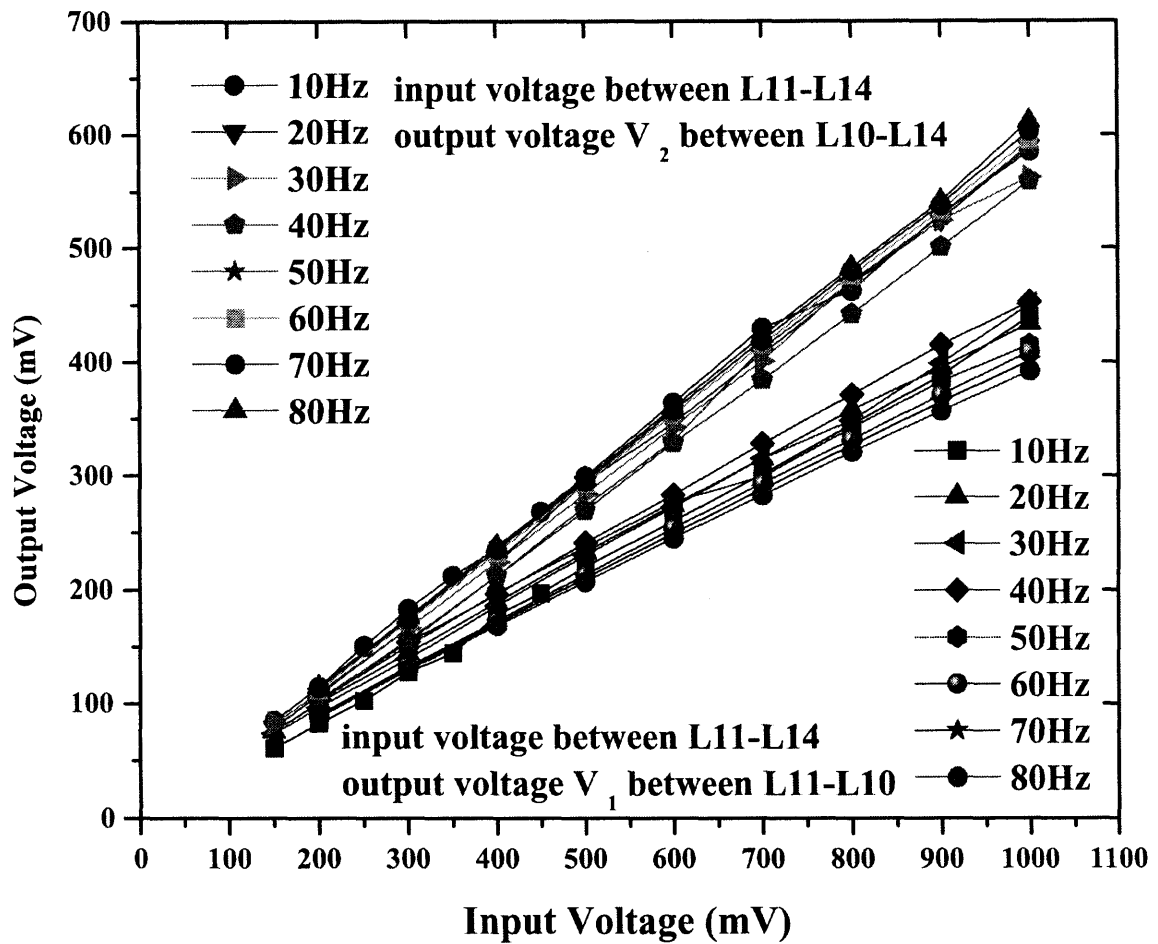
Figure 3.4 Output voltages response to different input voltages at fixed
frequencies.
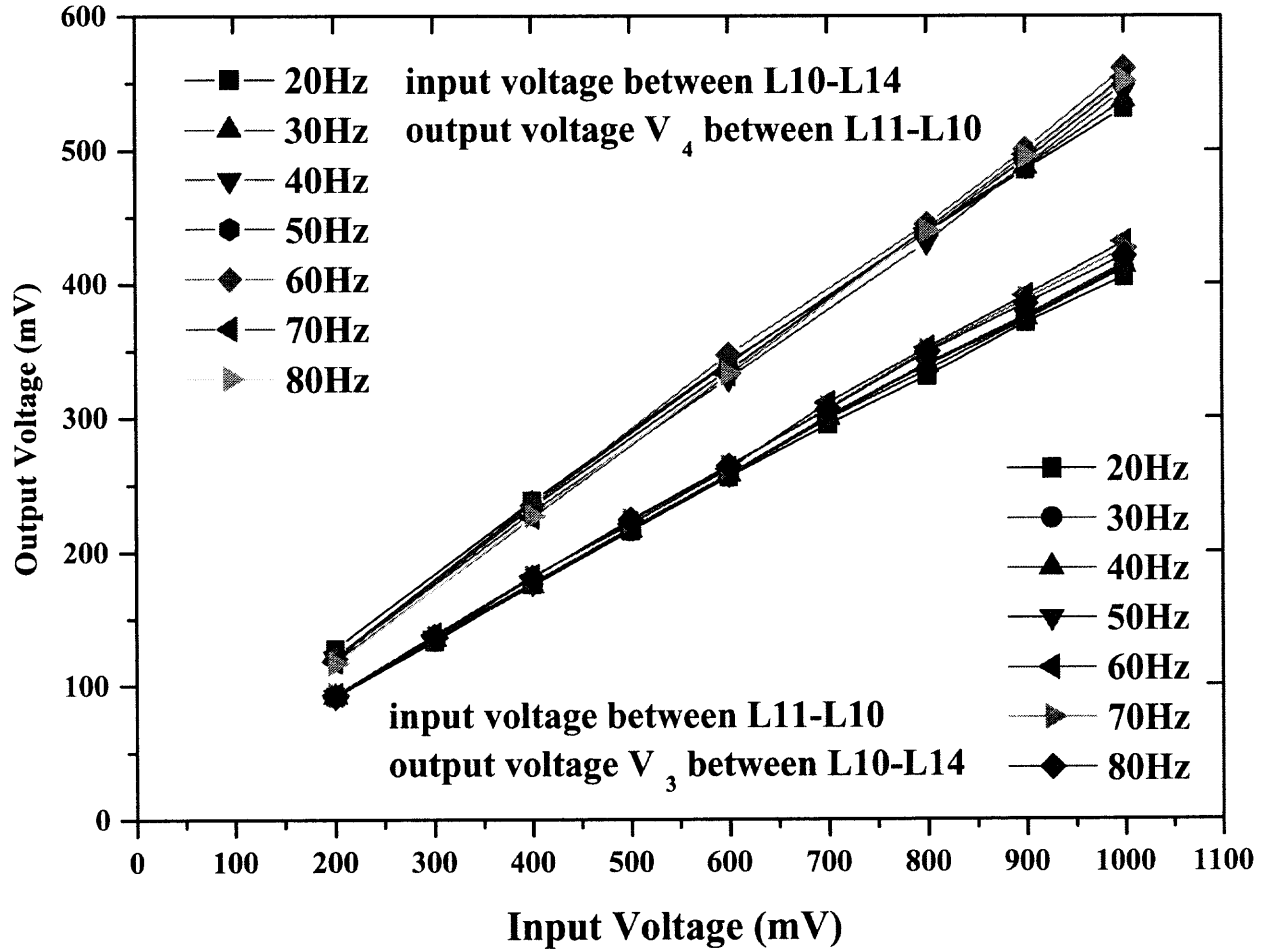
Figure 3.5   Output V_o (L11-L10) vs. input V_i (L10-L14), and output V_o' (L10-L14) vs. input V_i (L11-L10) at fixed frequencies.

3.4 Discussion

Acupuncture therapy has great effect on many medical disorders. Based on NIH

Consensus Panel's statement, acupuncture:

♦ Clearly works to treat a number of conditions, including nausea from chemotherapy,

surgery and pregnancy, and pain after surgery (including dental surgery).

♦ May also be an effective adjunct therapy for a number of other conditions, including

stroke rehabilitation, relieving addictions, headaches, menstrual cramps, and a variety

of muscle pains, carpal tunnel syndrome, tennis elbow, low back pain, osteoarthritis,

and asthma.

But why do acupuncture needles work when they are inserted into right

acupuncture nodes, and how do they work? Brief explanation of the hand manipulated

needle in the presence of Earth's magnetic field based on Faraday disk generator model

suggests that the needle may act as a potential current (or equivalent voltage) source. If

additional source is connected to a needle, it obviously enhances this effect. Connecting a

variable frequency source and observing the measured results have validated our

proposed model. The experiments we performed have presented solid evidence, that

results lead research approach as suggested for further study of the acupuncture system.

The results presented in Figures 3.4 and 3.5 can be described in the equation

following.

$$V_{out} = B(V_{in} - V')$$

where V_{out} is the output voltage between two acupuncture nodes, V_{IN} is the input voltage

between two acupuncture nodes, and B and V' are parameters.

The parameters B and V' of test #1, test #2 and test #3 have been computed and listed in Table 1. In test #1, the biggest B for V_1 is 0.45 at 40 Hz, and the smallest B for V_2 is 0.57 at 40 Hz. The biggest B for output V_3 between LI0-LI4 is 0.42 at 60 Hz in test #2, and the biggest B is 0.543 for output V_4 between LI1-LI0 at 60 Hz in test #3.

Table 3.1   Test result of Test#1, Test#2, Test#3

Frequency (Hz)	Test #1				Test #2		Test #3	
	V_1		V_2					
	B	V'	B	V'	B	V'	B	V'
10	0.44	10	0.58	-6				
20	0.42	-43	0.60	20	0.39	-44	0.50	-67
30	0.43	-22	0.58	9	0.40	-40	0.51	-49
40	0.45	-47	0.57	26	0.40	-36	0.52	-32
50	0.38	-99	0.62	48	0.40	-37	0.53	-33
60	0.40	-33	0.60	14	0.42	-25	0.543	-28
70	0.39	-37	0.61	15	0.418	-29	0.54	-15
80	0.38	-41	0.61	15	0.413	-35	0.54	-17

The output voltage is not constant as the input frequency changes given same input amplitude. In test #1, the output voltages V_1 and V_2 as functions of frequency at input 1000mV are plotted in Figure 3.6. When V_1 gets higher value, V_2 gets lower value. As V_1 gets lower value, V_2 gets higher value. They present a symmetric property at 500 mV output. At 40 Hz V_1 is biggest and V_2 is smallest. The results agree with the results of B.
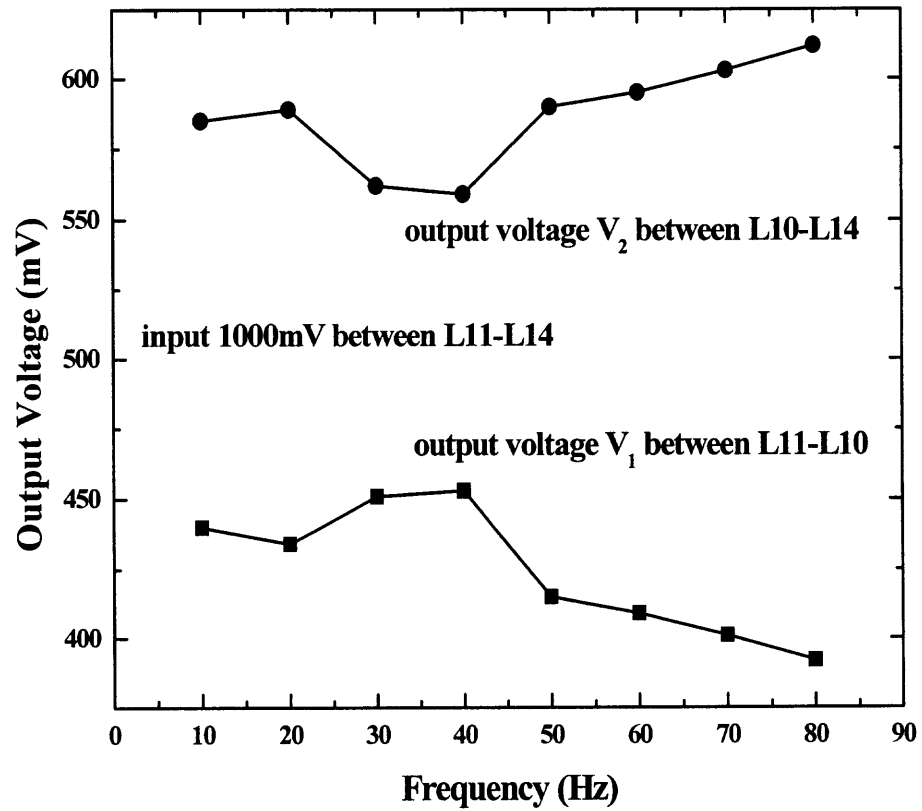
Figure 3.6 Output V_1 and V_2 responses to different frequencies at 1000mV input voltage.
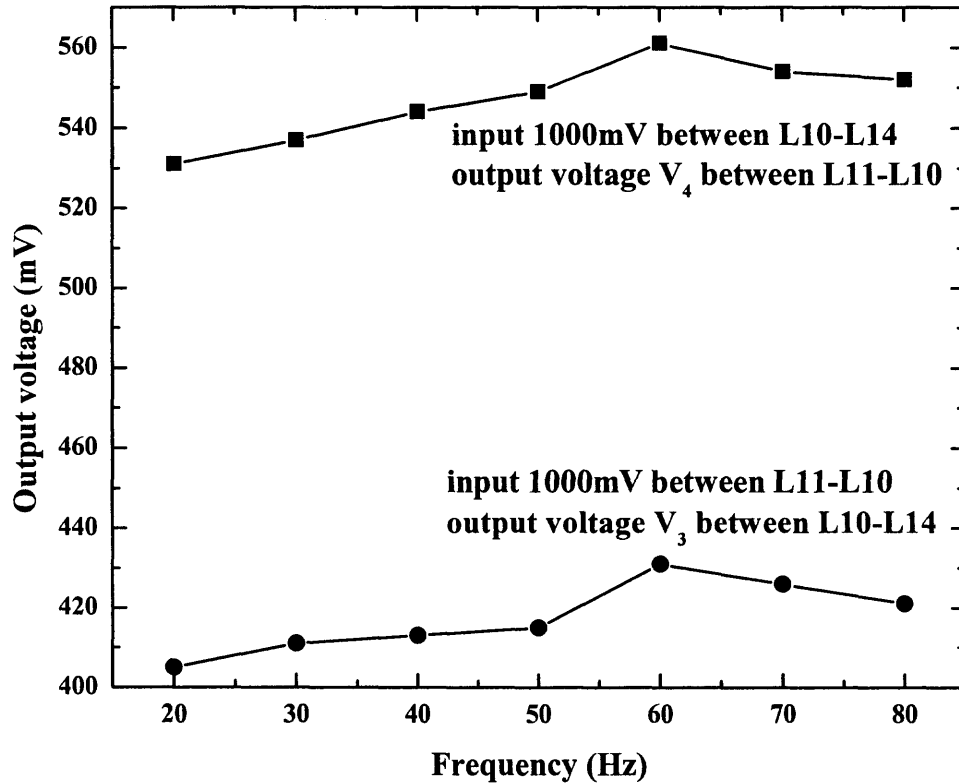
Figure 3.7 Output voltages V_3 and V_4 as functions of frequency at input
1000mV in test #2 and test #3.

Figure 3.7 presents the output voltages V_3 and V_4 as a function of frequency at

input 1000 mV in test #2 and test #3. V_3 and V_4 get their maximum value at 60 Hz. The

results of B shown in Table 1 also get the maximum value at 60 Hz. However, one has to

exercise a caution that at 60 Hz a strong component of atmospheric noise is present and

measures were taken to eliminate it during the measurements.

The corresponding acupuncture paths between two successive nodes exhibit frequency dependant properties from the test results. One electrical equivalent circuit model is suggested to describe properties of an acupuncture node shown in Figure 3.8. In this model two resistors, two inductances and one capacitor are included. The resistors are used to describe the path loss, the inductances are used to describe the magnetic energy along the path, and the capacitor is used to describe the stored electric energy. Therefore, based on this model the equivalent circuit of three tested acupuncture nodes is plotted in Figure 3.9. However, it would be more appropriate to model equivalent resistors as frequency dependent rather than fixed value ones. More detailed studies have to be conducted to achieve more accurate models.
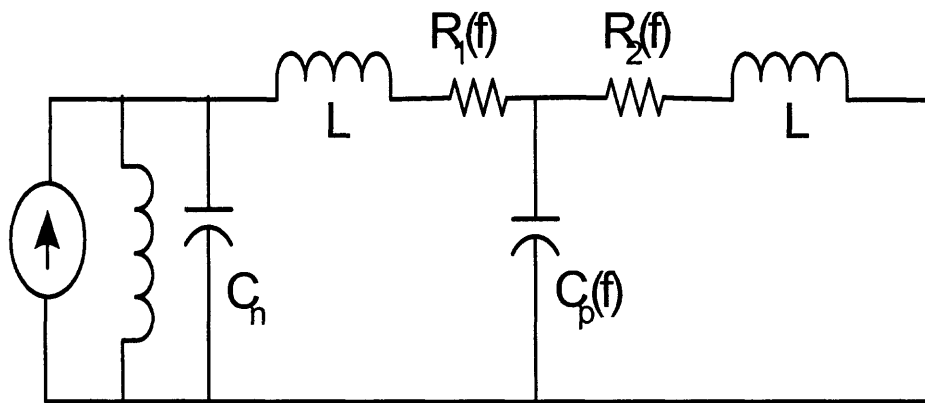
Figure3.8 The electrical equivalent circuit model of an acupuncture node.
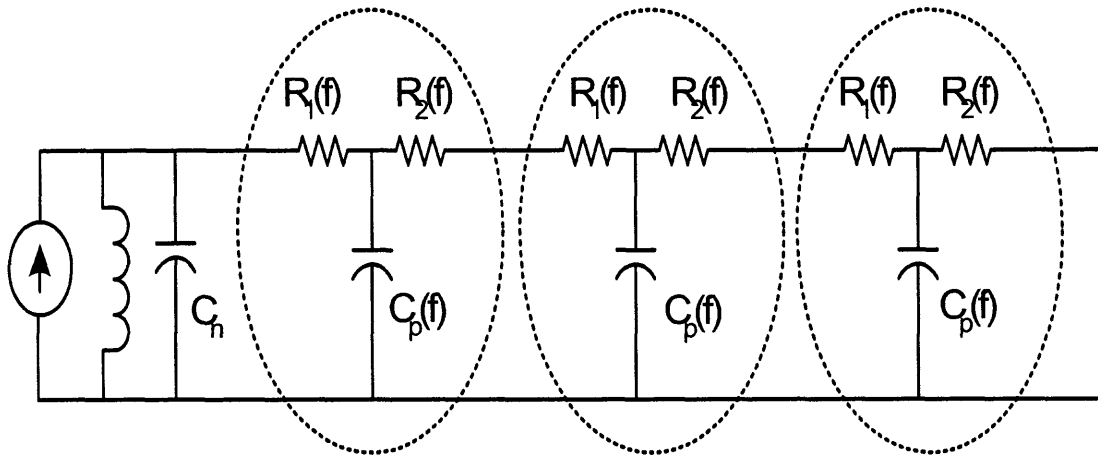
Figure 3.9 The electrical equivalent circuit model of three tested acupuncture nodes.

Here, inductances were omitted, since they can be treated as equivalent short circuits at low frequencies although they are shown in Figure 3.8.

Based on the test results, a hypothesis is that an acupuncture node excited by a needle behaves as a possible current (voltage) source, and frequency variation depends on how fast it is rotated during manual manipulation. Furthermore, an inductor can be inserted into a model due to current transmission. Combined with a capacitor equivalent to induce electric field effects, the whole structure could form an equivalent transmission line. The presence of such line could explain the propagations of some signals along the Meridian of the acupuncture system.

The finite element method (FEM) is used to simulate the electric field in acupuncture node as an acupuncture needle is inserted into the node. In this simulation, one parallel capacitor is used. The capacitor dimension is 3 mm wide, 6 mm deep.

The Comsol Multiphysics software is used. The result is shown in Figure 3.10.
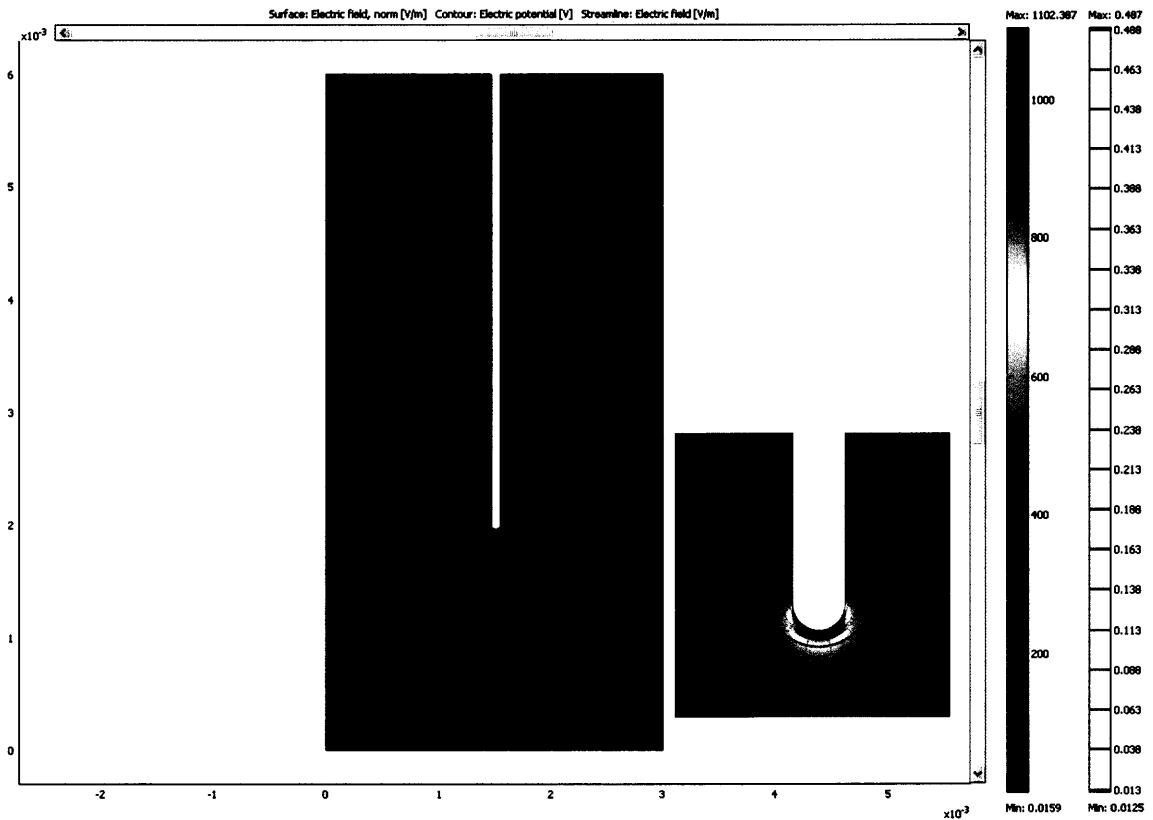
Figure 3.10 The electric field as a needle is inserted into an acupuncture node.

When one consider an acupuncture node, it is necessary to take look at the rearrangement of charge at the molecule level. Most of the molecules in the body are polar molecules. They build up an organized electric field. But as the needle is inserted into the acupuncture node, the needle changes the electric field, and at the tip point of needle the field is very strong. The strong field can force polar molecules to be in order and help reinstall the organized field gradually. As suggested before, the needle behaves as an equivalent current (voltage) source. Also, strong field is proportional to an excessive accumulation of charge at the tip of the needle, which correlates to the presence of strong electric energy density in the vicinity of this tip. Hence, the inclusion of a capacitor in the model becomes natural and usually excessive charge requires inclusion of nonlinear behavior of the capacitance.

CHAPTER 4

WATER MEMORY

4.1 Water Cluster and Clustered Water Wire

Natural snow water, spring rain and dew have been recognized to promote human health for thousands years. Homeopathy, the western traditional medicine, also indicates that ultra-diluted water remembers the bioactivity from naturally occurring substances, such as botanicals, influencing cell signaling. Water is fundamental for virtually all life forms. It is heavier when chilled, lighter when frozen. It absorbs enormous heat but experience very slight rise in temperature. The structure and function of water, especially water in the biological cells, is not clear yet. Dr. Linus Pauling, Nobel Prize laureate indicates that the water molecules in the human body are not present as isolated water molecules or as ice; they are present as liquid water, containing various substances in solution.

We are still largely ignorant about the structure of liquid water and the structure of aqueous solutions in general". In the past years, extensive terahertz laser vibration-rotation-tunneling spectra and mid-IR laser spectra were used for water structure research. As a dipole, water constitutes a series of clusters such as micro-clustered water (e.g., stable hexamer) and macro-clustered water (e.g., icosahedra water or buckey balls) [Liu, 1996; Lorenzen, 2000; Barhour *et al*, 1998; Ludwig, 2001; Mitsui 2002; Miyazaki *et al* 2004; Robertson, 2003]. Water is also a key component of bio-clusters with protein and DNA that form biological hydrogen networks. The Lawrence Berkeley National Laboratory is the first institution to obtain the photo of water hexamers, a particularly stable form of water cluster, using scanning tunneling microscopy [Mitsui, 2002]. Indeed,

there are five isomers of water hexamers: the planar hexamers (cyclic and boat) appear to be more stable than the other three-dimensional hexamers (cage and prism).

Water, being dipolar, can be partly aligned by an electric field, which can be shown by the movement of a stream of water passing an electrostatic source. Water is diamagnetic and may be levitated in magnetic fields. It is also known that resonant intermolecular transfer of vibration energy is possible in liquid water [Bramwell, 1999]. Theoretically, hydrogen-bond connectivity of water molecules could control the progress of ionic translocation in these systems.

All of us know a common etiquette in both eastern and western folklore and cultures, i.e., at a banquet host and guests lift the wine glass together, bless each other, and then they bottom up. A fewer people pay attention to the scientific connotation of this etiquette. But if we use the scientific language to describe this etiquette, we can find a surprising scientific insight: that mankind can input the good wish (information) into each other's body through the aqueous solution including ethanol. Indeed ancient philosophy from both Western and Eastern cultures all believed that water was the source of life and held universal messages. Chinese "Taoist theory" declares that "Heaven creates water and water then creates everything". Taoism also emphasizes that "Heaven creates water and then hides in the water; water and the universe are permeated as a one unit". A wise herbalist Li She Zhen (1518-1593 AD) was the author of the book *Bencao Gangmu* (Great Compendium of Herbs), the ancient Chinese pharmacopoeia. He believed that seasonal natural water, such as rain, snow and dew, contained the universal message to control all of the life-cycle. Greek philosophy also believes that water is the major life

force. Homeopathy was originated from such philosophy. The principle of homeopathy is water memory.

Dr. Jacques Benveniste is a pioneer of modern water memory research. In 1988, he and other 12 scientists from Canada, France, Israel and Italy, published an article in *Nature*, titled as *"Human basophil degranulation triggered by very dilute antiserum against IgE"* [Davenas, 1988]. They claimed that vigorously shaking water solutions of an antibody could evoke a biological response, even when that antibody was diluted out of theoretical existence. However, Benveniste's revolutionary ideas of "water memory" were criticized as heretical or misguided. In 1999, a pan-European team of four independent research laboratories in France, Italy, Belgium, and Holland, led by Professor M. Roberfroid at Belgium's Catholic University of Louvain designed "blinded" experiments. They used a refinement of Benveniste's original experimental model to examine another aspect of basophil activation with "ghost" dilutions of histamine against control solutions of pure water. The results from all four laboratories were positive for the ghost histamine solutions. In the last five years, more and more ultra-diluted water research indicated that certain structured water stored physical, chemical and biological information [Belon *et al,* 1999; Sukul *et al,* 2001; Jonas, 2001; Elia, 1999; Jerman, 1999; Samal, 2001].

Dr. Brian Josephson, Nobel laureate in Physics (1973) gave Benveniste a definitude support. He proposed the argument in *New Scientists* magazine that structured water perhaps had molecular memory [Josephson, 1997]. Later on a group of scientists from Harvard University also proposed a new "atomic memory" theory for application in quantum communication [Van *et al,* 2003]. Clusters are finite aggregates of atoms or

molecules that are bound by forces. They may be metallic, covalent, ionic, hydrogen-bonded or Van der Waals in character and can contain from a few to tens of thousands of atoms. The concept of "cluster memory" is being gradually accepted in the material science area, especially semiconductor clusters that have been the focus of particular attention. Water memory, particularly water cluster memory, is no longer unsubstantiated. New detection technology coupled with ancient philosophy will lead us the correct direction for exploring the scientific evolution of water memory research. It has to be emphasized that water memory mentioned here, implied to a specific molecule or ionic structure.

More and more reports indicate that positive ions, such as protons (H^+), or negative ions, such as hydroxide ions (OH^-) can be transported via the "clustered water wires". The water wire system is a one-dimensional head-tail water chain or a three dimensional hydrogen-bound water networks [Robertson, 2003]. The dipole reorientation and geometry of water molecules in electron tunneling are studied using scanning tunneling microscopy (STM) [Hong, 1998]. Electron transport in Molecular Wire Junctions was also observed [Nitzan, 2003]. An excess proton injected into the water wire is found to be significantly stabilized, relative to the gas phase, due to the high polarize ability of the carbon nanotube [Mann, 2003]. From the viewpoint of electrical engineering, this is due to the mechanism of a biological electromagnetic field. We hypothesize that the clustered water wire network provides a biophysical and biochemical base for understanding the Meridian signaling transduction system.

4.2. Digital Biology as a New Avenue for Bio-Signaling Research

Dr. Benveniste kept his indomitable research moving forward and finally established a new "Digital biology" hypothesis [*http://www.digibio.com*]. He mentioned that the current short range electrostatic theory of molecule interaction-recognition via random collision cannot help us understand how biological reactions really work. The key/keyhole and the structural matching are just cartoonesque descriptions of the exceedingly more sophisticated mechanism that is required to command the extraordinarily complex and rapid cascade of intricate biochemical reactions supporting life. By contrast, the electro-magnetic interactions afforded by the capacity of water to support long range EM fields provide fascinating possibilities for understanding:

1) The specific and rapid long distance attraction of the corresponding unit cells.

2) How the formation of aggregates with appropriate structure initiates the next step in the biochemical sequence;

3) How the steric structure of molecules can be altered or stabilized by subtle changes in their primary composition.

To support his hypothesis, he successfully conducted a series of experiments [Benveniste *et al*, 1999]. In year 2000, *Medical Hypotheses* published a research article titled as "Activation of human neutrophils by electronically transmitted phorbol-myristate acetate" provided by his DigiBio Group [Thomas, 2000]. It is well known that 4-phorbol-12-myristate-13-acetate (PMA) is a phorbol ester tumor promoter, which can induce reactive oxygen metabolites (ROM) in neutrophils. Neutrophils were placed at 37°C on one coil attached to an oscillator, while PMA was placed on another coil at room temperature. The oscillator was then activated for 15 minutes after which cells were

usually further incubated for up to 45 minutes at 37°C before the measurement of ROM production. In twenty blind experiments, PMA thus "transmitted" induced ROM production. ROM was not induced when: 1) PMA vehicle or 4-α-phorbol 12, 13-didecanoate (an inactive PMA analogue) was transmitted; 2) the oscillator was switched off; 3) superoxide dismutase or protein kinase C inhibitors were added to cells before transmission. These results suggest that PMA molecules emit signals that can be transferred to neutrophils by artificial physical means in a manner that seems specific to the source molecules.

Inspired by ancient philosophy and snow-forming process, Dr. Lorenzen developed a patented "Template Induction Processed clustered water" [Lorenzen, 1998; Lorenzen, 2000]. The resulting water is called Clustered Water for Short (CW). The starting water vapor is passed across through a simulated Sun-Earth radiation electric magnetic field, treated by laser, transcribed the chemical and physical signaling, and stabilized in a special ceramic unit, and finally yields micro clustered water (5, 6, and 7 membered rings), which was also called "Cellular resonance water". Shin Etsu Chemical Inc. (Japan) and Associated Laboratories (USA) tested such clustered water and concluded that it was "extremely pure". They used various analysis methods such as atomic absorption, flame photometry analysis, ion chromatography, high pressure liquid chromatography, and gas chromatography analysis. Generally smaller cluster size of water offers much smaller value of ^{17}O- nuclear magnetic resonance (NMR) of water. Table 1 shows a report of different water samples by Tsinghua University and Peking University [Li, 2003]. It indicates that the ^{17}O-NMR of clustered water is very close to natural Glacier water and human plasma. It is very impressive that the NMR study from

Shin Chemical Inc. also showed that the ^{17}O-NMR of CW was comparable to the melting snow water. Different from glacier water and snow water, clustered water is more stable in terms of membered ring structures.

Table 4.1 ^{17}O-NMR assay of different water samples with corresponding shift.

Water sample	^{17}O-NMR (Hz)
Saline	66
Clustered water, CSI, USA	67
#1 China Glacier water	69
Plasma	88
Rain	106
#1 contaminated underground water	122
#2 contaminated underground water	145

According to Laser Raman Spectra studies conducted by Laboratoire Forte Pharma (France) and France Academy of Sciences, an interesting behavior of CW is observed that in all the studied spectral fields (low, intermediate, high frequencies), its intensity of Raman Diffusion is much lower than that of Ultra pure water (UPW, 18.2 M ohms) that is the selected reference. The results are shown in Figure 4.1.

The Results are
derived from
the French
Academy of
Sciences
(27/05/02)
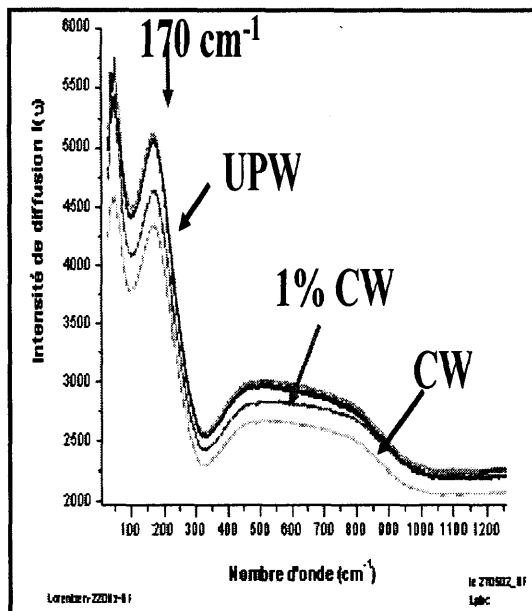
Test Waters

●Ultrapure water
(UPW): 12.8 M ohms

●Clustered water (CW,

◉1% CW: CW diluted
in UPW by 100 folds

●●● Other waters

170 cm⁻¹

UPW

1% CW

CW

Low Frequency (<1200HZ))

1640 cm⁻¹

UPW

1% CW

CW
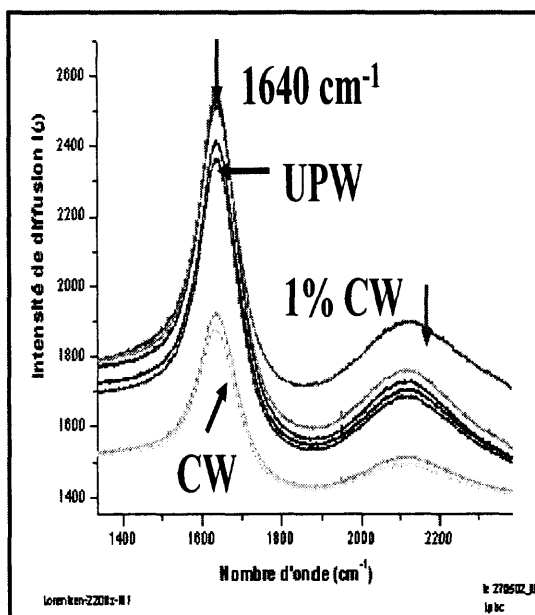
Intermediate Frequency (1400-2200 HZ)

3400 cm⁻¹

1% CW

UPW

CW
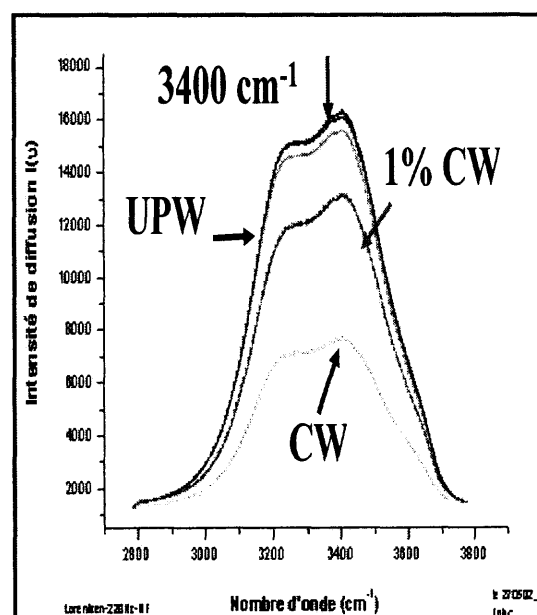
High Frequency (2800-3800 HZ)

Figure 4.1 Laser Raman Spectra study of UPW and CW with their corresponding
normalized Raman shifts.

One observation from these results is that the difference of peaks due to variation of samples can be attributed to their molecular change of the corresponding structures. Note that shifts occur at the same wavelength due to inherence identical composition.

4.3 Crystal Imaging of Clustered Water

The basic form of an ice crystal is a hexagonal prism including "plate-like" and "column-like" ones. However, the snowflakes are six-fold symmetry. In the early 90s, Dr. Lorenzen found that contaminated tap water could form neither cubic crystal nor six-fold snow-like crystal, but good quality spring water did, by using microscopic crystal photos. By cooperating with Masaru Emoto (Japan), he further developed a water crystal photography technology to characterize the "finger print" of his imprinted clustered water. It can be used as quality control of such water.

Individual templated clustered water has a unique, distinctive and symmetric hexagonal crystalline structure as shown in Figure 4.2. Figure 4.2 (A) is first successful crystal water picture taken for such clustered water. It is imprinted with a specific low resonance frequency. Figure 4.2 (B) is clustered water imprinted by yeast lactic acid drink information. This lactic acid is a habitual drink in southern Russia. Note that this area is famous for its many long-life people. Figure 4.2 (C) is distilled water imprinted with resin extract called Cat's claw treated and transcribed by laser. Cat's claw naturally grows in the Andes region of South America.
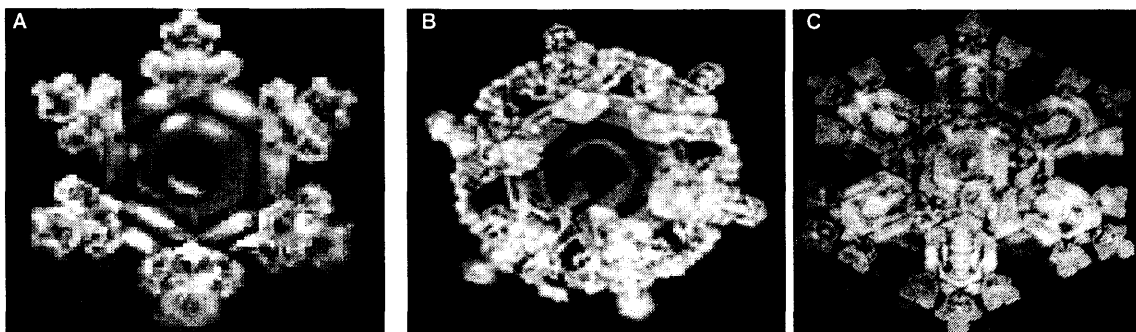
Figure 4.2 Clustered water has a unique, reproducible hexagonal crystalline structure.

Dr. Emoto's group performed additional excellent work and demonstrated that even sound and/or music made changes to the structure of the water crystal. They use a magnetic resonance analysis transcription machine to imprint different essential oil to distilled water, such as chamomile oil; and obtained distinct "finger print" photos [Emoto, 1999].

An *in vitro* isolated rat's jejune culture study was conducted by Dr. Lorenzen at the National Autonomous University School of Medicine in Mexico City to test the possible efficacy of the morphine templated clustered water (CW) and compare with that of 0.5 mg/ml of morphine sulfate (MP) [Pan *et al*, 2004]. Figure 4.3 shown that a small piece of rat's jejune is tied to the bottom of a 10 ml chamber with Ringer buffered solution. The upper edge is tied to the polygraphic arm to record the trace of tissue contractions. Once the basal trace is obtained (7.5 minutes), 0.5 ml or 1.5 ml of Ringer buffer solution is taken out, and 0.5 ml or 1.5 ml of MP or CW, is added into the chambers for another 7.5 minute testing traces. The trace peak value (TPV) of tissue contraction is calculated.

In Experiment 1, after adding 0.5 ml of MP to the chamber, TPV of MP (1.05±0.06 units) is similar to that of the baseline (0.98±0.04 units), indicating no

significant change comparing with baseline. It means that 0.5 ml of morphine has no effect on rat tissue contractions. But after adding 0.5 ml of CW to the chamber, the TPV of CW (0.83±0.12 units) is significantly increased compared with the baseline (0.57±0.09 units); and the p value is less than 0.0001.

In Experiment 2, after adding 1.5ml of MP to the chamber, the TPV of MP (1.23±0.31 units) is significantly increased compared with the baseline 0.48±0.04 units), the p value is less than 0.0001. After adding 1.5 ml of CW to the chamber, the TPV of CW (0.99±0.14 units) is also significantly increased compared with baseline (0.65±0.17), and all the P values are less than 0.0001. These experiments are repeatedly performed at the National Autonomous University of Mexico.

Animal studies conducted at the National Autonomous University School of Medicine in Mexico City and University Rene Descartes in Paris also indicate that the behavior of mice treated with morphine-imprinting CW is dramatically altered compared with the mice with DW. The effects can also be blocked by naloxone, the opioid receptor antagonist. However, HPLC (High Performance Liquid Chromatography) analysis indicates no difference between morphine-imprinting CW and DW. As a conclusion, morphine molecular characteristic signal is imprinted in the clustered water and plays the similar biological function of morphine.

As mentioned before we have found that templated clustered water has different NMR spectrum, laser Raman spectra solubility, surface tension and crystal imaging. However, there is no evidence to identify the distinct frequency in the water directly. In this study Quantum FAFA equipment is used that is based on quantum coherence principle. The quantum coherency effect is achieved by matching the virtual photon and

volt metric signature pattern of reactive substance in the tested target and then watching
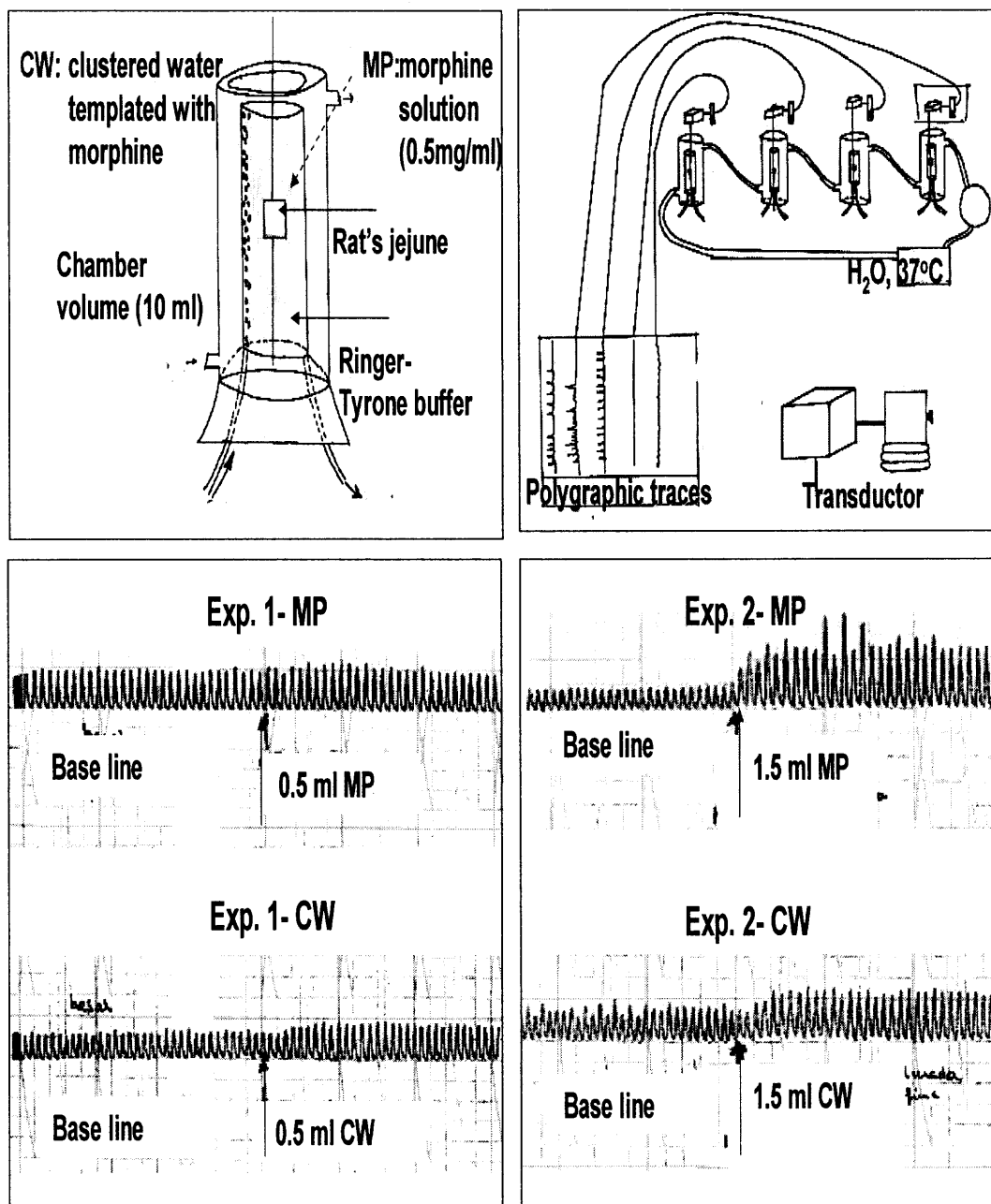
Figure 4.3 Comparative study of morphine and morphine templated clustered water on rat jejune contraction trace.

the volt metric resistance changes that occur in the tested target in response to the item. If there is a coherency, a reactive positive or negative pattern can be induced.

At first we compare the difference between distilled water (DW) and clustered water (CW). As shown in Figure. 4.4, it is clear that the frequency valley of CW is significantly different from DW's, especially in the range between 3500Hz and 3628 Hz.

In order to find out whether the clustered water is able to store frequency information, we divide CW into two parts. One part clustered water is imprinted with an additional frequency signal, and another part not, but used as reference water. Then we utilize Quantum FAFA analysis equipment to scan both parts. The result shows that several new frequency peaks (1740-1885 HZ) are detected in the new imprinted clustered water sample compared with non-imprinted clustered water as shown in Figure 4.5.

According to the preliminary experiments, Clustered water may be able to exhibit certain resonance frequency information, due to observed shifts in the measurement system.

"Water memory" is the key foundation for a clustered water-wire bio-signaling network. This work provides more experimental evidences to support the hypothesis that clustered water has certain distinct resonance properties. PMA and morphine molecular signaling can be transcribed to certain structured water, such as clustered water. Microscope imaging analysis and quantum resonance frequency assay technology represents a more practical way to identify and characterize the "finger print" of individual templated clustered waters [Wang et al, 2004].
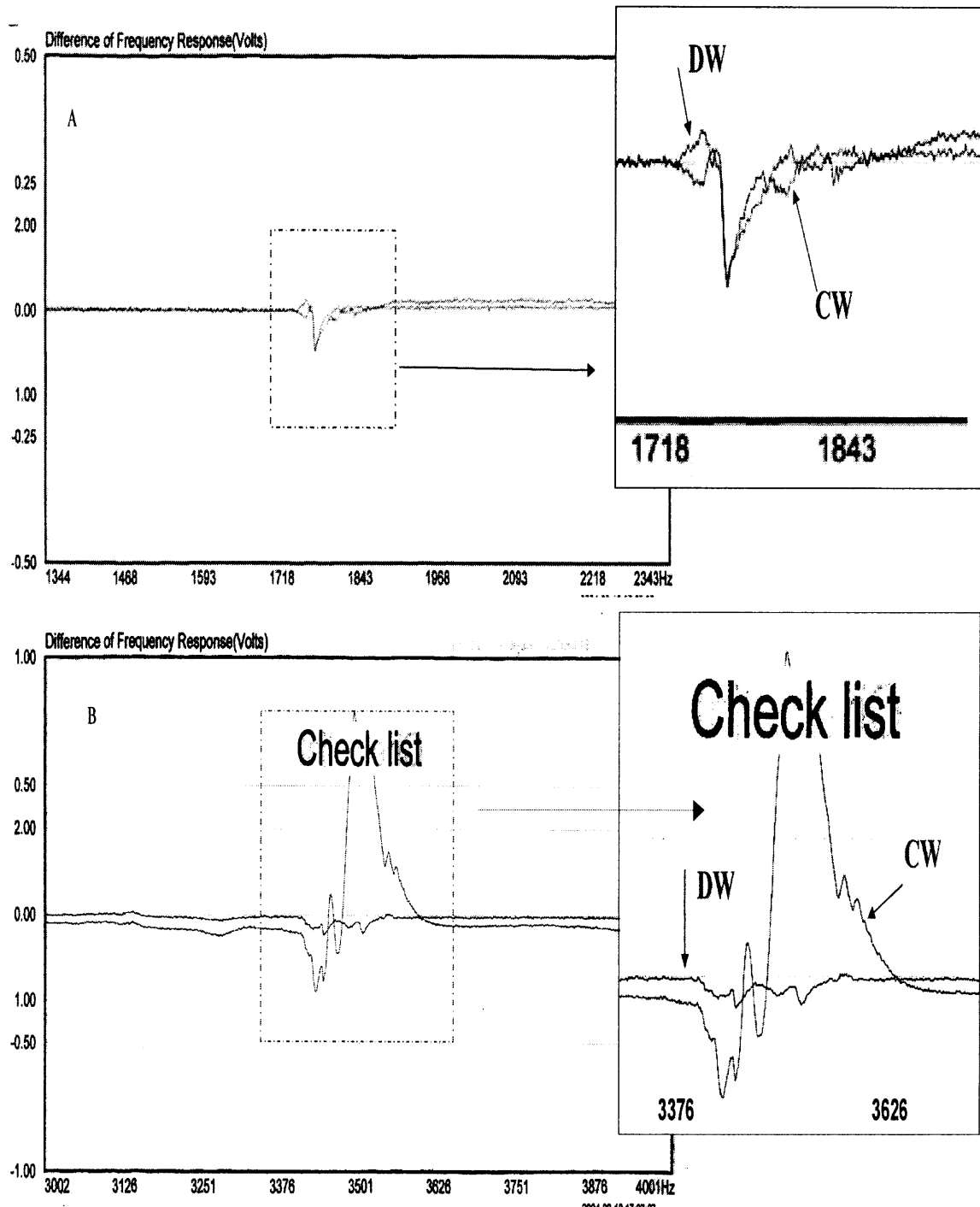
Figure 4.4 The resonance frequency valley of CW and DW.
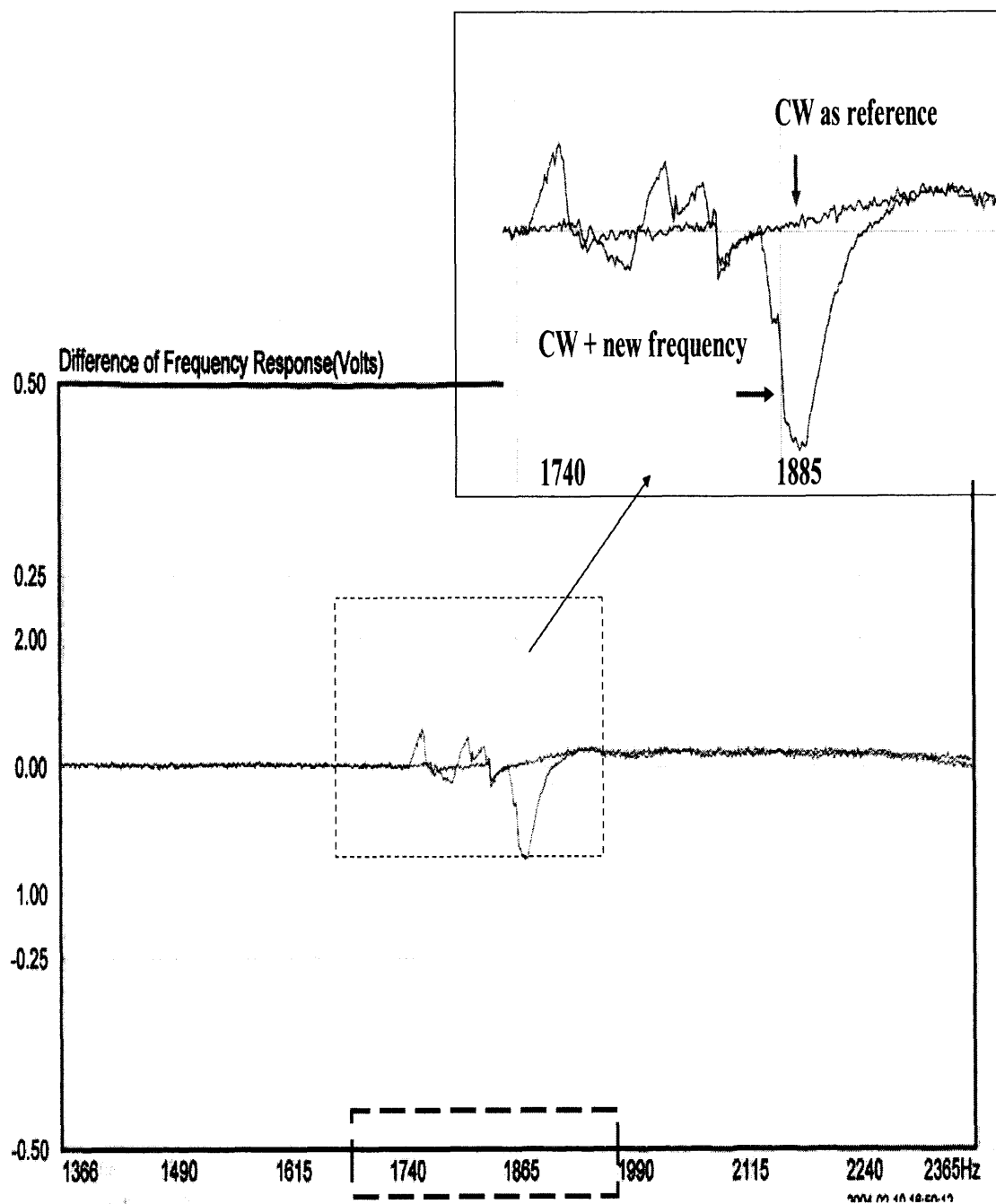
Figure 4.5 The resonance frequency valley of new imprinting CW compared with non-imprinted CW.

The mechanism of "water memory" and "molecular imprinting" are not clear yet. More and more hypotheses were proposed recently. One explanation is based on philosophical concepts. The ancient Chinese wisdom believed in the existence of the "intelligence universe" or that "intelligence is stored in everything". Of course, intelligence could be stored in water. Professor Gary Schwartz, the former Director of the Psychophysiology Center at Yale University, established a "Universal Living Memory theory" in 1990's. He demonstrated that from the subatomic to the cosmic, to the cells, all dynamic systems have memory, including water [Schwartz, 1999].

Dr. Wayne B. Jonas was a former director of the NIH Office of Alternative Medicine (OAM). He referred to the mechanisms of water memory in his book [Jonas, 1996], invoking such terms as coherence patterns, clathrate formation, isotopic self-organization, electrodynamic polarization fields, biophotons, chaos theory, and the collapse of quantum potentials. A mathematical model was proposed recently. It explains why the drug does not become non-molecular even in ultra-high dilution [Chattopadhyay, 2003]. This is due to loss of homogeneity in the solution, caused by the increase of dielectric constant of the medium during the process of potentization. Facilitated binding of the drug molecules with minute physiologically important protein factors may be the cause of visible physiological alterations.

Water, being dipolar, can be partly aligned by an electric-magnetic field, which can be shown by the movement of a stream of water past an electrostatic source. Theoretically, hydrogen-bond connectivity of water molecules could control the progress of ionic translocation in these systems. Proton-motive force (proton pump) is well-known to play an important role in the cell-to-cell communication. More and more reports

indicate that protons (H^+) can be transported via the "clustered water wires" [Mayer, 1992, Godoy, 2001, Chou, 2004; Woutersen, 1999; Tuckerman, 2002, Pomes and Roux 2002]. The water wire system may be a one-dimensional head-tail water chain or a three dimensional hydrogen-bound water networks. Cambridge University researchers provide a protonated water cluster database based on computer simulation [The Cambridge Cluster Database]. Figure 3.6 shows 4 typical protonated clustered water.

In May 2004, two breakthrough discoveries were published in *Science* that infrared spectroscopic signature was probed to approve nanoscale cages of protonated water clusters formation. The work was carried out by independent groups at Tohoku University, Yale University, University of Georgia and University of Pittsburgh [Shin *et al*, 2004; Miyazaki *et al*, 2004]. Data from their studies are remarkably consistent. They suggest that water clusters are chain structures at small sizes, two-dimensional nets at intermediate sizes, and cages at large sizes (such as 21 molecules).

Protonated water clusters with this magic number of water molecules are unusually stable. For investigating the structure, electronic properties, and proton conductivity of water confined inside single-walled carbon nanotubes, an excess proton injected into the water wire is found to be significantly stabilized, relative to the gas phase, due to the high polarizability of the carbon nanotube [Mann, 2003]. These discoveries can further help one establish the relationship between the Meridian system and cluster water wire signaling network.
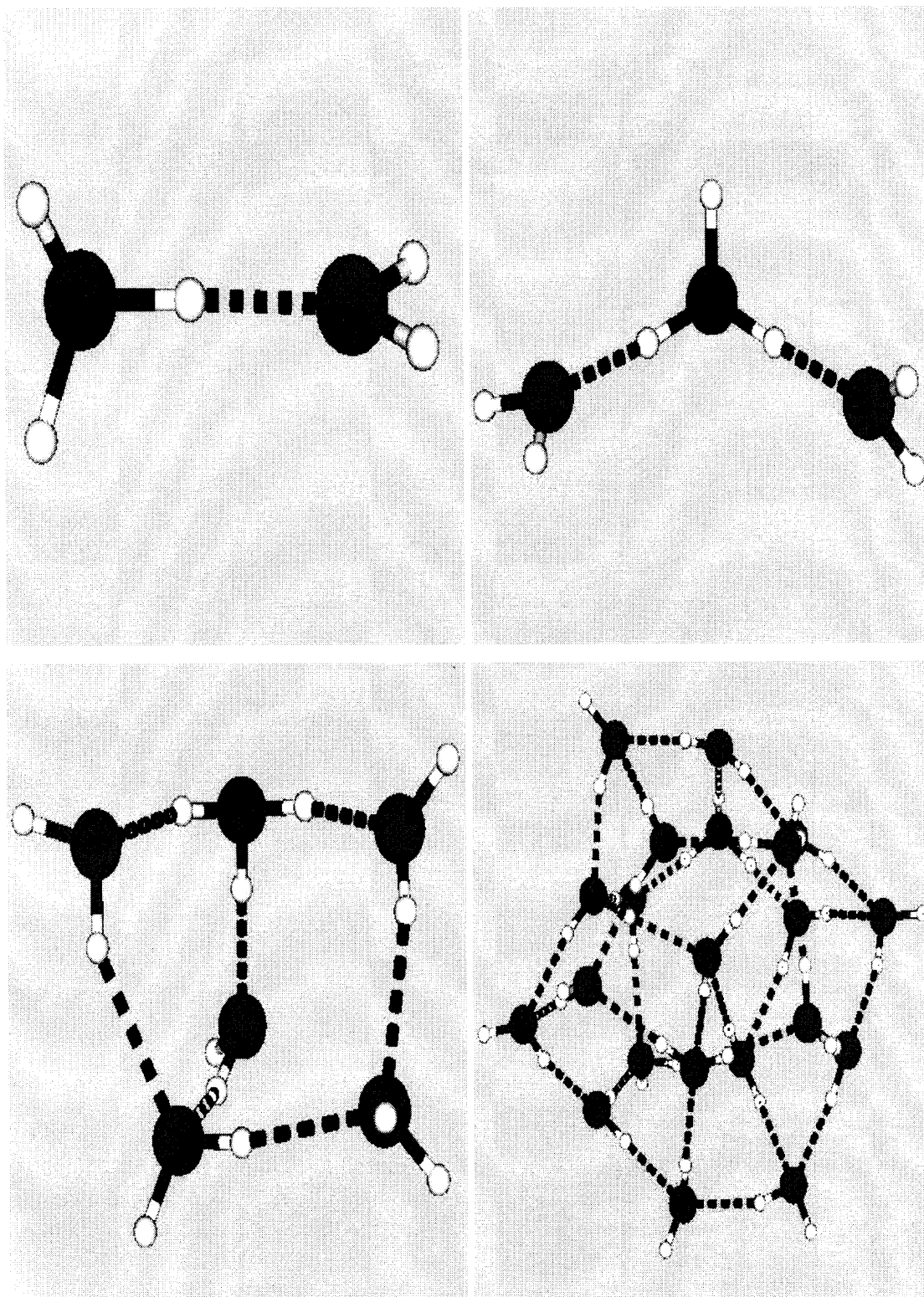
Figure 4.6 Four typical Protonated Water Clusters [The Cambridge Cluster Database].

4.4 Laboratory Studies

Using an in vitro testing system, the results show that clustered water significantly inhibits the growth of several infectious bacterial strains, over a broad range of pH values (similar to those found within the human body). Among the bacterial population showing positive inhibitions are: *E. coli, Staphylococcus aureus* and *Candida albicans* - some very serious disease-causing organisms. No inhibition is found with *Penicillium* and *Aspergillus*.

Two typical *in vitro* and *in vivo* Con-A Stimulated spleen lymphocyte proliferation models are used to evaluate the immune modulatory effect of clustered water.

In an *in vivo* model, twenty mice are given only clustered water, while 20 mice in the control group are given only de-ionized water. After two weeks, there is an approximately 60% increase in lymphocyte production measured in the clustered water group, indicating a significant increase in immune function (p<0.05). Using an *in vitro* spleen cell culture system, a similar immune stimulation effect is observed.

Mice are given alloxan (40 mg/kg, bw) by i.v. injection. Five days after alloxan treatment, 40 mice with blood sugar (180-400mg/dL) are divided equally into control and testing groups, and then treated by gavage of 0.5 ml distilled water and clustered water twice daily for 3 weeks, respectively. Blood sugar level is measured weekly. After three weeks, the control group (fed distilled water) shows a gradual increase in blood sugar levels. However, those fed with clustered water show a marked and continued decline in blood sugar levels during the same period of time as shown in Figure 4.7. Additionally, microscopic evaluation of damaged islet cells (pancreatic cells that produce insulin)

reveals that there is significant structure and function recovery in the clustered water group.

4.5 Clinic Studies

4.5.1 Effect of Clustered Water on Bio-phase Angle in Humans

This study uses the Bioelectric Impedance Analyzer (BIA, Made by RJL Inc., USA), to measure phase angle and measure hydration and cellular water movement. Phase angle is an established method to measure general cell function [Fein *et al,* 2002; Nagano *et al,* 2000]. Bioimpedance research has established that as we age, the ratio of intracellular to extracellular water changes dramatically (intracellular water levels drop with age accompanied by a reduction in cell water mobility). Low intracellular water compromises cell waste removal, nutrient absorption and protein structure. Phase angle is accepted as another important marker to evaluate general health in clinical studies.

This is a self-control study conducted by Dr. Zhi Y. Wang. All 31 subjects (average age 55) are cared by hospital physicians. Subjects are given 250 ml 30 minutes before breakfast and lunch. BIA measurements and related clinic examinations are conducted at days 1, 3, 6, 9, 12, 15 and 37, respectively. Over half of the patients notice initial (2-3 days) subjective increases in urine output and an increased frequency in bowel movements. Some notice headaches and itching (all signs of detoxification). Over 50% note improved sleep, vision and/or an increased thirsty. Phase angle measurements show significant increases in 55% of those studied (Figure 4.8), indicating improved overall health of these subjects.
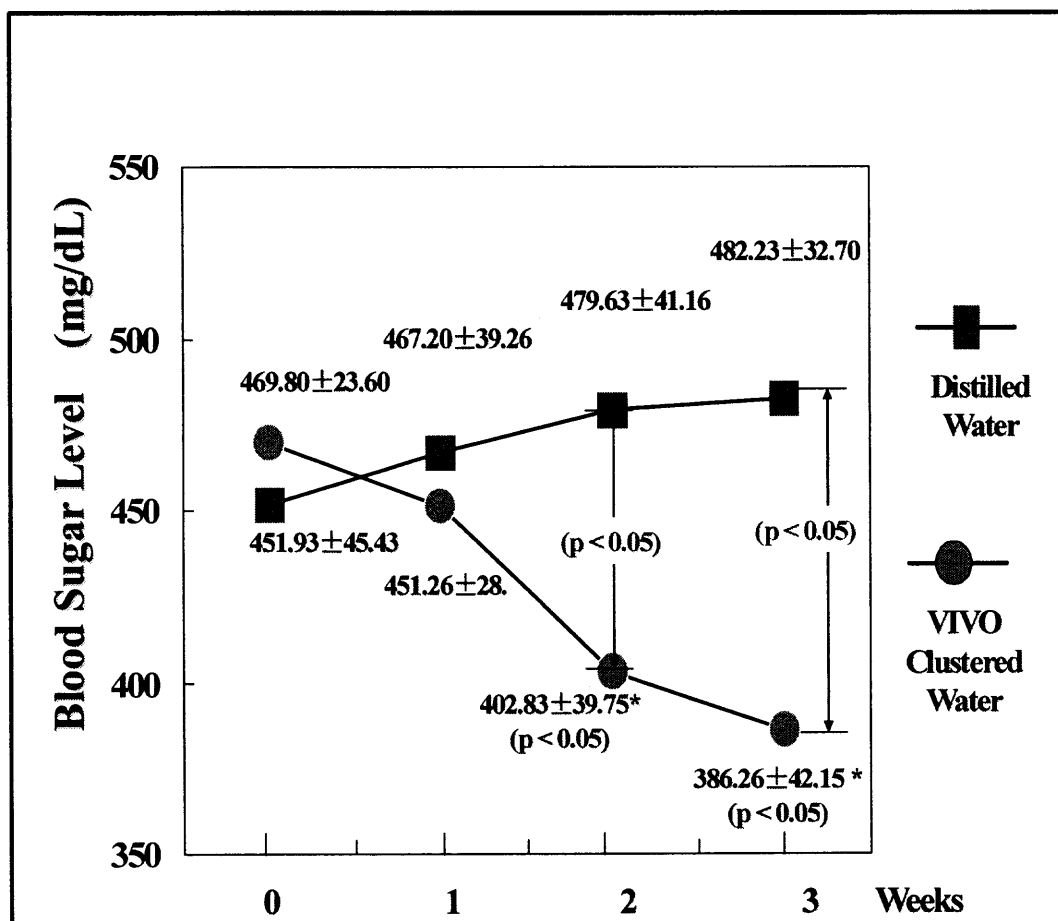
Figure 4.7 Effect of Clustered Water on Alloxan-induced Diabetes in Mice.
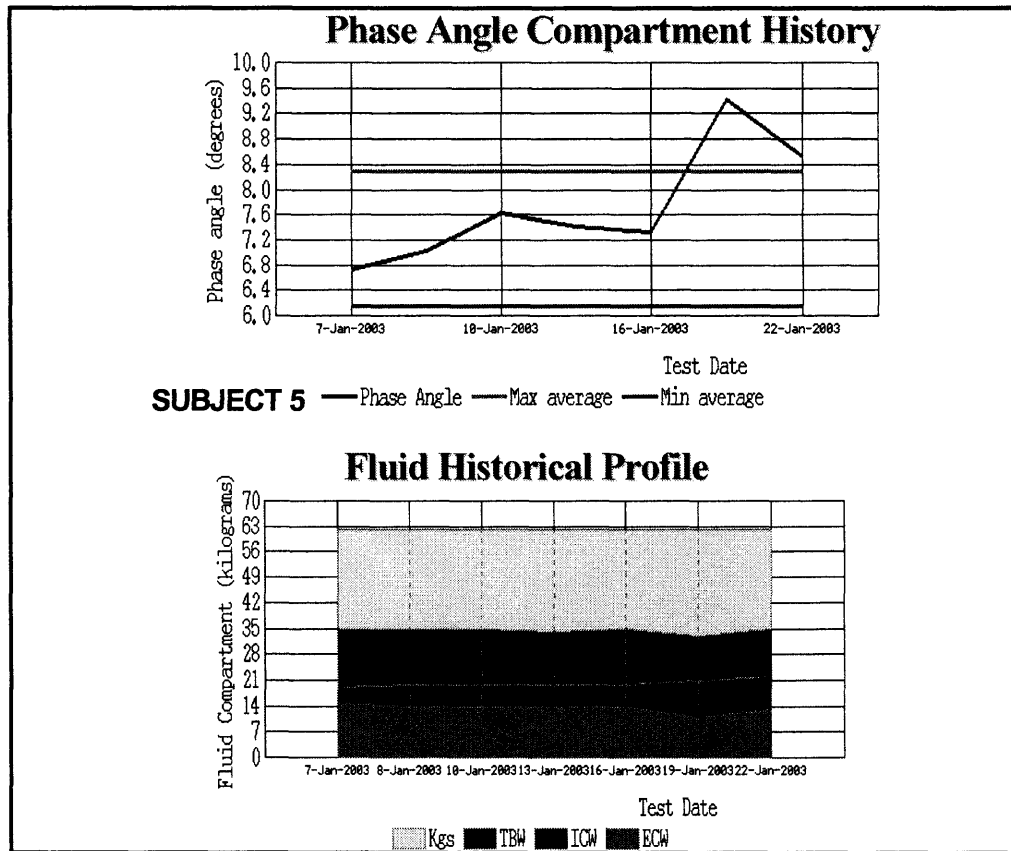
Figure 4.8 Phase Angle and Fluid Profile Measured from a Typical Subject

4.5.2 Effect of Clustered Water on Blood Sugar Level in Diabetes

Another clinical study is conducted on 57 diabetic patients. The average age is 59.52 ±

0.87. Patients who are selected for treatment have used consistent medication and normal

water for at least 3 months and their blood sugar level is kept steady at 8.92 ±

0.21mMol/L. Each individual drinks 250 ml serving of clustered water twice a day, while

no other variations in their medical treatments are made. The blood sugar level is

examined once per week for 4 weeks. Out of the 57 participating patients, 68.4% show

reductions in blood sugar levels, and only 5.3% show an increase. The summary results

as shown in Figure 4.9 indicate that clustered water may have a function in anti-diabetic

therapy.
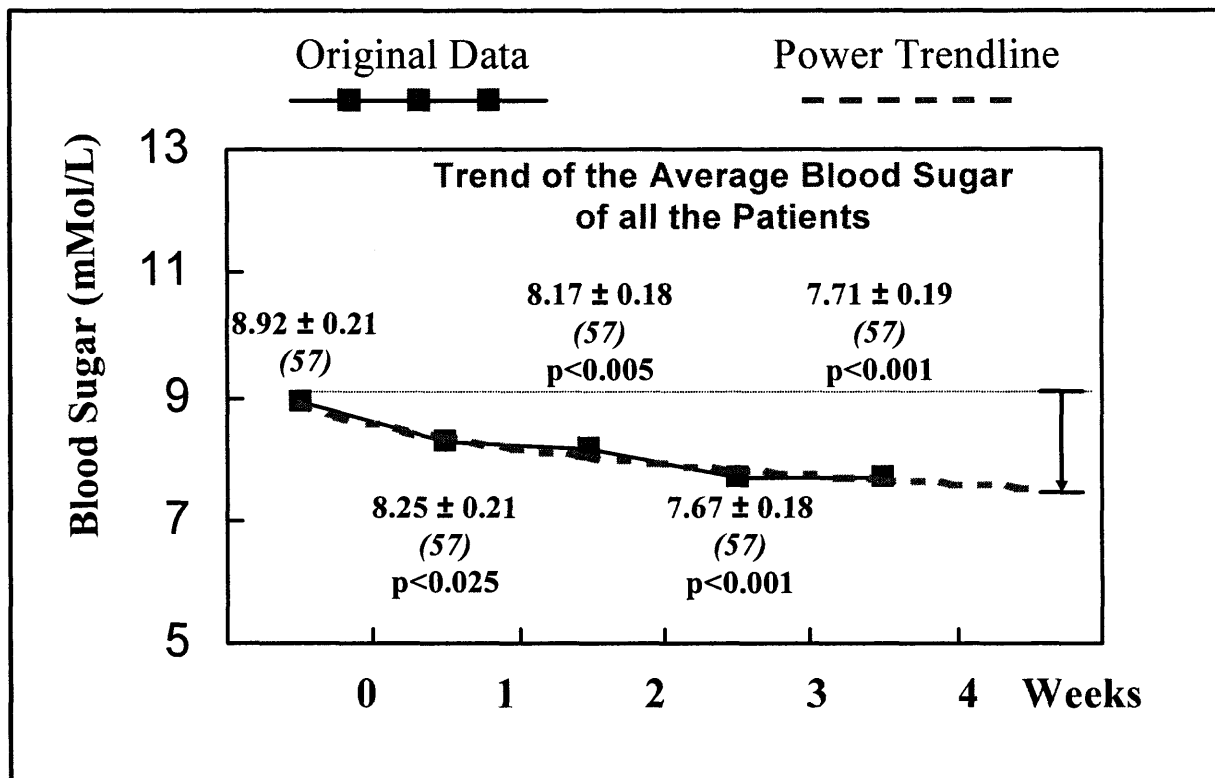
Figure 4.9   Effect of Clustered Water on Blood Sugar in Humans.

4. 6 Discussions

Based on the conventional theory it is very difficult to explain the above laboratory and

clinical studies of clustered water. Indeed the testing water is ultra-diluted "water", using

distilled water to dilute the "original microclustered water". Compared to distilled water,

this "extremely pure" clustered water possesses many beneficial functions, such as anti-

bacteria, anti-oxidant, immune stimulation, balancing of intra- and extra-cellular water

metabolism, and stabilization of blood sugar level activity. The impressive characteristics

of this clustered water is that the starting water vapor is passed across a magnetic field,

treated by laser, stabilized with certain trace metals and templated with a low resonance

frequency [Samal, 2001; Josephson, 1997]. It leads us to believe that clustered water may

retain the molecular structure for long periods of time needed to induce biological changes when it is consumed. It may be this molecular structure that exhibits itself with cytoplasmic water, induces accelerated cellular water turn-over, resulting in improved intracellar water levels, and contributing to bio-signaling transduction functions.

There is a trend that more scientists clustered to cluster science research. In 1999, Nobel laureate Dr. Brian D. Josephson addressed the hypothesis of Molecular memory. Later, a *Science* paper from Department of Physics, Harvard University proposed another theory of "atomic memory" for the promotion of "quantum communication" techniques.

Quantum communication is an attractive concept for life scientists, especially for brain signal transduction researchers. In 1995, Jibu and Yasue specified "Quantum Brain Dynamics" (QBD) in which the quantized electromagnetic field interacted with the rotational field of water molecule dipoles within neural dendrites and glia. Lowest energy eigenstates "ground or "vacuum" states of the water dipole field are memory states in QBD. Hameroff, the pioneer of quantum brain theory also pointed out that ordered water might play an important role in biological quantum coherence essential for living systems and consciousness. He also emphasized that Cytoplasmic water had unique characteristics related to being a major component of a living organism - the water was somehow alive. But how? Layers of ordered water coupled to cytoskeletal surfaces may enable quantum coherence in cytoplasm - a phenomenon closely related to life, and consciousness. In the 1970s, the relation between cerebral cortex and acupuncture alteration of visceral function was explored by examining the cortical evoked potentials, single unit discharges and neurochemistry associated with acupuncture. These studies

brought forth the Meridian-Cortex-Viscera correlation hypothesis. Meridian signaling system may be also one of a quantum communication via conjugation of clustered water (ordered water) with the gap-junction proteins that provide the physical basis for the Meridian. It is well established in cell biology that gap junctions facilitate intercellular communication and increase electric conductivity. Gap junctions are known hexagonal protein complexes that form a nano-size channel between adjacent cells. Our tested clustered water has a six-ring shape according to inventor, Dr. Lorenzen. In fact, he cooperated with Masaru Emoto to obtain six-ring crystal photos similar to the shape of organized snowflakes under a microscope at magnifications between 2000 and 5000 times. It is one of the evidences to reflect the hexagonal shape of the individual clusters. It also helps one understand why clustered water can more easily penetrate hexagonal gap-junction channels to promote cell-cell communication.

In summary, the studies have further confirmed that structured clustered water can retain its molecular configuration more stable compared to other water types. It may provide a platform to explore the mysteries of the Meridian signaling transduction network. The presented case studies have enhanced our understanding about properties of water memory, water wire, and provided an orientation for further work.

This chapter on clustered water is included in this thesis to indicate that one hypothesis that is considered but not proven due to lack of time and effort is that liquids can play a significant role in transmitting a signal along the acupuncture Meridians. Due to decreased size of molecules in clustered water, water could be the medium in nanosize environment of the Meridians and provide paths of low loss to transmit signals generated

at the nodes due to insertion of acupuncture needles. The whole bio-network consisting of 400 nodes and 20 Meridians could be assumed interconnected by such water filled pipes capable of transmitting signals.

CHAPTER 5

MODELING MERIDIAN SYSTEM WITH PETRI NETS

5.1   Definition of Petri Nets

A Petri net can be defined as a particular directed graph populated by four types of objects. These objects are places, tokens, transitions, and directed arcs connecting places to transitions and transitions to places. The following definitions are based on the work in [Hruz and Zhou, 2007].

A marked Petri net $Z=(P, T, I, O, m)$ is a five tuple where

(1) $P= \{p_1, p_2, \ldots p_n\}$, $n>0$

(2) $T= \{t_1, t_2, \ldots t_s\}$ $s>0$, with $P \cup T \neq \emptyset$ and $P \cap T = \emptyset$

(3) I: $P \times T \rightarrow \{0, 1\}$

(4) O: $P \times T \rightarrow \{0, 1\}$

(5) m: $P \rightarrow \{0, 1, 2, 3, \ldots\}$

In this definition p_i is called a place, and t_i is called a transition. I is input function defining the set of directed arcs from P to T. O is an output function defining the set of directed arcs from T to P. m is an n-dimensional marking whose i-th component represents the number of tokens in the i-th place p_i. m (p) denote the number of tokens in place p.

Pictorially places are represented by circles and transitions by horizontal bars. If I (p, t) =1, a direct arc links from place p to transition t. If O (p, t) =1, a direct arc links from t to p. A marking assigns to each place a nonnegative integer k. We say that p is marked with k tokens. We place k black dots (tokens) in place p or use a numeral k in a place to represent k tokens [Zurawski and Zhou, 1994].

The behavior of a system can be described in terms of system states and their changes. A state or marking in a PN changes according to the following execution rule:

(1) A transition t is enabled if and only if m (p) $\geqslant$ I (p, t), $\forall p \in$ P.

(2) An enabled transition t fires at marking m yielding a new marking

m' (p)=m (p) +O (p, t) -I (p, t), $\forall p \in$ P

Marking m' is said to be reachable from m. Given Z and its initial marking m_0, the reachability set is the set of all markings reachable from m_0 through various sequences of transition firing. It is denoted by R(Z, m_0). Reachability is fundamental for studying the dynamic properties of any modeled system [Zhou and Dicesare, 1993].

A Petri net (Z, m_0) is said to be live if, no matter what marking has been reached from m_0, it is possible to ultimately fire any transition of the net by progressing through some further firing sequences. The liveliness implied that a system is free from deadlock.

A Petri net is said to be B-bounded or simply bounded if the number of tokens in each place does not exceed a finite number B for any marking reachable from m_0. A Petri net is said to be safe if it is 1-bounded.

5.2 Petri Net Model

We first construct Petri net models in order to analyze system behavior. A certain order of activities needs to be followed by each acupuncture nodes of the Meridian system. For example the activity sequences of channels should be followed by acupuncture nodes needled. Therefore, the first important issue is the modeling of sequential activities. A sequence {insertion, manipulating angle and depth of insertion, retaining and withdrawing} should be followed at each acupuncture node. The Petri net modeling of such sequences is illustrated in Figure 5.1(a).

The second modeling issue is synchronization. The acupuncture nodes are on the different Meridians. The tokens from different Meridians reach the input places of transition t_i, and they together fire t_i. After firing it, the tokens are sent to the next places. The next channel is then ready and available.

The third one is concurrence. By concurrence we mean that there are parallel relationships among the concerned activities. For example, several needles can be used in different channels simultaneously. They can represent concurrent activities [Zhou and Venkatesh, 1998].

Insertion   Manipulation   Retaining   Withdrawing

(a)

Needle #1

Needle #2

(b)

(c)
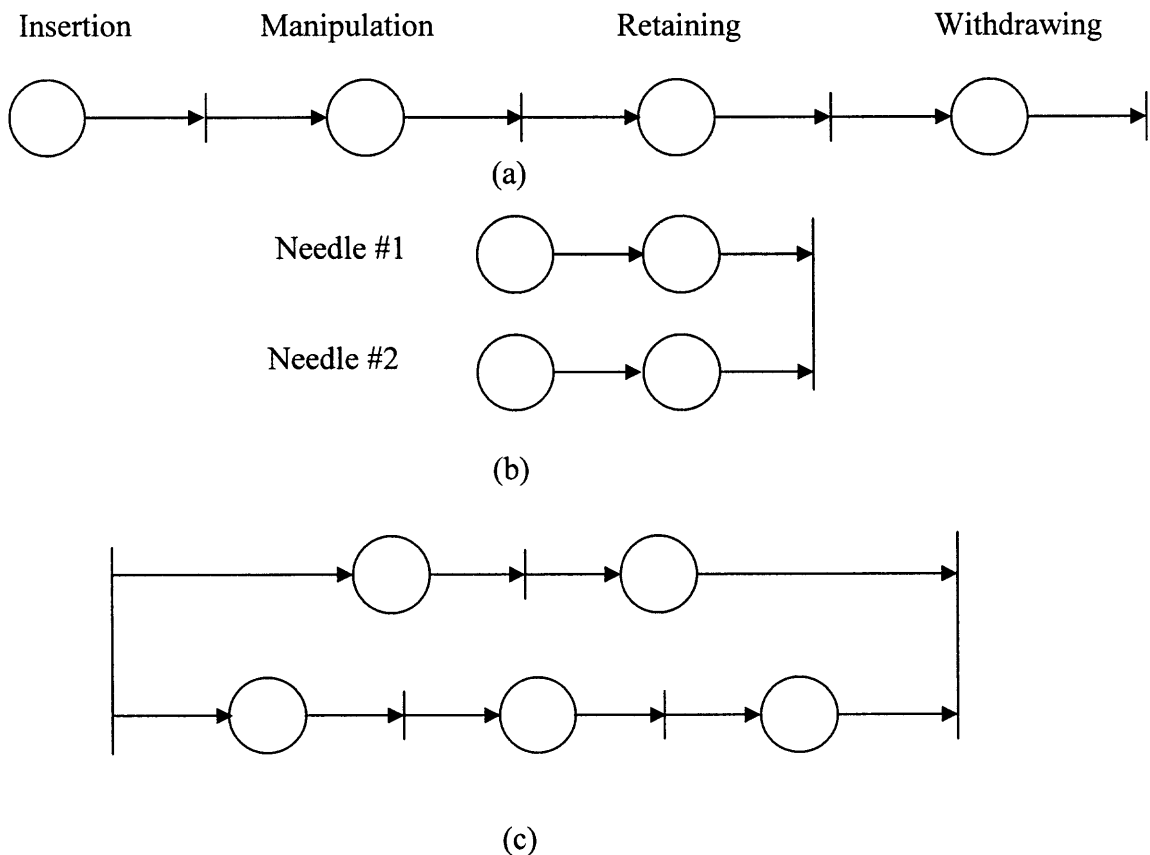
Figure 5.1   Examples of Petri Net Model: a) sequence, b) synchronization, and c) concurrence.

5.3   Petri Net Model for Meridian System

Given the specification of the Meridian system, we construct a Petri net based on the following general methodology,

- Identify the acupuncture node.

- Ordering these acupuncture nodes according to the channel.

- For each acupuncture node or activity in order, create and label a place to represent its status. Add a transition (start activity) with an output arc(s) to the places. Add a transition (stop activity) with an input arc from the place.

- Specify the initial marking.

    According to such a procedures we design a Petri net model shown in Figure 5.2, on the assumption that all acupunctures points are in the same priority class.

    p_1: macro place of Zhujueyin, representing a sequence of acupuncture nodes on the Zhujueyin channel.

    p_2: macro place of Zhushaoyang, representing a sequence of acupuncture nodes on the Zhushaoyang channel.

    p_3: macro place of Shouyangming, representing a sequence of acupuncture node on the Shouyangming channel.

    p_4: macro place of Shoushaoyang, representing a sequence of acupuncture nodes on the Shoushaoyang channel.

    p_5: macro place of Zhuyangming, representing a sequence of acupuncture nodes on the Zhuyangming channel.

    p_6: macro place of Zhushaoyin, representing a sequence of acupuncture noses on the Zhushaoyin channel.

p_7: macro place of Zhutaiyin, representing a sequence of acupuncture nodes on the Zhutaiyin channel.

p_8: macro place of Shoushaoyin, representing a sequence of acupuncture nodes on the Shoushaoyin channel.

p_9: macro place of Shoutaiyang, representing a sequence of acupuncture nodes on the Shoutaiyang channel.

p_{10}: macro place of Zhutaiyang A sequence of acupuncture nodes on the Zhutaiyang channel.

P_{du}: macro place of Du channel.

P_{ren}: macro place of Ren channel

t_1-t_{10}: links between each pair of channel.
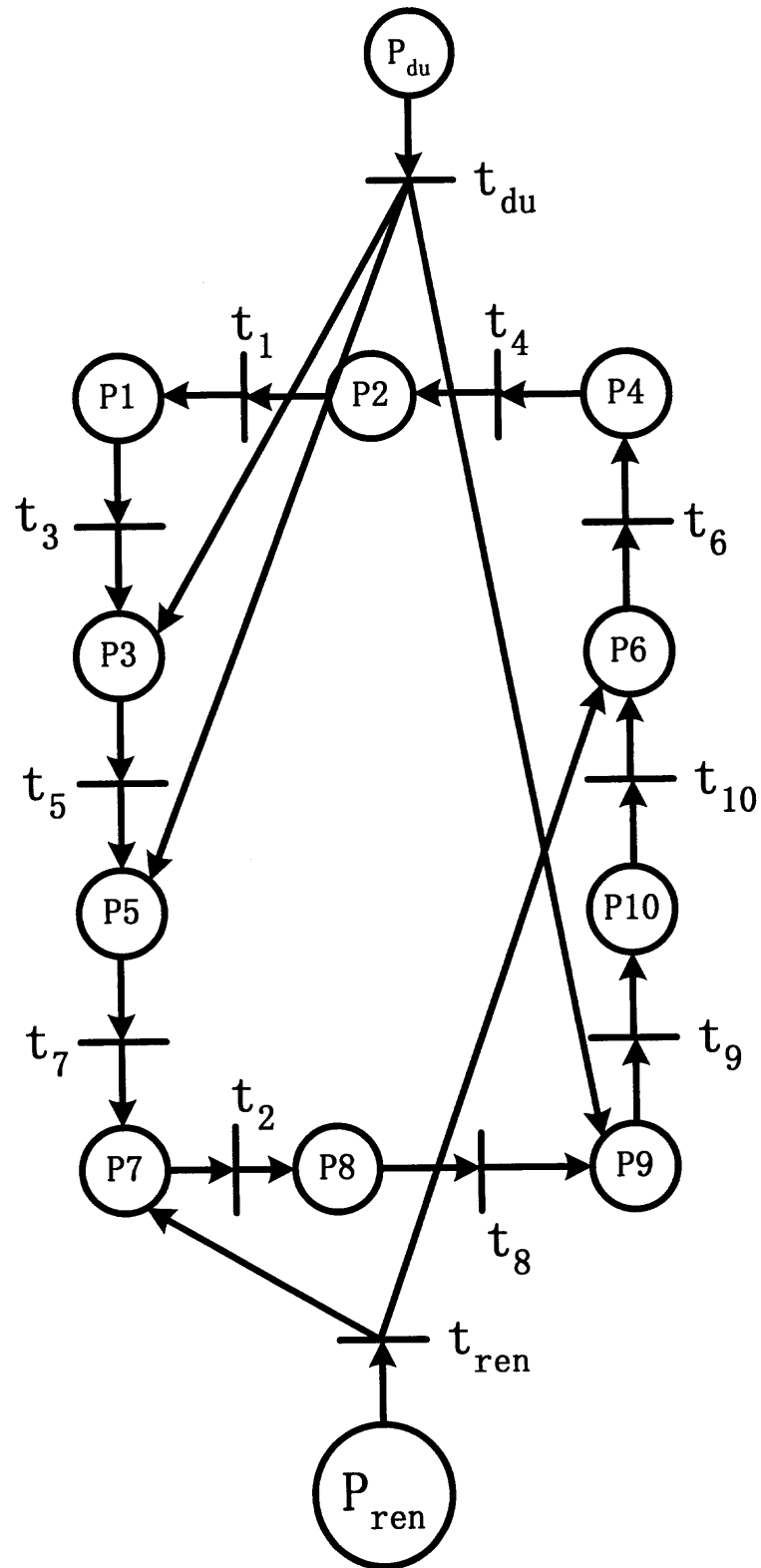
Figure 5.2 Petri Nets Model of Meridian System.

5.4   Case Study

Influenza is an acute infectious disease of the respiratory tract due to influenzal virus characterized clinically by sudden onset, high fever, headache, myalgia, acratia, and anorexia. It may be accompanied with nasal obstruction, rhinorrhea, cough, and sore throat. Influenza occurs more often in autumn and winter. Based on the traditional Chinese medicine, there are three major types of influenza.

- Wind-cold type: mild fever, headache without sweating, nasal obstruction, running nose, and soreness of limbs.

- Wind-heat   type: High fever, slight aversion to cold, headache, cough, thirst, and sore throat.

- Gastrointestinal type: headache, fever, nausea, vomiting, abdominal pain, and distension.

These three types of influenza are all associated with three Meridians [Pan and Zhou, 2005]. Since they lead to different symptoms, they may need extra token for each type. Let us take the gastrointestinal type as an example. It is associated with three Meridians, and an extra point that does not belong to any Meridian. They are:

- *Shouyangmin* Meridian

- *Zhuyangming* Meridian

- *Du mai* Meridian

- Extra point: *Taiyang*
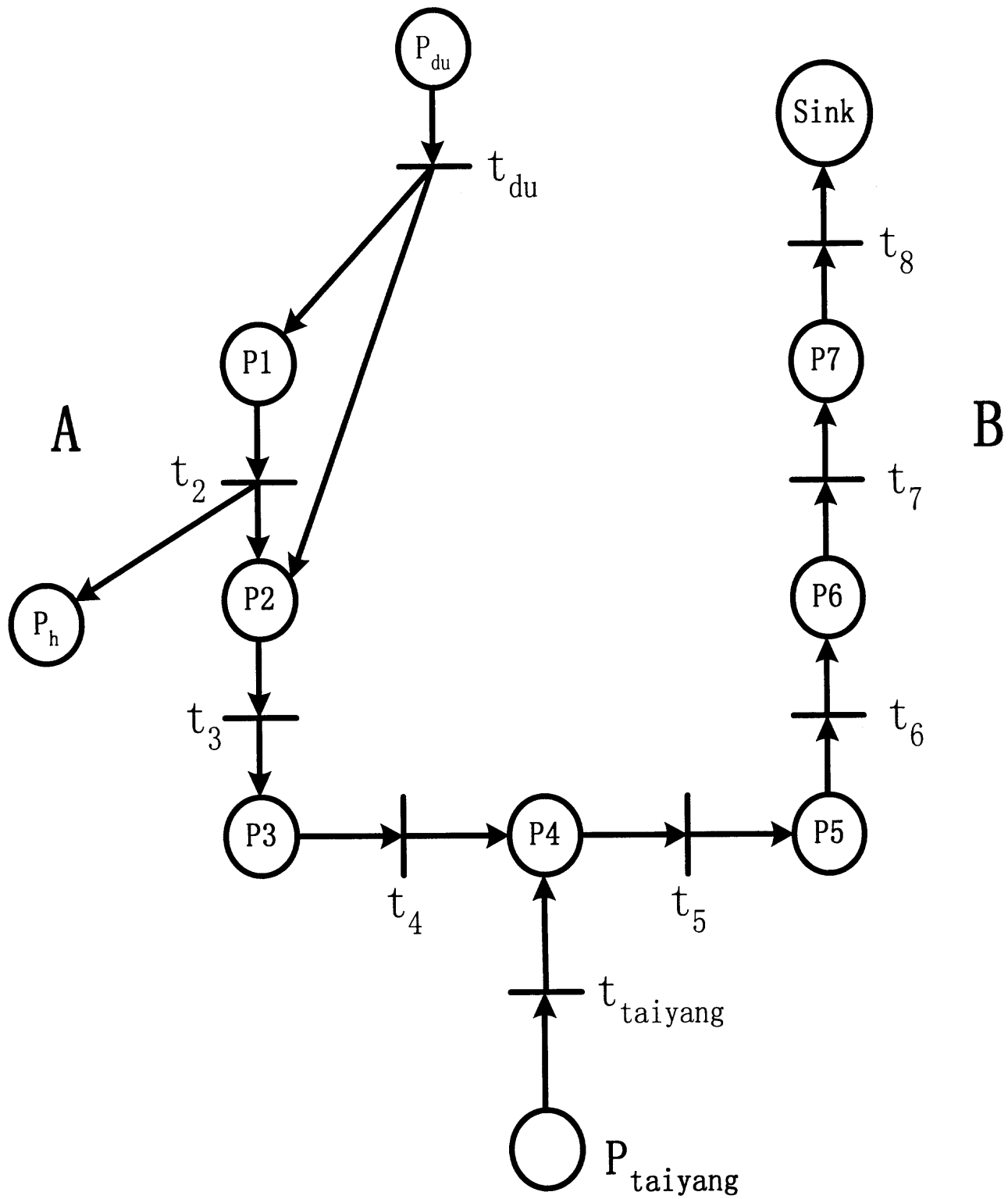
Figure 5.3 Petri net model of Influenze

According to Traditional Chinese Medicine, this disease is caused by blocking of *Qi* and blood; hence they cannot ride along the Meridian in the *shou* channel, since the blockage is formed. Thus *Qi* and blood cannot transfer from one place to another. Hence if we can resolve the blockage, *Qi* and blood can freely transfer from channel A to channel B. The disease is then cured.

This case involves two channels. On the right side of Figure 5.3 is *shouyangming* channel, a major channel in this case. On the left side is *Zhuyangming* channel, a secondary channel in this case. Places p_1 through p_7 are local acupuncture nodes of both channels. Places p_{1-3} are acupuncture nodes along the secondary channel. This disease is caused by transitions t_2, t_4 and t_5 that cannot fire, since all or part of them causes some deadlock in the related channels. This blockage or deadlock prevents *Qi* and blood from freely traveling through the Meridian system, specially traveling through *ShouYangming* channel. This blockage results in influenza. In order to recover from influenza, and remove these blockages, the simplest way is to give a token (needling the acupuncture nodes) to p_2, p_4, and $p_{taiyang}$. Hence, transitions t_{3-5} are enabled, and can fire. Then a token is given to $p_{taiyang}$, which enables t_7. p_7 receives a token, and t_8 fires. Petri net now becomes live again.

The meaning of all places is as follows:

p_1: Local acupuncture node of *Zhuyangming* channel (acupuncture node *Zhusanli*).

p_2: Local acupuncture node of *Zhuyangming* channel (acupuncture node *Tianshu*).

p_3: Extra point not belongs to any Meridian (acupuncture node *Taiyang*).

p_4: Local acupuncture node of *Zhuyangming* channel (acupuncture node *taiyang*).

p_5: Local acupuncture node of *shouyangming* channel (acupuncture node *hegu*).

p_6: Local acupuncture node of *Zhuyangming* channel (acupuncture node *Shaoshang*).

p_7: local acupuncture node of *Dumai* Meridian channel (acupuncture node *quchi*).

p_{Du}: next to local acupuncture node of *Dumai* channel (acupuncture node *Du*).

A token inside places can be a token with parameters: such as depth, vibration, time, and direction respectively. This work proposes to use Petri nets to model the Meridian system. Since this is first time we use a Petri net method in this field, many problems remain to be solved. There are still many great challenges.

The research is concerned with the mathematical analysis of a Meridian system. It is a substantial long-term project, which on the one side is practical, and on the other side involves deep and nontrivial mathematics.

CHAPTER 6

CONCLUSIONS AND FUTURE RESEARCH

6.1 Conclusions

The current work to explain the mystery of an acupuncture system in the context of biological system has only scratched the surface. The physical effect of injecting a needle is suggested by an equivalent model of a current (voltage) source based on a simple Faraday disk generator concept. The motion of the needle due to hand manipulation in the presence of Earth's magnetic fields acts as a Faraday's dynamo and causes the accumulation of positive (negative) charges at the tip of the needle. Due to clockwise (counter clockwise) rotation, further increase of accumulated charges at the tip results in their release in the form of an equivalent current (voltage) source. This effect has been enhanced by connecting a variable frequency source on a needle inserted into one of the nodes of the Meridian system. Voltage variations at the adjacent nodes along the same Meridian are measured and the relative connectivity is observed to verify the concept of a network. It is observed that the induced voltages are proportional to the corresponding path lengths, and further more, the existence paths are found to be frequency dependent.

The presence of minute electrical currents also suggests that there is a magnetic field along the Meridian and, therefore, the inclusion of series inductance in the model is appropriate. This is already confirmed by SQUID measurements carried out and reported by [Lo, 2003]. The presence of the inductive (resistive) path suggests that capacitive effects due to the accompanying electric field have to be included as shunt capacitance in the equivalent model. It shows that distributed resistance and inductance plus the shunt

capacitance well simulate the equivalent transmission line that is essential for signal propagation along the Meridians of the acupuncture system.

Additional hypothesis is made suggesting that the clustered water wire can be used to model the pathways of the acupuncture system. One of the reasons for this approach is that clustered water wires are ideal to model tiny nano-size capillaries, that may be present but their presence has not been verified yet physically, even through the SQUID measurements have confirmed the flow of minute currents along the acupuncture Meridians.

Future work includes much more accurate modeling of pathways and nodes on each Meridian, their coupling with each other. As well as further frequency dependent system identification, in terms of equivalent parameters and their coupling behavior in the complex network. Also a Petri-net formation is required, to solve the unexplained acupuncture Meridian system that has been used for several centuries. The presence of 20 Meridians involving more than 400 nodes suggests that an acupuncture system is ideal to model a biological network. Further detailed work is needed to develop a full Petri net model.

6.1.1 Summary of Contribution

The contributions of this dissertation are summarized into three aspects.

1) The electrical properties of acupuncture nodes are investigated, and a semi-quantitative model is derived. Numerical evaluation results support this model. At the fixed frequency, the output voltage response to input voltage has the linearity property. Under different frequencies, the output voltage response to input voltage exhibits non-linearity, but they are counterpart to each other in

the opposite direction. The higher input voltage value, the lower output voltage value. One electrical equivalent circuit model is suggested to describe the properties of an acupuncture node. The resistors are used to describe the voltage linear property, and the capacitor (inductor) is used to include the frequency dependent properties.

2)   A hypothesis is proposed and certain significant evidence is provided. Clustered water can be not only an excellent carrier for nutrition and energy, but also an excellent carrier for low resonance frequency signal. Meridian system could be composed by protein and cluster water wire lined inside of nanotube, they form a bio-signaling system. Our study has shown that low frequency electromagnetic radiation treated clustered water has many attractive biological functions. It is thus important to understand how to modify the structure of water clusters to transfer the low resonance frequency to living cells.

3)   A Petri net model about the Meridian system is developed. The Meridian system consists of about 400 acupuncture nodes and 20 Meridians connecting most of the points. It deals with routing and distributing energy to achieve physiological functions. This is the first work that adopts Petri Net modeling methods to define and model the Meridian system. It can help industry to develop the new methods and new devices to improve human being's health life.

6.1.2 Limitations

This research has the following limitations:

1) In order to develop a complete Petri net model for the Meridian system, all the Meridian channels need to be investigated.

2) Although a semi-quantitative mathematical model is developed at acupuncture nodes, a quantitative model needs to be developed and its development requires more experiments at and near acupuncture nodes.

6.2   Future Research

There are several ways in which this work should be extended in the future. Some important and promising directions are listed as follows:

1)   Water memory has gained more and more attention recently in the world. Low frequency signal storage and transfer in clustered water may require the concept of water wire. The structure of such water wire and its properties require deep theoretical and experimental investigations.

2)   While applying Petri net technology in modeling the Meridian systems, parameterized tokens in Petri net should be introduced to better describe the system and analyze the relevant properties. Petri nets models should be developed to describe the whole Meridian system. The current research needs to be extended to a general model. The color tokens concept should be introduced to model and analyze the different parameters used in each process, and how they impact each

other. New multidisciplinary experiments should be conducted for both applied mathematics analysis and bio-signal engineering device.

3)   Clarification of the properties of the Meridian system is another area requiring further work. As an alternative medical treatment method, right frequency, current values applied to acupuncture nodes can significantly affect the performance of acupuncture treatment. Hence, more research and development work needs to be conducted.

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