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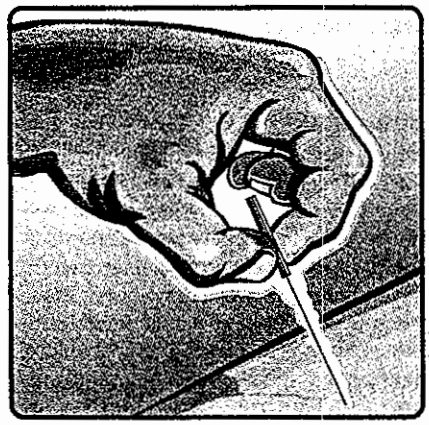
The Science of Acupuncture — Theory and Practice

I. Introduction



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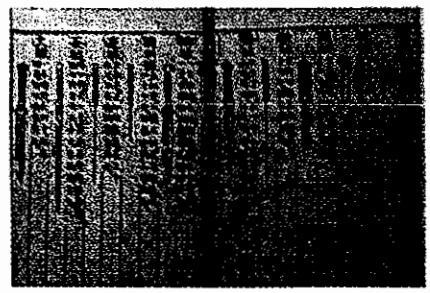
Acupuncture is a therapeutic modality used in China as early as the late stone age. Throughout Chinese history, both acupuncture theory and practice have steadily evolved into an increasingly rich and complex system, eventually offering treatments for virtually every form of medical condition. Much of the history of the development of acupuncture therapeutics can be seen in the evolution of the needles themselves (Figs. 1 and 2), but the meridian system is of primary importance, and the conceptualization of the system has changed very little in the last 2000 years. (Figs. 3 and 4).

Acupuncture has long been considered more important then herbal pharmacology. The earliest classical books on traditional Chinese medicine discuss acupuncture but not herbal pharmacology. These references include Huangdi's Internal Classic (ca. 100 B.C.E.) and two other works that pre-date it: the Moxibustion Classic with Eleven Foot-Hand Channels and the Moxibustion Classic with Eleven Ying-yang Channels, both of which were discovered during the Mawangdui tomb excavations in 1973. [1] There is even a traditional saying: "first you use the needle (acupuncture), then fire (moxibustion), and then herbs."

Acupuncture did not enter modern Western consciousness until the 1970s, when China ended a period of isolation and resumed foreign political and cultural contacts. In 1972, the respected New York Times columnist James Reston underwent an emergency appendectomy while in China. He latter wrote about acupuncture treatment for post-operative pain, which was very successful. This report attracted attention and many American physicians and researchers went to China to observe and learn acupuncture techniques.

It appeared as though acupuncture was used to treat everything in China, but the number of accepted acupuncture applications has grown very slowly in the West. The first area of partial acceptance was in analgesia, which is still where its effectiveness is best documented [2]. Acupuncture research has since become a very broad active area both in Asia and the West. Research at the Shanghai Institute has demonstrated acupuncture's effect on various biological systems, including the digestive tract, cardiovascular system (helpful in hypotensive states), immune system (phagocytosis), and the endocrine system (the secretion of ACTH, oxytocin, vasopressin, norepinephrine, follicle stimulating hormone, prolactin, and 17-hydroxycorticosteroids) [3]. A recent issue of the bilingual, Chinese journal *Acupuncture Research* includes successful studies of acupuncture treatment for hemiparalysis, facial paralysis, cervical spondylosis, humeral epicondylitis, herpes zoster, and lumbago [4]. Current research in North American and Europe includes uterine contractions [5], pulmonary disease [6], addiction, mental disorders, and as an adjunct to AIDS treatment [7].

The primary reason for the slow acceptance of acupuncture is the lingering suspicion that there is no substantial scientific reality behind it because a demonstrable mechanism of action has yet to be found. For the most part, early attempts to "explain" acupuncture have been either thinly disguised denials or have embraced and verified acupuncture only partially, disproving traditional acupuncture as much as validating it. The most prevalent example of the former is the argument that any effect acupuncture may have is psychogenetic, i.e., a placebo effect. This conjecture has been disproven by successful studies of acupuncture in animals, many examples of which can be found in Kuo and Kuo[2]. Two important forms of partial validation of acupuncture are the neuralphysiological and neurohormonal schools. The neuralphysiological school defines acupuncture points on a "roughly dermatome basis; partially involving 'long' reflexes to distant parts of the body,



1. Diagram dating from 1601 AD of the nine standard needle types used in acupuncture for approximately the previous 2000 years. From left to right, they are an arrowhead needle for pricking the skin to drain heat, a round needle for superficial message, a pressure needle for pressing against a meridian, a sharp needle for blood letting, a sword needle for draining pus, a round sharp needle for eliminating acute obstructions, a filiform needle for strengthening normal chi, a long needle for deep-seated obstructions, and a large needle for arthritis with effusion [18].

which implicates a distribution by specific spinal segments or nerves; and are partially via unknown connections" [8]. This hypothesis could explain remote stimulation, but as the quotation suggests, it is a very incomplete explanation. Neurohormonal theories center on the release of neurohormones triggered by the pain and microphysical damage caused by needle insertion. This hypothesis has been used primarily to explain acupuncture-induced general analgesia, but it can explain little else.

Both of the above explanations are attempts to use structures and concepts acceptable to the mainstream medical community to explain acupuncture. But in

2. Modern, stainless steel acupuncture needles.

grafting acupuncture to Western medical theory, aspects foreign to orthodox medicine are simply jettisoned. Because of the emphasis on genetics, anatomy, physiology, and bio-chemistry in modern medicine, and a near complete denial of energetic processes in the body, chi (body energy) and meridians (paths of body energy flow) are either ignored or considered fallacies with some metaphorical or pneumonic value. Emphasis is placed by most researchers on the needle and the physical effect of its insertion into the skin, but this side of acupuncture is not essential. According to our research, acupuncture is essentially manipulation of bodily energy as it flows through the meridian system. The acupuncture needle is only one of many possible tools used to accomplish this activity. In the remainder

Bodily energy, called chi, is generated in internal organs and systems

of this article, "meridian theory" will be understood to include acupuncture theory and practice. "Meridian" is used to stand for both the meridian itself and the acupuncture points along the meridian.

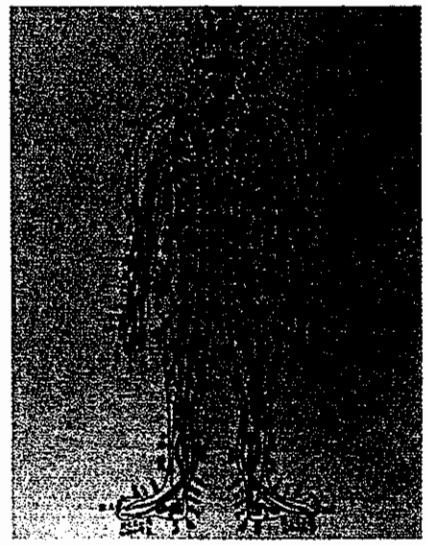
A bio-physical or bio-chemical approach to acupuncture robs it of its actual foundation, and because of this, acupuncture research to date has been only partially successful. Fortunately, advances in physics, electromagnetism, quantum mechanics, and bioenergetic research have enabled researchers to develop a paradigm that, for the first time, successfully explains a majority of acupuncture related phenomena [9]. We have embraced this bioenergetic paradigm, not simply because it can explain more of acupuncture phenomena, but because it is a true description of acupuncture's mechanism of action as well as an important facet of all life processes. The only way to address acupuncture successfully and scientifically is through the meridian system.

This four-article series will attempt to give a fairly complete representation of meridian theory research based on the bioenergetic paradigm. This, the first article, covers traditional acupuncture, early research into the the electrical properties of acupuncture points, and basic electrodermal screening test (EDST) methodologies. The theoretical foundation for the bio-energetic paradigm is discussed in two articles by physicist Kuo-Gen Chen. The fourth article is a review of research into an application of bio-energetic properties called the electrodermal screening system (EDSS). In that article, Dr. F.M.K. Lam, Prof. Pesus Chou, and I hope to demonstrate the effectiveness of the EDSS as a screening/diagnostic method and offer evidence of the casual connection between points, meridians, and internal organs.

Traditional Acupuncture

According to traditional Chinese medicine, a form of bodily energy, called chi, is generated in internal organs and systems. This energy combines with the breath and circulates throughout the body, forming paths called meridians. The meridians form a complex multilevel network that connects the various areas of the body, including the surface with the internal. All of the various meridian systems work together to assure the flow and distributon of chi thoughout the body, thus controlling all bodily functions. The interwoven meridian systems and the possibilities for diagnosis and treatment they offer, are called meridian theory. When an organ or system is not balanced, related acupuncture points may become tender or red, providing a mechanism for diagnosis. For treatment, a point on the skin is stimulated through pressure, suction, heat, or needle insertion, affecting the circulation of chi, which, in turn, affects related internal organs and systems.

"Meridian" is the most common translation of the Chinese ching-lo (jingluo), but it is a very imperfect translation. Ching means to pass through, and lo means a net or to connect. "Meridian" was originally used by French researchers to describe all meridians, and is used in this article in that sense. The term "channel" is used increasingly for all meridians. Some prefer to maintain the original distinction between ching and lo and to use the terms channels and collaterals respectively. With that dis-



3. Traditional diagram of the meridians along on the front of the body.

tinction, meridian theory would be reffered to as the theory of channels and collaterals. There is another sub-classification of meridians, called vessels. Although it is a valid distinction, it is not important to the immediate discussion here.

Meridians are classified into six groups, according to their location and function. The best known of the meridians are the 12 regular meridians, also called the major trunks. They connect with the organ they are named for by way of collateral meridians (see below) and run along the surface of the body, either on the chest or back and along either both of the arms or both of the legs. These are the primary conduits for the passage of chi through the body, which flows through this network in a regular 24-hour pattern. The 12 regular meridians, therefore, control or take part in every facet of the daily metabolic and physiological functioning of the body.

There are 3 meridian groupings, each with 12 meridians, directly associated with the 12 regular meridians. 1) Each of the divergent meridians arises from one of the 12 regular meridians, passes through the thorax or abdomen to join with the named organ, and then surface at the neck or head. 2) The muscle network meridians distribute chi from the 12 regular meridians among muscles, tendons, and joints, ensuring normal body motion and flexibility. This circulation of chi is referred to as superficial because there is no direct connection with an internal organ. 3) The cutaneous network meridians run parallel to the regular meridians in the cutaneous skin layer and are therefore considered even more superficial. We believe that they are a part of the function of the sensory nervous system.

The 8 extra meridians (also referred to as vessels) are the paths by which the 12 regular meridians connect, share chi, and support each other. None of the individual extra meridians are associated with a specific organ or regular meridian, though all of them connect with a number of other meridians. Their paths are considered superficial but deep. It is through the extra meridians that imbalances in chi are regulated through storage and drainage. The most important of the extra meridians are the govorner meridian, which runs along the middle of the back, and the conception meridian, which runs along the middle of the chest and stomach.

The system of 15 collateral meridians is responsible for the thorough and complete circulation of chi. One collateral meridian arises from each of the 12 regular meridians, the governor and conception meridians, and from the spleen (which does not have a regular meridian). Each of the collateral meridians branch out, forming minute or "grandson" collateral meridians, creating both horizontal and vertical connections within the complete meridian system.

Energy Medicine

The energetic view of the body is not entirely new to Western medicine. The basic concepts were present in the work of "vitalist" scientists such as Galvani, Hahnemann, and Mesmer, who were active in the 17th through 19th centuries. Vitalism was gradually pushed out of the realm of accpeted medical science in the 19th and 20th centuries because of its apparent descriptive inefficacy. However, the real problem was inadequate instrumentation and a medical paradigm that made no room for energetic processes. Technology has now advanced to a point where devices can successfully and consistently measure biological energy. The body's energetic processes have always been there and were always important, as the history of acupuncture suggests. It is now time to standardize and integrate energetic practices into modern health care and make energy medicine an essential part of medical science.

The basic premise of energy medicine (also called bio-energetic medicine) is that energetic processes, including electrical and magnetic processes, vibrational resonance, and bio-photon emission, are essential to life processes. Bio-energy functions as a carrier of "bio-information" and is crucial to biological self-regulation. With this in mind, there are at least three areas where medical practitioners could find useful applications: (1) keeping in mind the role of the electromagnetic energy network whenever diagnosing or choosing treatment modality, (2) use of beneficial, external energies in amounts similar to that already present in body in order to balance or reinforce natural energetic functions, (3) use of greater amounts of external energy to actively influence body function by way of the energy network, correcting functional imbalances. Traditional acupuncture belongs to category (2), and many modern meridian-based techniques belong to category (3).

4. A modern "acupuncture doll."

Chi combines with breath and circulates, forming meridians

According to what we have observed in our research, a complete, bio-energetic definition of meridians includes four facets, or "units": structure of the organ of origin, function of the organ, the electromagnetic pathway, and emotional/vibrational interaction. All four are crucial to the creation and existence of the meridians. An organ, by its physical existence and functioning, relases energy (chi) and creates an electro-magnetic field. This energy contains information about the organ and its activity. Thus, both the physical structure and the functioning of the organ affect the quality and strength of the energy and information that are created. This activity is the source of the meridians. An imbalance in one meridian often brings about imbalances in others, and other factors, including emotions, can effect individual meridians and the meridian network as a whole. Each meridian can be viewed as existing individually or as a part of the intricate meridian system and can be treated as such, though the synergistic

totality of the meridian system is always of primary importance. It is precisely for this reason that diagnostic and therapeutic procedures based on meridian theory are successful at approaching the body holistically.

In electroacupuncture treatment, direct electric current is administered through the acupuncture points. This electrical energy follows the electromagnetic tracks to the system, effecting treatment. (Electroacupuncture therapeutics is a separate area of research and will not be discussed in detail here.) On the other hand, anything that alters or interferes with a system's function or structure also changes the performance of the related meridian and acupuncture points. The electrodermal screening device (EDSD), described below, determines the balance of a system by measuring resistance and polarization at these points. In other words, acupuncture and standard electroacupuncture are therapeutic, while the electrodermal screening test (EDST) can be integrated into diagnostic procedures.

The Device (EDSD) and Method (EDST)

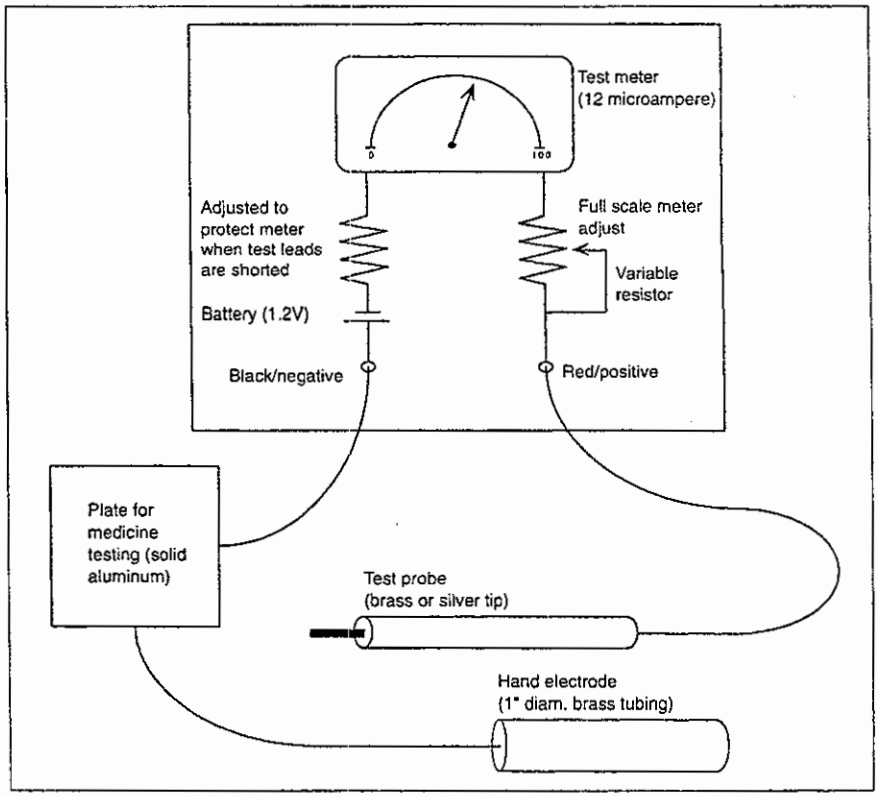
In the 1950s and 60s two distinct electrodermal screening methodologies were developed, one by Nakatani in Japan (Ryodoraku) [10] and one by Voll in Germany (EAV, electroacupuncture according to Voll) [11]. The most obvious difference between the two systems were the types of points they measured. In Ryodoraku, meridian passage points on the wrists and ankles are measured. The points used in EAV are located all over the body, though the distal points on the hands and feet are used most often. EAV is the more versatile and precise of the two methods, and for this reason we were attracted to it. EAV is the basis of the EDST, and the standard device used in EAV, the Dermatron (Pitterling Electronics, Munich), is the prototype of modern EDSDs.

There are some variations in the construction and performance of EDSDs, but all share the same basic design (Fig. 5). The core of the EDSD is an ohmmeter designed to deliver approximately 10-12 μa DC at 1-1.25 v, a perfectly safe amount. (The ionization potential of hydrogen atoms is 1.36 volts: only at this level and above could any physical damage occur.) On the majority of the devices, the meter is calibrated to read from 0 to 100, such that the standard skin resistance of 100 μΩ reads 50. The minimum value of zero represents infinite resistance (no electrical conductivity), and the maximum value of 100 indicates zero resistance at the given voltage and current. Some of the devices use a range of 0 to 200, with 100 being normal skin resistance [12].

Meridians are classified into six groups, according to location and function

The EDSD testing probe consists of an insulated body with a tip of brass or silver, connected to the positive side of the circuit. The examiner holds the probe by the insulated body and presses the tip against the measurement point of the patient (Fig. 6). The negative side of the circuit is connected to a hand electrode made of brass tubing, which is held by the patient in one hand. If medicine testing (described below) is to be done, a metal plate or holding device, usually made of aluminum, is placed in the circuit between the device and the hand electrode. The pressure of the probe tip on the skin might create a temporary dimple and be slightly uncomfortable, but it should not be painful. To assure adequate electrical contact, it is usually necessary to slightly dampen the probe tip and the hand electrode with water.

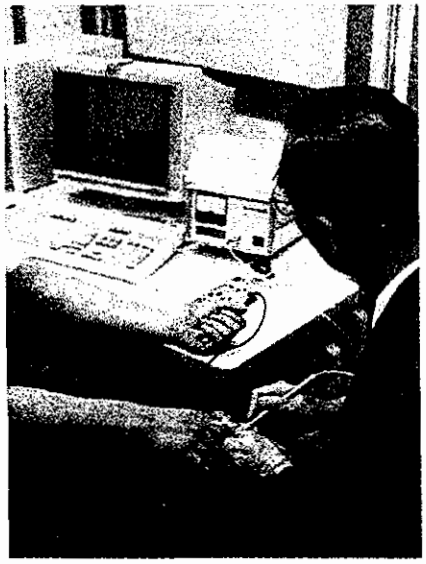
A reading taken with the EDSD is usually described using two values, the initial reading (generally the highest value) and the indicator drop (ID). Many practitioners also note the length of time of the ID. An initial reading of approximately 50 followed by little or no indicator drop is considered to be balanced. Initial readings above 60 may indicate inflammation in the system being measured, and initial readings below 45 may indicate changes caused by degenerative processes. An ID indicates a probable imbalance. When an ID is present, it is considered the most important part of the reading. Through a process called medicine testing, the ID can be used to determine the nature and cause of an imbalance.



5. A simple schematic diagram of an EDSD. Reprinted from Tsuei JJ. The Past, Present, and Future of the Electrodermal Screening System (EDSS). *Journal of Advancement in Medicine*, 1995; 8(4):217-232.

Voll expanded upon traditional acupuncture point classification in three directions: by discovering (1) unknown meridians (which he referred to as "systems"), (2) unknown points on traditional meridians, and (3) unknown functions of existing points. Voll's understanding of the traditional meridians is in agreement with the Chinese tradition in that each meridian relates to a specific internal organ (lung, stomach, heart, etc.). Voll's new meridians go beyond to cover type of tissue and structure and categories of biological function. These meridians cover joints, skin, fibrous tissue, fatty tissue, serous membranes, the nervous system (including autonomic innervation), lymphatic drainage, capillary circulation and allergic reactions. Many of the branch points are examples of newly discovered points and point functions. Branch points help tremendously in pinpointing the exact location of abnormal function. For example, the branch points on the two heart meridians (one on each of the hands) include the aortic valve, mitral valve, pulmonary valve, tricuspid valve, conduction system, and coronary arterioles. By combining information from all of the different types of measurement points, it is possible to determine the exact location of a given disturbance, including the layer of tissue effected.

A typical examination with the EDSD begins with the four quadrant measurements (hand to hand, foot to foot, right hand to foot, and left hand to foot) which



6. A hand point measurement taken with the electrodermal screening device, EDSD (Department of Physics, Soochow University, Taipei, Taiwan)

Organ structure, function, EM pathways, and emotional interaction are crucial to the meridian

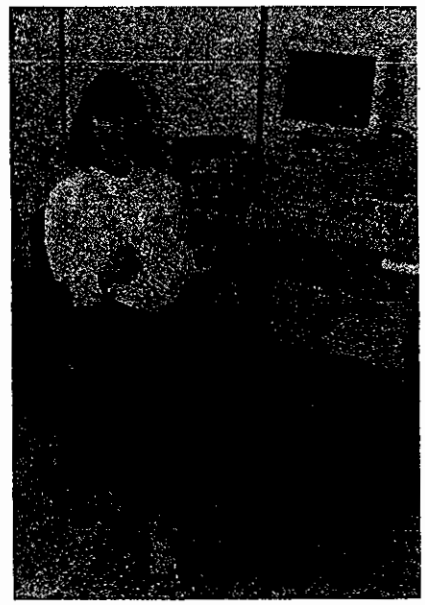
are measurements of whole-body energy levels (Fig. 7). These readings are taken using a pair of brass-tube hand electrodes and a pair of brass-plate foot electrodes. Using the probe, the control measurement points (CMP, some of which are also referred to as summation measurement points) are then measured to ascertain the general condition of an entire meridian. The branch points along the same meridian are checked if there is a positive reading at the CMP or if symptoms suggest that a complete check of a meridian is warranted, regardless of the CMP reading.

When a point exhibiting an ID is located, various reagents can be tested against that point in a process referred to as medicine testing. It is the goal of the physician to find one or a combination of reagents that will balance the point, i.e. cause the point tested to have a reading near 50 and not have an ID. Reagent samples in sealed glass containers are put into the measurement circuit by placing them on a metal plate designed for this purpose. The physician tests various reagents, basing the selection on medical knowledge and experience, until an appropriate reagent or combination of reagents is found. A reagent that balances the reading may have a positive effect on the system being measured and therefore be an appropriate medication or dietary supplement. No response implies that the reagent would have no effect on the system, and a worsening response implies a negative effect. For example, pancreas CMP readings of a person with diabetes will become balanced when the proper dose of insulin is placed within the circuit and will show a larger ID if refined sugar is put there.

Medicine testing is perhaps the most controversial aspect of the EDSS, though many also consider it the most promising [13]. It was discovered and used by Voll in connection with homeopathy, and the effectiveness of the EDSD in testing homeopathic remedies has been demonstrated in clinical studies [14]. Homeopathic remedies serve as particularly useful reagents for medicine testing because they are prepared at various dilutions, which increases the likelihood of finding an appropriate "resonance," a phenomenon which will be discussed in Kuo-Gen Chen's second article. Medicine testing has also been shown effective in the testing of herbal and allopathic medicines [15] and has been used very successfully to test for allergies [16] and for the presence of environmental pathogens such as insecticides. [17] Virtually any sort of biological reagent can be tested in this fashion.

Conclusion

Acupuncture has been used for thousands of years and is effective in a wide range of situations. It has not been integrated into modern health care primarily because of lingering suspicions that it is not scientific. A bio-energetic model has been developed to explain nearly all aspects of acupuncture and meridian theory, but there remains a definite prejudice against human energetic theories in the



7. A four quadrant measurement taken with the EDSD (Department of Physics, Soochow University, Taipei, Taiwan, earlier model). Reprinted from Tsuei JJ. The Past, Present, and Future of the Electrodermal Screening System (EDSS). *Journal of Advancement in Medicine*, 1995; 8(4):217-232.

medical-scientific community, which must be overcome before integration can take place.

The EDST and EDSD are outgrowths of the scientific, electro-magnetic understanding of meridian theory. The EDST may appear similar to other modern diagnostic techniques such as MRI, but there are important differences. The EDST is also based on ancient practices and is safer and more holistic, versatile, and cost effective. The device is elegantly simple and not extremely expensive. Hopefully, it will help free medical progress from its dependence on ever more expensive and specialized medical instrumentation. This alone would have a profound effect on health care cost and accessibility. The quality of health care will also improve with integration of the EDST into modern medical practice. Because the EDST makes use of the body's meridian system, it can map and help analyze the body's own signals, making it particularly useful in early diagnosis. With its solid theoretical foundation in modern physics and quantum mechanics, it is perhaps the most "modern" medical methodology available today.

References

1. **Lu J, Cui Y, Shi R:** A Practical English-Chinese Library of Traditional Chinese Medicine: Chinese Acupuncture and Moxibustion, Publishing House of the Shanghai College of Traditional Chinese Medicine, Shanghai, 1988, pg 40.

2. **Kuo FF, Kuo JJ:** Recent Advances in Acupuncture Research. Institute for Adnanced Research in Asian Science and Medicine, Garden City, New York, 1979, pp 401-499.

3. Shanghai College of Traditional Chinese Medicine: Acupuncture: A Comprehensive Text, translated and edited by O'Connor J and Bensky D, Eastland Press, Seattle, pp 529-543, 1981.

4. **Lu Z,** chief ed: Acupuncture Research 19(3-4):118-138, 1994.

5. **Tsuei JJ, Lai YF, and Sharma SD:** The influence of acupuncture stimulation during pregnancy, the induction and inhibition of labor. Obstetrics and Gynecology 50:479-488, 1977.

6. **Jobst K:** A critical analyss of acupuncture in pulmonary disease: efficacy and safety of the acupuncture needle. J Alternative Complementary Med 1:57-85, 1995.

7. **Strohecker J,** exec. ed.: Alternative Medicine: The Definitive Guide, Future Medicine Publishing, Puyallup, Washington, 1994, pp 38-43.

8. **Mann F:** Acupuncture: The Ancient Chinese Art of Healing and How it Works Scientifically, Vintage, New York, 1973, pg 225.

9. **Royal FF, Royal DF:** A review of the history and scientific bases of electrodiagnosis and its relationship to homeopathy and acupuncture. *Am J Acupunct* 19:137-152, 1991.

10. **Nakatani Y:** Skin electric resistance and ryodoraku. *J Autonomic Nerve* 6:52, 1956.

11. **Voll R:** Twenty years of electroacupuncture diagnosis in Germany: a progressive report. *Am J Acupunct* 3:7-17, 1975.

12. **Tsuei JJ, Lam Jr. F, Zhao Z:** Studies in Bioenergetic Correlations—Bioenergetic Regulatory Measurement Instruments and Devices. *Am J Acupunct* 16:345-9, 1988.

13. **Voll R:** The phenomenon of medicine testing in elecroacupuncture according to Voll. *Am J Acupunct* 8:97-104, 1980.

14. **Lam F, Jr, Tsuei JJ, Zhao Z:** Studies on the bioenergetic measurement of acupuncture points for determination of correct dosage of allopathic or homeopathic medicine in the treatment of diabetes mellitus. Am J Acupunct 18:127-33, 1990.

15. **Baker DW:** An introduction to the theory and practice of German electroacupuncture and accompanying medications. *Am J Acupunct* 12:327-332, 1984.

16. **Tsuei JJ, Lehman CW, Lam F, Jr, Zhu D:** A food allergy study utilizing the EAV acupuncture technique. *Am J Acupunct* 12:105-16, 1984.

17. **Tsuei JJ, Chun C, Lu CY:** Study of pesticide residues in the bodies of workers at a chemical factory by bioenergetic measurements. R.O.C. National Science Council Reports, Mar. 1989.

18. **Wang XT:** An Illustrated History of Acupuncture and Moxibustion, Chinese Medical Press, Beijing, 1987, pg 21.

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II. Electrical Properties of Meridians

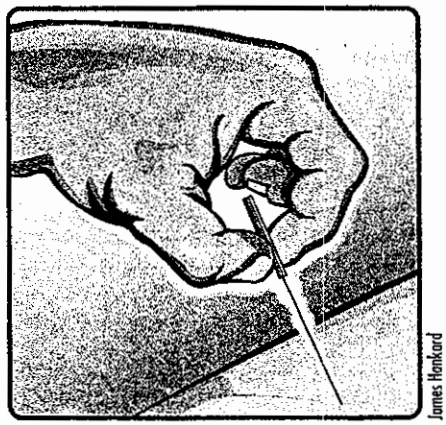
With an overview of the electrodermal screening test

The electrical properties of acupuncture points have been studied extensively [1-3]. It has been shown that more than 90% of skin points of particularly high conductivity coincide with traditional acupuncture points [4-6]. An important outgrowth of these discoveries was the development of the electrodermal screening device (EDSD), test (EDST), and system (EDSS). Research in the energetic properties of the skin has continued, including the successful imaging of meridian and acupuncture point activity [7] and imaging of various human biological energetic properties, including infrared thermal, radiothermal, acoustothermal, electric, and magnetic radiation and chemiluminesence [8].

In early studies, the stratum corneum and epidermis as a whole are generally described using a frequency independent RC-parallel circuit. Deep tissue, or dermis, is understood to be a pure resistance (Fig. 1). Further advances in the model included skin and interface potentials in considering the electrolyte effect [9], which in turn brings about ionic motion in response to the applied voltage [10,11], but the model remained essentially the same. The old model contains only passive elements, which can not adequately describe the activity of living organisms. It does not include a response mechanism of the measured meridian, and therefore can only elucidate responses where meridian function is not a major aspect. Beginning in 1988, I tried to construct a new model based on a systematic conceptualization that included the active elements found in living organisms. The result was a model that can generate possible response currents that qualitatively and quantitatively match all known clinical data.

Body's Response to Small DC Stimulation

The old model fails to adequately describe measured phenomena because it is based on two restricted assumptions: 1) that a living organism can be modeled using only passive elements, and 2) that



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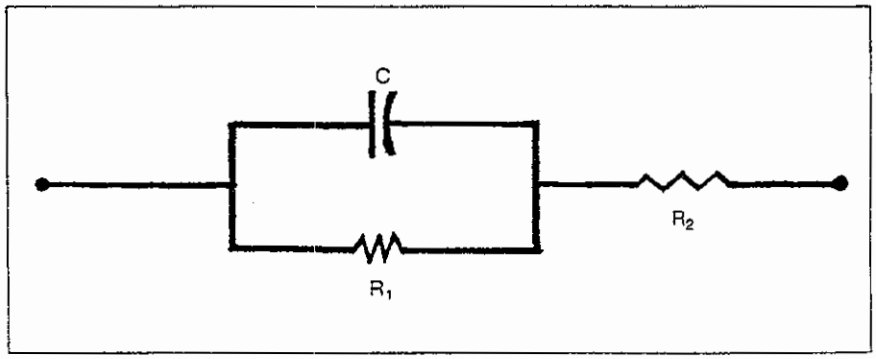
the electrical current passes only through skin and not through other tissues. Both traditional meridian theory and my experience suggest just the opposite, that active responses are involved and that the current passes through many parts of the body. In reality, a weak electrical DC stimulus evokes three mechanisms in the body: electric conduction, dielectric polarization, and self-regulation by an organic defense system. The first two are physical and the third is biological.

The moment that a direct current of about one volt is applied to two electrodes attached to the skin, such as during the EDST, electrons and ions propelled by the circuit begin to move through the body. The mobility of electrons is influenced by cellular metabolism and the concentration of charged particles suspended in body fluid. The net effect can be described using a resistance function of time. A constant, swift change takes place from the moment the circuit is closed till it reaches a final, steady state. From the point of view of statistical physics, the resistance function would be:

$$R(t) = R_o/[1-(1+t/\tau_1)\exp(-t/\tau_1)] \quad (1)$$

where R_o is the final resistance of the circuit (including both the device and the patient), after the circuit is closed for a time longer than τ_1 . τ_1 is the relaxation time of electrons in the circuit. Experimental data show that τ_1 is always less than 50 ms.

In addition to electrical conduction, the cells will be polarized by the force of applied voltage, E, as shown in Fig. 2. The charge on the cellular membrane will cause displacement in such a way as to produce an opposing field. There is a slight separation between the positive and negative charges, causing a small electric dipole in each cell. All dipoles are aligned along the force lines of external voltage, E. This alignment results in dielectric polarization potential $V(t)$, which acts



1. This standard model of the electrical properties of the skin was proposed by Rosendal in the 1940s. In this model, stratum corneum combined with epidermis is represented by a capacitor, C, and a resistor, R_1, in parallel connection. The dermis is simply denoted by a resistor, R_2.

against voltage E.

The motion of cellular charges is over-damped due to the high viscosity of cytoplasm and the relative deformation of the cellular state caused by polarization. There also exists polarized long molecules suspending in body fluid, although these do not dominate the process. The net potential, $V(t)$, is actually the sum of all types of polarization. The behavior of dipolar alignment can be expressed by the equation of motion of a driven over-damped oscillator:

$$\ddot{P}_j(t)+2\beta_j\dot{P}_j(t)+\omega^2{}_jP_j(t)=H_j(E) \quad (2)$$

where $P_j(t)$ is the moment, β_j the damping effect, and the characteristic frequency of the type $_j$ dipoles. $H_j(E)$ is the action of external voltage E applied on $P_j(t)$. If the initial conditions were $P_j(0)=0$ and $\dot{P}_j(0)=0$, the complete solution of $P_j(t)$ is:

$$P_j(t)=(H_j/\omega_j^2)[1 - Z_j \exp(-t/\tau_{2j})+ (Z_j -1)\exp(-t/\tau_{3j})] \quad (3)$$

In the above, Z_j is a constant and τ_{2j} and τ_{3j} are the two relaxation times for an over-damped oscillator. τ_{2j} and τ_{3j} are related to β_j and ω_j :

$$\tau_{2j} \equiv 1/\left[\beta_j - (\beta_j^2 - \omega_j^2)^{1/2}\right]$$
$$\tau_{3j} \equiv 1/\left[\beta_j + (\beta_j^2 - \omega_j^2)^{1/2}\right] \quad (4)$$

And it is now possible to define :

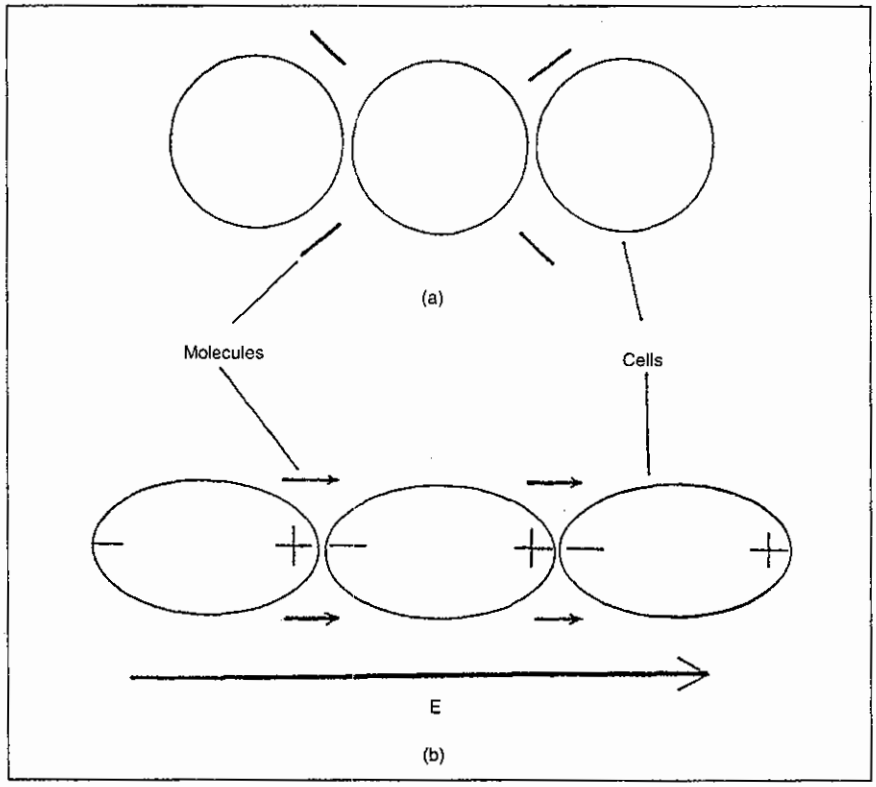
$$Z_j \equiv \tau_{2j} / (\tau_{2j} - \tau_{3j}) \quad (5)$$

If N_j were the number of type j dipoles per unit volume and D the separation distance of the two electrodes, then the potential difference $V(t)$ induced by dielectric polarization is:

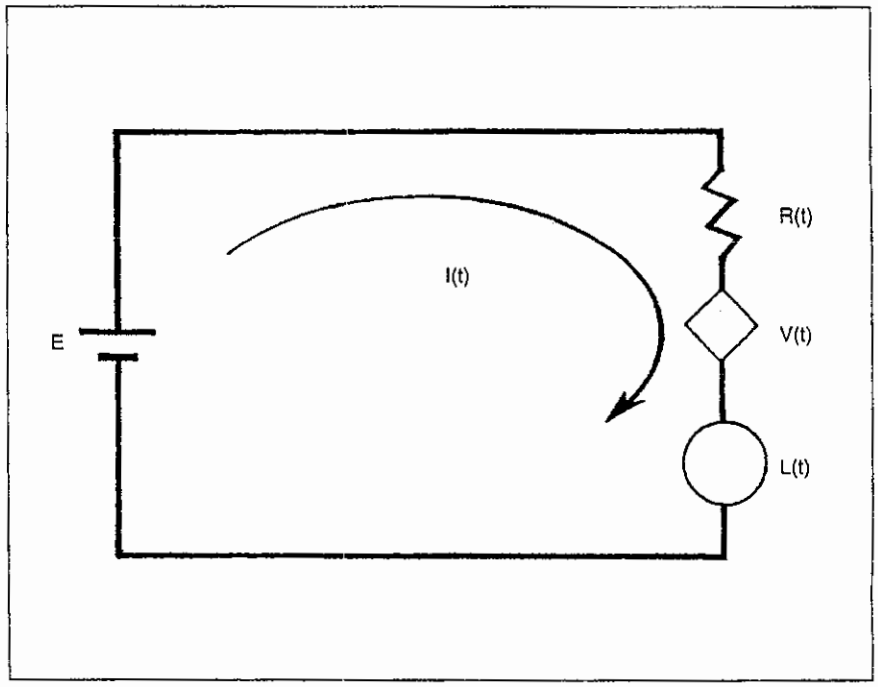
$$V(t) = \sum_j N_j P_j(t) D / \varepsilon_0$$
$$= \sum_j V_{oj}[1 - Z_j \exp(-t/\tau_{2j}) + (Z_j - 1)\exp(-t/\tau_{3j})] \quad (6)$$

In the above, ε_o is the permittivity of free space, and V_{oj} is the final polarization potential of type j dipoles as time t tends to infinity. The summation includes all types of dipoles.

Every living organism has a strong immune system to protect itself from disturbance at all times. Naturally, polarization induced by an external voltage will provoke the cellular immune system. The immune system responds with an oppos-



2. Cells before (a) and after (b) polarization. Applying an external DC voltage, E, will induce a charge displacement of the cellular membrane, or a small electric dipole inside each cell, which causes all cells in the circuit temporarily to be elliptically deformed. The long molecules suspended in body fluid are also polarized and aligned along the applying direction of *E*. The induced dipole moments of both cells and molecules between the electrodes thus produces a polarization potential, *V(t)*, which opposes the voltage *E*.



3. The circuit formed between the EDSD and the patient during a measurement. *R(t)* is the resistance, and *V(t)* is the polarization potential induced by the applied voltage, *E*. The self-regulating function of the cells results in an electromotive force (emf) called life potential, *L(t)*, which acts against *V(t)*.

ing behavior, a net electric energy gradient or electromotive force (emf), which is brought about by complicated processes taking place inside the cells. These processes covert chemical energy (stored within the cells in the form of bio-mass) into electrical energy. Because this function is peculiar to living organisms and is not found in inanimate objects, I refer to it as life potential $L(t)$.

With the above considerations, the effective circuit for electrodermal screening test, including both the device and the patient being measured, can be depicted as in Fig. 3. The current passing through the human body would therefore be:

$$I(t) = [E + L(t) - V(t)] / R(t) \quad (7)$$

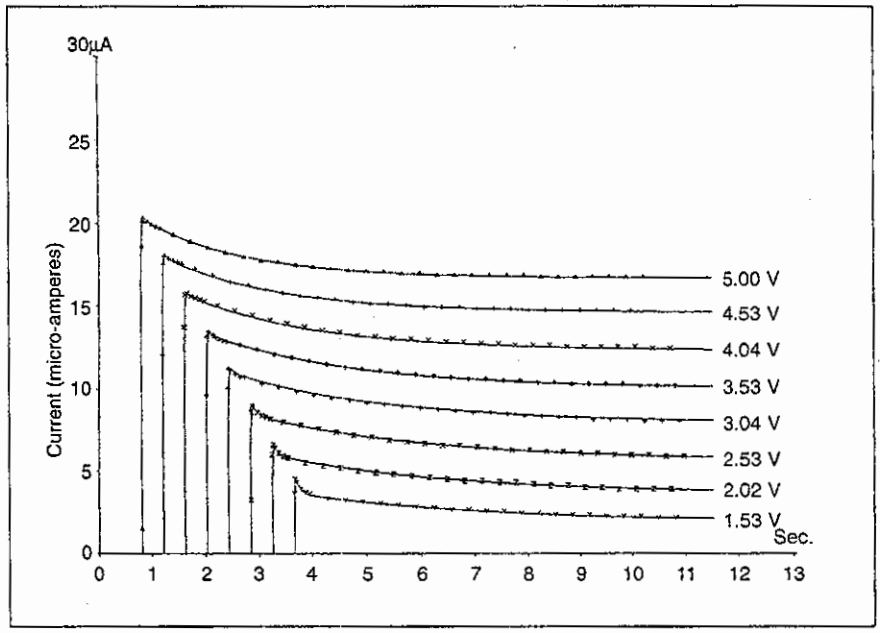
In experiments it is only possible to get the net balance between life and polarization potentials. They can not be obtained separately. Balance potential $B(t)$ is the difference between life potential $L(t)$ and polarization potential $V(t)$. Therefore, Eq. 7 becomes:

$$I(t) = [E + B(t)] / R(t) \quad (8)$$

In healthy people, the life potential $L(t)$ behaves similarly to polarization potential $V(t)$. It is thus possible to compute current $I(t)$. We have done this repeatedly and compared the observed data with a curve based on theoretical computations made with Eq. 8 (Fig. 4). I personally have taken over 10,000 readings in the last 6 years, and every curve I have seen can be analyzed in this fashion.

The above theoretical discussion is true for all skin areas, but there are also implications specific to EDST readings, particularly Eqs. 6 and 7. The first reading in the EDST curve, generally the highest point on the curve, is the peak value of the response current, which is inversely related to the electric resistance of the measured point. Voll developed standard interpretations for clinical EDSD readings which are discussed briefly in the preceding article by Julia Tsuei. Curve behavior after the peak is an expression of the competition between life potential and polarization potential. A representation of the five standard curve types and their interpretation using values from Eq. 7 are found in Fig. 5.

The figure does include an example of a reading drop, but possible variations in the drop are not depicted. Three variations are commonly observed: steep drop, gradual drop, and uneven drop. A steep slope generally corresponds to acute disease, while a gradual sloping may indicate chronic conditions, such as cancer. If a gradual drop is found, it is crucial that the measurement be taken until the dropping stops, so that the complete amount of the drop can be noted. An uneven, wavy slope is probably due to either unsteady functioning of life potential or electro-chemical reactions taking place within the body during the measurement.



4. The small symbols are examples of typical experimental data (human response currents) for various strengths of applied voltage, E (from 1.5 to 5 V). The lines represent values created using the formula developed to describe this phenomena (Eq. 8). Note that the experimental data and theoretical values are in excellent agreement.

Theoretical Properties Specific to Meridians

We then continued this line of theoretical research in the hope of understanding properties specific to meridians. It would have been possible to continue the process of fitting mathematical formulas to experimental curves, but this would have been an extremely difficult process involving eight parameters. The decision was made to proceed with a further evolution of the equation analysis based on two indicators, one to show conductance (I_p) and one to show net polarization (FD). Preliminary research shows that results attained by continuing the process of fitting curves would have yielded very similar results.

Relaxation time, τ_1, of resistance function $R(t)$ is usually less than 50 ms, while the relaxation times of balance function $B(t)$ is always several seconds. The response current reaches its peak value, I_p, much earlier than the reaction of the balance function. One could say that the human body functions as a resistor during the first 50 ms following the closing of the circuit and then as a semi-dielectric. The peak current,, can be expressed as:

$$I_p \approx E / R_o \quad (9)$$

R_o is the final resistance. It is clear from Eq. 9 that the magnitude of I_p is an equivalent measurement of conductance.

After the circuit is closed for a time much longer than τ_1 resistance $R(t)$ will reach its final constant value R_o, and balance potential $B(t)$ will reach a value very close its asymptotic value, B_o. Hence the final current I_f becomes:

$$I_f \approx [E + B_o] / R_o \quad (10)$$

It is now possible to introduce a new indicator, called fractional drop (FD):

$$FD \equiv [I_p - I_f] / I_p \approx -B_o / E \quad (11)$$

B_o which can be measured using the FD value, is the final balance of the measured meridian under the application of the external voltage.

The phenomenon behind the FD (Eq. 11) and Voll's ID is the same. The only difference is the mathematical expression. Strictly speaking, the ID is expressed as:

$$ID \equiv I_p - I_f = -B_o / R_o \quad (12)$$

Note that there are two inter-dependent

variables in Eq. 12, so it is much more difficult to resolve the equation, possibly resulting in misinterpretation of the reading. For this reason, I prefer FD as an expression of the polarization phenomenon.

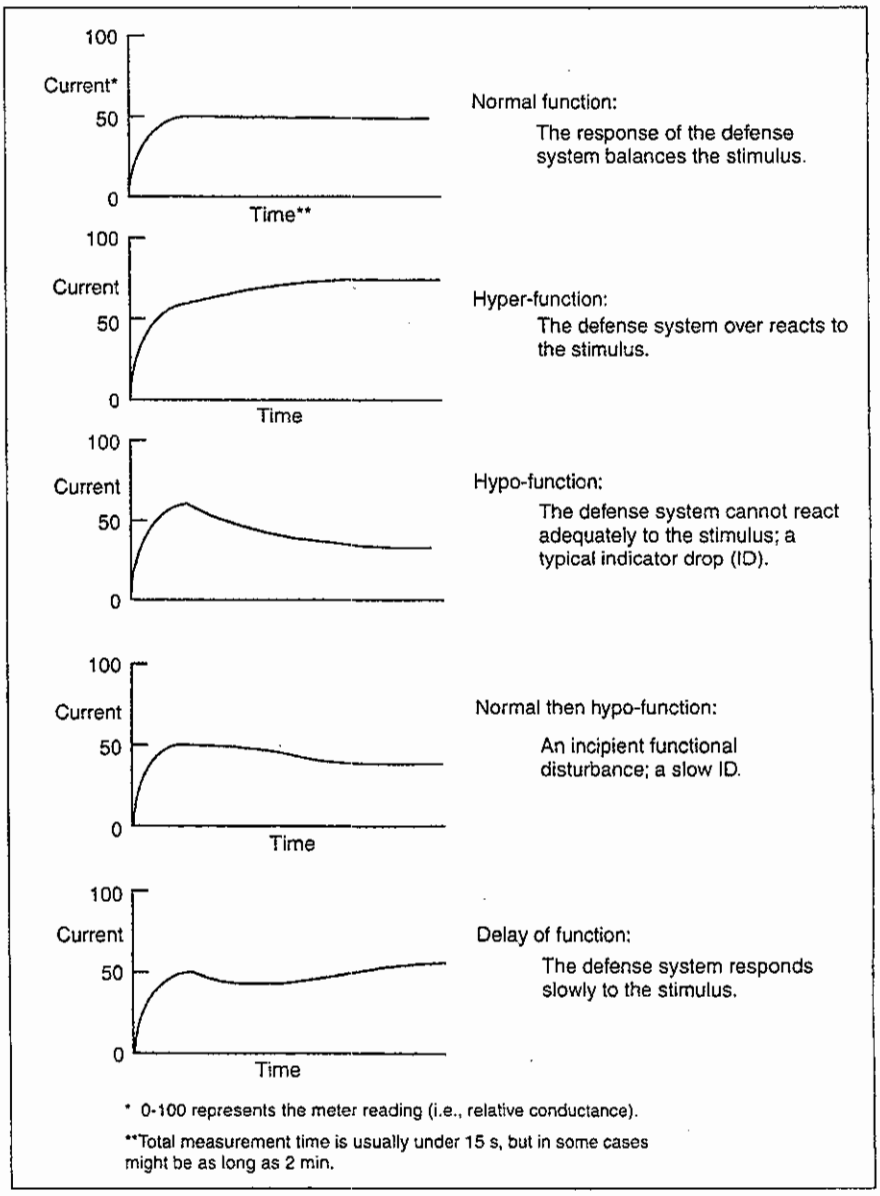
Clinical Measurement of Meridian Properties

We have completed two small studies to test the above theoretical formulations, one in 1991 of arm points on the large intestine meridian [12], and one in 1993 of arm points on the pericardium meridian [13]. The following is a description of the pericardium meridian study, though the same methods were used in both. All data quoted below are from the pericardium meridian study.

In the pericardium meridian study, there were 30 volunteers: 19 males and 11 females, ages 19 to 30, average age 25.06. Electrodes were affixed over two genuine acupuncture points ("Chiu-tsa" HE3 and "Nei-kuan" HE6) and two non-meridian points located 1 cm away from the two above mentioned points (Fig. 6). Points were located using both traditional methods and by measuring skin conductance. Applied voltage, E, in this case 1.5V, was turned on and off from a distance to avoid any direct or indirect contact between the technician and the subject. After each measurement, the electrodes were shorted in order to erase the resulting polarization around them. The time interval between any two successive measurements was at least 20 s, so as to avoid any carry over effect. Both pairs of points were measured 20 times on each subject, switching current direction so that we had 10 readings in each direction. The current direction and order in which the various pairs of points were tested was determined randomly. The data were recorded and analyzed using a computer. Wilcoxon signed rank test was used to discriminate the properties of meridian-point and control-point groups. The paired-t test was used to determine preferential direction.

Both meridians demonstrated higher conductivity than the non-meridian skin areas ($P<0.001$, Table 1), which is in agreement with work of Nakatani [14], Niboyet [3], and Reichmanis, et al., [7]. This finding means that meridians are good paths for electric current, because less energy dissipates flowing through meridians than when flowing through neighboring (non-meridian) tissues. Analysis of the FD shows that less polarization occurs along meridians ($P<0.05$, Table 1). The effect of this property is that meridians have a smaller dielectric constant than neighboring tissue. Because of this, electromagnetic waves move faster through meridians than through non-meridian tissue. It is the combination of these two characteristics, higher conductivity with lower polarizability, that makes the meridian system an efficient bio-information communication network. [6]

We then organized the data according to the direction of energy flow and did further analysis (Table 2). Less resistance results in higher conductance, so the preferential direction of conductance would be the direction of less resistance. The preferential direction of conductance along the pericardium meridian is from the finger toward the body ($P<0.005$). Electric current moving along the pericardium meridian toward the body will encounter less resistance and attenuate less. Polarization in meridians is a different facet, which must be analyzed separately. The lower the polarization, the faster electromagnetic waves will be able to move, so the preferential direction of electromagnetic wave propagation (EMWP) is the direction in which there is less polarization. The preferential direction of EMWP on the pericardium meridian is from the body to the finger. ($P<0.001$) Moving in this direction, there would be less delay in bio-information carried by EMWP [15]. To our surprise, this is the one major area where the two studies differed. On the large intestine meridian, the



5. Five examples of typical readings taken with the EDSD.

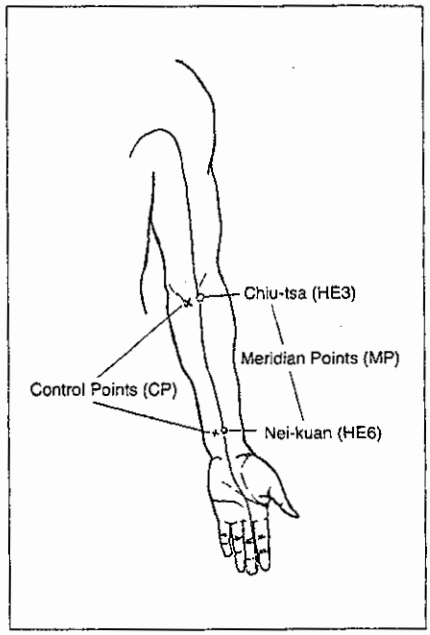
Table 1: From a study of the electrical properties of pericardium meridian points on the left arm: point type analysis.

	toward the body			toward the finger		
Point Type	meridian	control	P value	meridian	control	P value
Avg. I_p*	1.60±1.37	0.41±0.54	P<0.001	1.52±1.27	0.40±0.52	P<0.001
FD*	9.51±10.01	3.99±14.10	P<0.05	-8.10±21.41	2.76±13.05	P<0.05

Table 2: From a study of the electrical properties of pericardium meridian points on the left arm: direction of current analysis.

	meridian points			control points		
Current Direction	toward the body	toward the finger	P value	toward the body	toward the finger	P value
Avg. I_p*	1.60±1.37	1.52±1.27	P<0.005	0.41±0.53	0.40±0.52	P<0.05
FD*	9.51±10.01	-8.10±21.41	P<0.001	3.99±14.10	2.76±13.05	N.S.

*I_p in μA, FD in percent, representing the degree of polarization



6. Line represents the pericardium meridian. Specific measurement points included both meridian points (circles) and control points (crosses).

preferential direction of both conductance and EMWP is from the finger to the body.

The phenomenon of preferential direction in meridians, as observed in our studies, agrees completely with rules of chi circulation in traditional Chinese medicine, including those expressed in the *The Yellow Emperor's Classic of Medicine* (ca. 100 B.C.E., also reffered to as the Neijing). The Neijing describes two types of chi: meridian chi (MC) and subtle nutritious chi (SNC) [16]. The MC in all of the twelve regular meridians is said to flow from the distal points inward toward the body. SNC can flow in either direction. If the meridian runs along the outside of the arms or the inside of the legs, the SNC flows inward toward the body. If the meridian runs along the inside of the arms or the outside of the legs, then the SNC flows outward toward the distal points (Fig. 7). SNC flow directions correspond with the preferential direction of EMWP. The preferential directions of leg meridians, also in agreement with the Neijing, were observed in another study in 1991 [unpublished]. Rosendal observed this phenomenon in the form of differences in DC anodic and cathodic skin conduction, though he incorrectly interpreted the phenomenon as the result of an electrolyte enhancement diffusion process in the stratum corneum [17].

Role of the Meridian System in Biological Development

A fertilized egg first splits into two cells, but these two cells are still physiologically dependent on each other. They are members of an integrated, though relatively simple, living system. They must maintain an extremely high level of integration in order to develop into a human fetus, an extremely complicated living system. To maintain integration between the two cells of a new embryo, both cells must constantly exchange matter, energy, and information. If this is not done, the two cells will develop separately, and either the embryo will die or twins will be born. The communication of matter includes the movement of ions, resulting in an electric current flowing between them through the cellular membrane gap junctions [18]. This pathway must be of lower resistance or higher conductance. The types of energy used in embryonic biocommunication include heat, electromagnetic waves, and electrical potential energy. All of these are transferred back and forth between the two cells at extremely fast speeds, assuring the integration of the larger organism, the embryo.

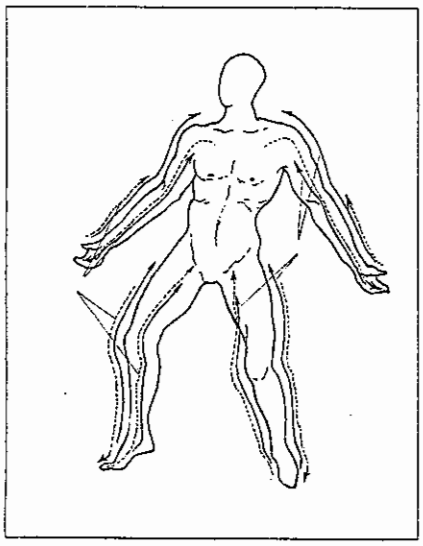
To be as simple and efficient as possible, living organisms channel current and energy waves along the same path. Therefore, one can assume that the various types of information-carrying media in the early embryo travel along the same meridian running between the two cells. Because the circulation, nervous, and hormone systems have not yet developed, this first meridian is the primary route for biological communication and control within the system. The first meridian actively brings about integration of the embryo by controlling cellular generation.

When the two cells split into four cells, the meridian connecting them must become more complicated in order to integrate the four, and thus a meridian system begins to develop. The more the cells split, the more complicated the meridian system becomes. At a certain stage, the organism becomes so large that cellular communication by way of the primitive meridian system is inadequate for continued physiological development. Gradually, many functions of the early meridian system are executed, instead, by differentiated tissues (the early circulation, nervous, and hormonal systems). Naturally, these tissues, which are developing in order to replace various meridian functions, are often located in the same areas and along the same paths as the meridian system. This has been observed in anatomic studies of acupuncture points or meridians [19].

By the second trimester, the circulation and hormone systems have assumed responsible for the transportation of matter, and the nervous system for most electrical signal communication. But throughout the life of the organism, the meridian system continues to execute its primitive function of cellular integration, and it is never totally replaced by differentiated tissues and organs. The meridian system and the regulative physiological systems supplement and compliment one another, thus guaranteeing perfect physiological functioning. None of them can be damaged without affecting the others. In a histological comparison, the meridians

are more primary and flexible than the differentiated systems, and can adjust more quickly to external forces. Differentiated tissues, such as blood vessels and nerve fibers, are more rigid due to their pipe-like structure.

Though the meridian system itself does not have a definite physiological structure, it creates and maintains structure, a role it plays for the entire life of an organism. This role was made clear in the proceeding example of embryo development. However, how does this function express itself in the mature organism? One of the most important functions of the mature meridian system is the control of cellular regeneration. An example of this is the electrical properties discovered by Becker to be active during limb regeneration in salamanders [20]. Though limb regeneration is not possible for humans, the body is capable of healing processes. One such process, the repair of biological structures by the generation of cellular mass, is controlled primarily by the human meridian system. We have found that preferential meridian direction is reversed in some cases of disease, which is similar to the reversal of magnetic polarity that Becker observed in salamander leg stumps during the regeneration process.



7. Directions of flow of two types of chi described in the Neijing (The Yellow Emperor's Classic of Medicine). According to the Neijing, meridian chi (solid lines) flows along all of the twelve regular meridians, from distal points toward the body. Subtle nutritious chi (broken lines) flows in the same direction, along meridians located on the outside of the arms and the inside of the legs. The direction of flow of subtle nutritious chi is the opposite (body to distal) in meridians that are located along the inside of the arms or outside of the legs. Our experiments suggest that the direction of meridian chi corresponds to the preferential direction of conductance, while the direction of subtle nutritious chi corresponds with the preferential direction of electro-magnetic wave propagation.

Conclusion

A model of electrical properties of the skin had been the accepted scientific standard for decades. But this model was based entirely on mechanistic principles and failed to explain many biological phenomena, particularly those relating to acupuncture points and meridians. I have developed a model which, unlike the standard model, includes an active biological response and the fact that the electricity passes though different types of tissue, not just skin. This model not only explains much of acupuncture phenomena, in general, but can also be used to explain all possible EDST readings.

We followed the studies of electrodermal properties with studies of qualities specific to meridians. We discovered that meridians have higher conductance, faster EMWP, and patterns of preferential direction. Because of these factures, the meridian system acts as a particularly good network for the communication of bio-information and thus plays an essential role in biological function. It is very interesting that much of what we have learned through our studies (in which the most modern equipment and methodologies were used) is in agreement with meridian theory dating from 100 B.C.E. and earlier.

Acknowledgments

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References

1. **Rosendal T:** Studies on the conductivity properties of human skin to direct current. *Acta Physiol Scand.* 5. 130-151. 1943.

2. **Nakatani Y:** Skin electric resistance and ryodoraku. *J Autonomic Nerve.* 6. 52. 1956.

3. **Niboyet JEH:** Nouvelle constatations sur les proprietes electriques des ponts Chinois. *Bull Soc Acup.* 30. 7. 1958.

4. **Zhu ZX:** Research advances in the electrical specificity of meridians and acupuncture points. *Am J Acupunct.* 9. 203-216, 1981.

5. **Reichmanis M, Andrew A, Becker RO:** Electrical correlates of acupuncture points. *IEEE Trans Biomed Eng.* 22:533-235, 1975

6. **Reichmanis M, Andrew A, Becker RO:** DC skin conductance variation at acupuncture loci. *Am J Chin Med.* 4:69-72. 1976

7. **Darras JC, de Vernejoul P, Albarède P:** Nuclear medicine and acupuncture: a study on the migration of radioactive tracers after injection at acupoints. *Am J Acupunct* 20(3):245-256. 1992.

8. **Godik EE, Gulayev YV:** Functional imaging of the human body: dynamic mapping of physical E-M fields signals a breakthrough in medical diagnostics. IEEE Engineering in Medicine and Biology (10)4: 21-9. 1991.

9. **Gatzke R:** The electrode, a measurement system viewpoint. in Hood J, Purser P (eds): *Biomedical Electrode Technology.* Academic Press, New York, pp 96-116, 1974.

10. **Yamamoto T, Yamamoto Y:** Electrical properties of the epidermal stratum corneum. *Medical and Biological Engineering.* 151-158 March 1976.

11. **Tiller WA:** Explanation of electrodermal diagnostic and treatment instruments, part I: electrical behavior of human skin. *J Holistic Med* 4(2):105-127. 1982.

12. **Chen KG, Chen CM, Chen AC, Chen CC, Lu CC, et al:** Transient responses of a human body to a small dc voltage and electrical properties of meridians. In: *International Congress On Traditional Medicine (Beijing Ô91). Modern Interpretations of Qi and Blood. Bioenergetic Medicine* . Foundation for East-West Medicine, Taipei, pp 16-25. 1991.

13. **Lan CT, Chen KG:** Electrical identification and polarity of pericardium meridian. Master Thesis, National Yang-Ming University, Taiwan. 1993.

14. **Nakatani Y:** An aspect of the study of ryodoraku. *Clinic of Chinese Medicine,* 3, 54. 1956.

15. **Smith CW:** Coherent electromagnetic fields and bio-communication. In: Popp F, Warnke U, Kšnig H. Peschka W (Eds): *Electromagnetic Bio-Information.* Urban & Schwarzenberg, Munich, pp 1-17. 1979.

16. **Lu HC:** The Yellow Emperor's Book of Acupuncture. Academy of Oriental Heritage, Vancouver. 1973. [This is a partial translation of a section of the Neijing called the Lingshu. The material related to meridian chi and subtle nutritious chi is located between pages 120 and 230, though Lu does not use the same translations of the terms.]

17. **Rosendal T:** Further studies on the conducting properties of human skin to direct and alternating current. *Acta Physiol Scand.* 8. 183-202. 1944; and 9. 39-49. 1945.

18. **Jingyu F, Shiyuan X, Zhe L, Zhemei W:** The role of gap junctions in determining skin conductance and their possible relationship to acupuncture points and meridians. *Am J Acupunct.* 18:163-170. 1990.

19. **Kellner G:** Bau und Funktion der Haut. *Deutsche Zeitschrift fŸr Akupunktur* 3:75. 1966.

20. **Becker RO, Selden G:** *The Body Electric.*

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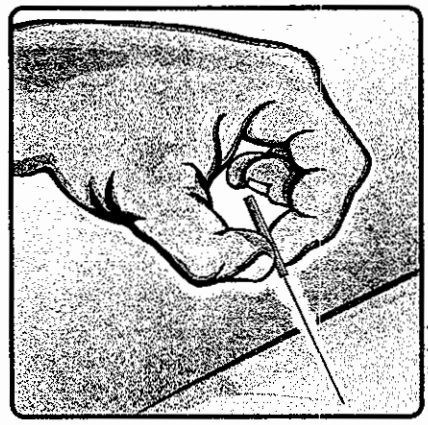
III. Applying Quantum Interference to EDST Medicine Testing



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In 1945, Dr. Reinhold Voll, the inventor of the electrodermal screening test (EDST, referred to in Voll's writings as EAV, electroacupuncture according to Voll), discovered by accident that medicine placed in contact with a patient's body affects the readings of the electrodermal screening device (EDSD). Voll writes:

"I diagnosed one colleague as having chronic prostatitis and advised him to take a homeopathic preparation call Echinaceae 4x. He replied that he had this medication in his office and went to get it. When he returned with the bottle of Echinaceae in his hand, I tested the prostate measurement point again and made the discovery that the point reading which previously was up to 90 had decreased to 64, which was an enormous improvement of the prostate value. I had the colleague put the bottle aside and the previous measurement value returned. After holding the medication in his hand the measurement value want down to 64 again, and this pattern repeated itself as often as desired" [1].

Dr. Voll studied this phenomenon and found it to be consistent in all of his patients, thus allowing him to develop electrodermal medicine testing [1-3]. Many clinical tests have been done to support medicine testing [4,5], and a variety of related applications have been developed for both diagnosis and treatment [6-9]. These will be discussed in detail in the fourth article in this series by Tsuei, Lam, and Chou. I have researched medicine testing and have come to the belief that the mechanism involved is quantum mechanical quasi phase matching. My previous article in this series addresses the bio-energetic aspects of the meridian system. This present article addresses the bio-informational aspects of the meridian system. The following will concentrate on the mechanism behind EDST medicine testing, though I believe this mechanism to be present in all meridians. Both traditional theory and my work suggest that this type of biological communication is the very "purpose" of the meridian system.

It has long been suggested that biological self-regulation is not the result of the function of the nervous system and biochemistry alone and that an additional bio-information mechanism must exist. Important work in this area has been done by Fritz-Albert Popp and his associates [10-11]. The main area of disagreement between their theories and mine is the exact nature of the physical mechanism. Popp sees bio-photon emission as the result of delocalized coherent electromagnetic fields within the tissue, while my theory concerns the localized coherent quantum states within tissues or organs. The information itself is expressed through these quantum states. The quantum states trigger various process, including bio-photon emission and reception, which in turn triggers other reactions within the body. Bio-photon emission is critical to the communication process, and the process can be monitored by way of bio-photon emission, but communication by way of quantum states is primary.

In modern electrical systems, such as computer technology, energy is used to carry information. Theoretically they are separable, but in a practical sense this is not possible. In the human body, information is carried along the body's "wiring," with includes both the meridian and nervous systems. In the case of the meridian system, one could argue that the information contained in meridian energy is primary and the energy itself is secondary, but this is moot. They are inextricably linked, though they can be analyzed separately by means of their expression. For example, in the EDST, the initial reading is primarily an expression of energy, while the indicator drop (ID) and its manipulation through medicine testing is primarily an expression of bio-information.

Phase Modulation of Electron Waves and the Electromagnetic Potentials of Matter

The chemical and physical properties of matter are nothing but the features of electron populations around their component nuclei. However, the distribution of electrons will result in characteristic potential space surrounding matter with a more or less specific range. All electron populations are dynamic, not static. The oscillatory behavior of electrons is a basic characteristic of matter and is the result of their continuous interactions with the matter that surrounds them. Therefore, the corresponding potential of a given type of matter oscillates according to the atomic characteristics of its components. According to quantum mechanics, even if the spacial derivative of this potential has no effect on electromagnetic fields, the electromagnetic potential is still significant to the quantum states of all systems in a given space.

As long as an electron wave continues to pass through the potential space of matter, it will experience an action $S(t)$, which in principle can be calculated using the following integral:

$$S(t) = e\int (V dt' - \vec{A} \bullet d\vec{r}) \qquad (1)$$

The potential space consists of scalar part, V, and vector part, $\vec{A}$.

According to quantum mechanical significance of gauge transformation, an

Quantum mechanical quasi phase matching may be the very purpose of the meridian system

electron wave in such a potential space is transformed by a phase shift:

$$\exp[iS(t)/\hbar] \quad (2)$$

In the above, i is the imaginary unit and $\hbar$ is Planck's constant h divided by 2π. When a beam of electron waves passes through the potential space of matter, the beam will be phase modulated. Therefore, this beam dynamically carries characteristic information of the matter in its shifted phase.

The beam-like electron wave traveling along an EDS circuit, including the effect of matter placed within a circuit (i.e., medicine testing) can now be expressed as:

$$\varphi_m(\bar{r},t) = M(\bar{r})\exp[i\theta_m(\bar{r},t)] \quad (3)$$

$M(\bar{r})$ is a real amplitude determined by the driving voltage of the circuit, and $\theta_m(\bar{r},t)$ is the phase of the modulated electron beam. The time dependence of the phase is determined by the sample of matter in the circuit, i.e., the medicine being tested.

Organ and Tissue Condition

All physiological and pathological phenomena can in some manner be viewed as an expression of characteristic distributions of resident electrons over any volume of organ or tissue mass. These distributions oscillate and evolve according to life processes and environmental interactions. Within the limited time interval used in the EDST, it is reasonable to assume that such electron distributions will change appreciably at some point, $\bar{r}$. The oscillating distribution of electrons at $\bar{r}$ can now be expressed using a state function:

$$\varphi_b(\bar{r},t) = B(\bar{r})\exp[i\theta_b(\bar{r},t)] \quad (4)$$

$B(\bar{r})$ is a real amplitude and $\theta_b(\bar{r},t)$ is its corresponding phase function.

This expression can be used to denote normal or abnormal physiological states of the human body, i.e., it can describe a state of health or of disease. When it denotes health, the electron distribution over the organ or tissue is correct. In an unhealthy state, the distribution is physiologically wrong. When the strength of the improper electron distribution is greater than the intrinsic tolerance of a human body, one begins to feel uncomfortable or ill. If the strength of the improper electron distribution is weaker than bodily tolerance, then one would still feel fine and may have no evident symptoms.

Quantum Interference and Medicine Testing

When a medicine sample is put on the metal plate of the EDS circuit, the electron waves passing through the plate will be phase modulated. When these waves later pass through the patient's body, a given signal is transported to the proper organ or tissue by resonant absorption. The signal waves mix with local electron waves resident in organs or tissues according to the principle of superposition. The resulting wave is:

$$\Psi(\bar{r},t) = \varphi_b + \varphi_m = B\exp(i\theta_b) + M\exp(i\theta_m) \quad (5)$$

According to quantum mechanics, the probability density of electrons existing in such a state is related to the intensity of $\Psi(\bar{r},t)$. However, the intensity is proportional to the time average of the absolute square of resultant wave $\Psi(\bar{r},t)$, i.e:

$$\left\langle|\Psi|^2\right\rangle \approx B^2 + M^2 + 2BM\frac{1}{T}\int_o^T \cos(\theta_b - \theta_m)dt \quad (6)$$

where T is the test duration. The last term of the above equation is the interaction of electron waves entering and already existing within the body.

The phase difference, $\theta_b(\bar{r},t) - \theta_m(\bar{r},t)$, can now be divided into time dependent and independent parts:

$$\theta_b(\bar{r},t) - \theta_m(\bar{r},t) = \Theta(\bar{r},t) + \delta(\bar{r}) \quad (7)$$

In order to obtain a non-vanishing interaction term for Eq. 6, it is clear that the time dependent part of phase difference $\Theta(\bar{r},t)$ must tend to zero.

Under this requirement, Eq. 6 becomes roughly:

$$\left\langle|\Psi|^2\right\rangle \approx B^2 + M^2 + 2BM\cos\delta(\bar{r}) \quad (8)$$

If the constant phase difference $\delta(\bar{r})$ is zero, then Eq. 8 can be rewritten:

$$\left\langle|\Psi|^2\right\rangle \approx (B+M)^2 > B^2 \quad (9)$$

This is the result of constructive interference. In this case, the body electron distribution wave $\varphi_b(\bar{r},t)$ is enhanced by phase modulated electron wave $\varphi_m(\bar{r},t)$. If the phase constant $\delta(\bar{r})$ is equal to π, then Eq. 8 will become:

$$\left\langle|\Psi|^2\right\rangle \approx (B-M)^2 < B^2 \quad (10)$$

which is an expression of destructive interference. The body electron distribution wave $\varphi_b(\bar{r},t)$ is now depressed by the phase modulated wave $\varphi_m(\bar{r},t)$.

Diagnosis and Treatment

The condition $\Theta(\bar{r},t) \approx 0$ for the interaction term in Eq. 6 means that both the phase-modulated electron waves emitted by the EDSD and the electron-distribution waves existing within the body must have similar and approximately equal phase spectra, excluding their DC components. (It is very possible that this relationship is the scientific basis for the similarity principle in homeopathy, though that is a complicated matter that must be discussed separately.) In other words, what we have here is quasi phase-matching between these two electron wave groups. In practice, it is impossible to find a medicine which has a phase characteristic spectrum identical to that of the disease. Only similar ones can be found for treatment of a disease. This principle holds true for all types of medicine, including traditional, herbal, and allopathic.

Constructive interference results in the enhancement of body wave $\varphi_b(\bar{r},t)$ by the phase modulated electron beam $\varphi_m(\bar{r},t)$, while destructive interference depresses it. If the physiological state of the body is acceptable, constructive interference is a supplement mechanism and destructive interference is one of reduction. On the other hand, if the state of the body is pathological, the condition will be intensified by constructive interference (Eq. 9) or weakened by destructive interference (Eq. 10). Both kinds of interference can be employed in diagnosis and treatment. For example, samples of bacteria or virus that

have been treated to reverse there signals are commonly used in the EDST. When a point with an indicator drop is located, the point is retested with various such samples placed on the medicine testing plate. If bacteria sample X improves the reading, it is very possible that the patient is suffering from a condition caused by or marked by the presence of bacteria X. One could then test various possible antibiotics to find the one that best improves the point reading. It is also possible to test the antibiotic against other points to test for possible side effects. For example, in most cases, antibiotics will cause a drop on some points associated with the digestive track because of their effect on the "good bacteria" needed for proper digestion.

Disease can be treated quite well by using the signals of the material collected from the body. The reason is that the signal from such a sample is very similar, perhaps even identical, to the signal of the disease present in the patient. A theoretical treatment for cancer is a good example of this (this method has yet to be thoroughly tested; I use it here as an example only). A sample of the cancer tissue is taken and it's signal is inverted. The inverted signal is administered to the patient by way of a small DC current, similar to that emitted by the EDSD. This current can be administered directly to the site of the cancer, to the cancer site by way of the meridian system, or to the entire body by way of hand-held electrodes. The results should be similar, no matter how the DC current is administered. The inverted signal will conflict with the cancer's signal (quantum interference, Eq. 10), either diminishing or removing the signal. This might have a negative effect on the cancer cells, either killing them or slowing their growth. At the very least, it should improve the patient's feeling of well being because the treatment countereffects a large portion of the cancer's effect on the rest of the body, hopefully also strengthening the body's natural defense and repair systems.

Both constructive and destructive interference can be employed in diagnosis and treatment

Conclusion

Both traditional meridian theory and modern applications such as the EDST demonstrate an essential link between bio-information and meridian phenomena. From the theoretical and clinical work thus far performed by many researchers, it is clear that meridians and bio-information are essential elements of the functioning of the human body. There are many possible clinical applications of the human meridian system and the body's bio-informational processes, including differential diagnosis and therapy to individual patients which is practicable, systematic, and effective, even in the case of complex, multi-faceted medical conditions.

Although this article is almost entirely theoretical, it is in complete agreement with and helps illuminate numerous clinical studies (see the following article in the series by Tsuei, Lam, and Chou). It is my hope that because of this agreement between theory and practice, we are much closer to realizing a broad scientific acceptance of all facets of the meridian theory and the EDST, including medicine testing.

References

1. **Voll R:** The phenomenon of medicine testing in electroacupuncture according to Voll. *Am J Acupunct* 8:97-104, 1980.

2. **Voll R:** Twenty years of electroacupuncture diagnosis in Germany: a progress report. *Am J Acupunct* 3:7-17, 1975.

3. **Voll R:** Nosodenanwendung in Diagnostik und Therapie, ML-Verlag, Uelzen, Germany, 1977.

4. **Tsuei JJ, Lehman CW, Lam FMK, Jr, Zhu DAH:** A food allergy study utilizing the EAV acupuncture technique. *Am J Acupunct* 12:105-116. 1984.

5. **Lam FMK, Jr, Tsuei JJ, Zhao Z:** Studies on the bioenergetic measurement of acupuncture points for determination of correct dosage of allopathic or homeopathic medicine in the treatment of diabetes mellitus. *Am J Acupunct* 18:127-33, 1990

6. **Royal FF, Royal DF: Homeopathy and EDT:** upheld by modern science—with case histories. *Am J Acupunct* 1992:20:55-66.

7. **Khoe WH:** Homeopathic detoxification combined with electroacupuncture according to Voll. *Am. J Acupunct* 9;319-325, 1981.

8. **Schuldt H:** The application of nosodes in electroacupuncture according to Voll. *Am. J Acupunct* 9:161-164. 1981.

9. **Thomson J:** Energetic remote effects of odontons on organs measured by electroacupuncture. *Am J Acupunct* 9:63-67, 1981.

10. **Popp F, Warnke U, Kšnig H, Peschka W (Eds):** Electromagnetic Bio-Information, Urban & Schwarzenberg, Munich, 1979.

11. **Popp F, Nagl W:** A physical (electromagnetic) model of differentiation (parts 1 and 2). *Cytobios*, 37:45-83, 1983.

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Electrical Properties of Meridians

(continued from page 63)

Electromagnetism and the Foundation of Life, New York, Quill, pp 23-102, 1985.

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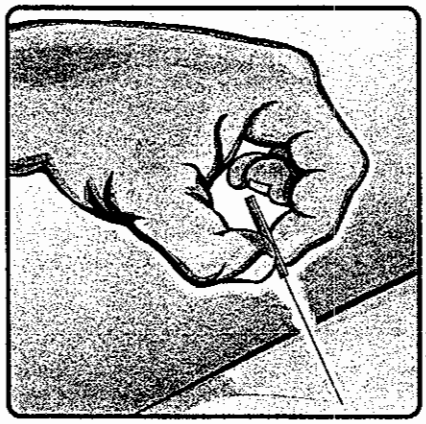
IV. Clinical Applications of the EDST

With an investigation of the organ-meridian relationship

The basic facts regarding the electrodermal qualities of acupuncture points have been adequately described and proven by Becker, et al. [1], Chen [preceding articles], and others. The facet of traditional acupuncture theory most in need of clarification is the relationship between the meridians and internal organs, i.e., proof that internal organs and systems (both their structure and function) are the primary source of the energy present in meridians and acupuncture points.

Many clinical studies of acupuncture treatment have shown the possibility of such a connection. However, it is extremely hard to definitively prove this point in studies of the efficacy of treatment because there are too many confounding factors. There may be one of many factors or a combination of factors responsible for the success of the treatment being observed. Besides, if the goal of a study is to demonstrate therapeutic effectiveness, the exact nature of the mechanism of action is often not considered important. In an excellent review article by Jobst [2] on acupuncture treatment of pulmonary disease, the importance of study design and the definition of effectiveness are discussed in detail. The following is said in regard to study blinding and its effect on results: "These issues are only of paramount importance if the *specific* effects of acupuncture are to be researched. They are not as important if the efficacy of acupuncture as an intervention, inducing its capacity to mobilize the placebo or 'self-healing' response, on the outcome of measures of breathlessness is the subject of inquiry."

For acupuncture and the electrodermal screening test (EDST) to become accepted medical procedures, their mechanisms of action must first be thoroughly studied and at least partially accepted; and an essential part of the mechanism of action is the organ/meridian relationship. Clinical trials of the EDST can not completely prove this connection. But they do bring us much closer, hopefully to the point that the scientific and medical communities are adequately convinced that a definite form of relationship exists. We have found that results from standard testing procedure are similar to results of *skin-level measurements* of electrical properties of acupuncture points, and that changes in measurements can be *predicted based on traditional organ/meridian relationships*. This is an extremely important point, which can not be emphasized enough. This consistent relationship demonstrates a link between organs and meridians. Hopefully, someday soon, we will be able to measure quantifiably meridian energy on the inside of the body at the source organ, on the surface of the body, and along all of the interconnecting tracts of the meridian system. Only then will it be possible to definitively prove the organ/meridian connection.



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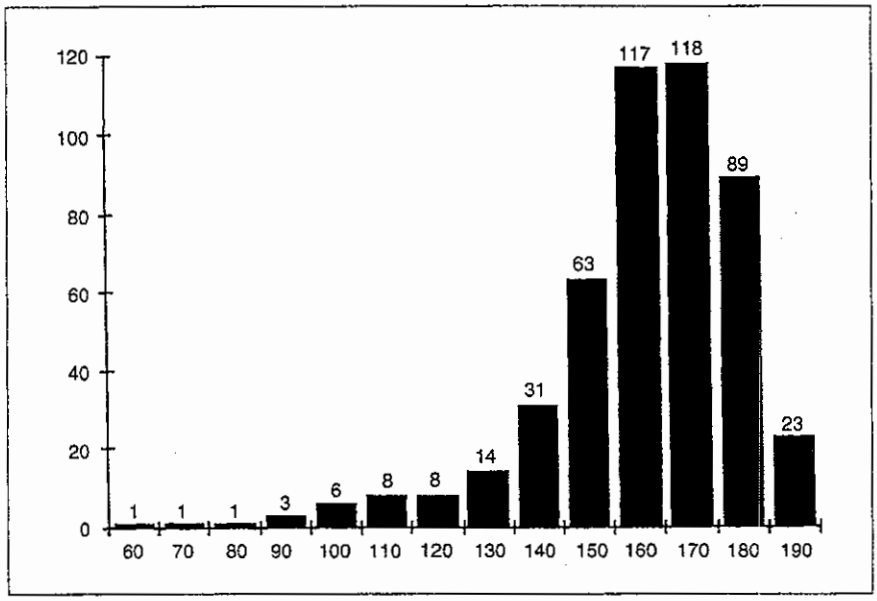
Advantages and Challenges of Clinical Studies

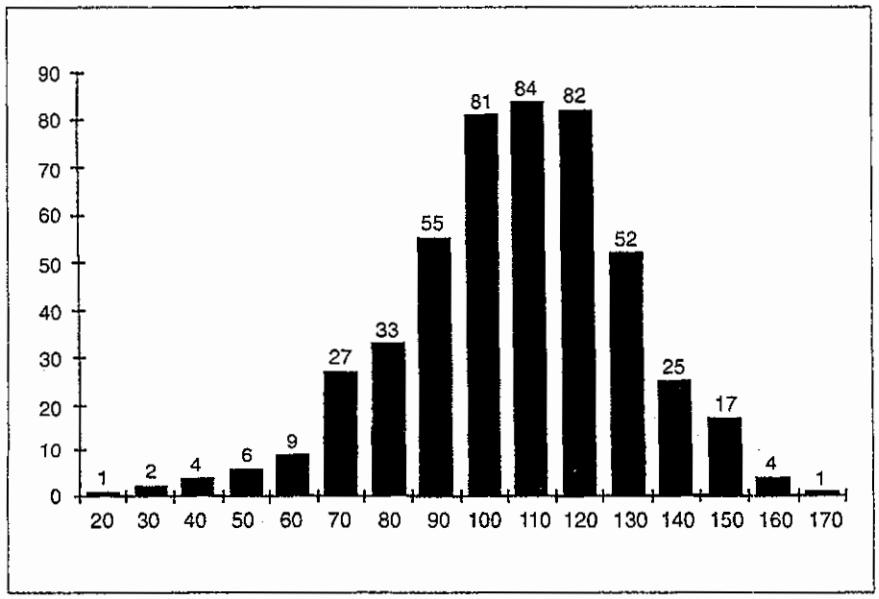
Basic scientific medical research usually emphasizes in vitro and in vivo analysis of the chemical composition of a reagent or the body's physiological response to a reagent or process. For most medical products and procedures, issues of the mechanism of action are addressed during the basic research phase. Today, basic research alone is not enough for a medical product or process to be accepted by the medical community. Applied research, in particular well-designed clinical trials, is the only convincing way to establish the efficacy of a drug or procedure. This is also true of the EDST and the electrodermal screening device (EDSD) and system (EDSS), but here we also have the extra burden of questions regarding the mechanism of action, which have not been resolved in basic research.

Fundamental clinical trial procedures must be followed in studying the effectiveness of any new modalities. They must be compared to conventional, established modalities, even though this is extremely difficult in the case of acupuncture related modalities. Since the presence and movement of meridian energy is not expressed chemically, it is impossible to monitor quantitatively or qualitatively using standard chemical-based testing procedures. For this reason, researchers such as Jobst had to be content with the study of the therapeutic effect on the patient, something which often can be confirmed using physiological measurements.

There are other difficulties specific to EDST research. Since the purpose of EDST measurements is to record vital phenomena in real time, the measurements need to be taken within a specific range of hours during the day. For example, in a study, readings might be taken



1. Bioenergy in healthy subjects, quadrant initial readings. The frequency distribution of initial readings during hand-hand quadrant measurements in Chin values (1 Chin value ≈ 0.5 standard EDST value).



2. Bioenergy in healthy subjects, specific point initial readings. The frequency distribution of initial readings at the left allergy measurement point (AL-cmp-L) in Chin values (1 Chin value ≈ 0.5 standard EDST value).

over the course of months, but all readings must be taken between 11 AM and 1 PM. Due to the large number of variables, a large sample size is preferable, usually requiring highly-selected study populations. A typical study group might be the patients at a large hospital or in a community with well-organized public health services, where records are maintained and standardized. In order to establish a uniform base-line, much time and effort must be spent collecting and reading all varieties of personal and health data of the study population, much more so than in standard clinical trials.

The EDSDs presently available are all manually operated. The technique is not difficult, though training and practice are required. It is our experience that a technician must have at least three months of hands-on experience before he is competent enough to participate in clinical studies. The tester and subject sit across from each other and make some physical contact during testing. There is thus an intermingling of the magnetic fields that emanate from their bodies. It is possible that there are interactions on that level which could effect results; a possible confounding factor to consider during data analysis. There are EDSD models currently available that have electrodes that are affixed to the body, so that no direct examiner participation is required while the reading is taken. We tested various such, but they are still less effective than manual EDSDs. Hopefully, future developments in the device and testing procedure will address such limitations.

A requirement of all scientific procedures is reproducibility. In the EDST, reproducibility can be a problem because the target of the measurement, the meridian system, is extremely dynamic and complex. The more sensitive the device, the more inconsistent the readings. Furthermore, a healthy person's meridian system is more flexible and is able to adjust to the environment more quickly. At the moment of testing, this environment includes the DC stimulus created by the EDST. Because of this flexibility, a healthy person's readings may be less reproducible than an ill person's. In clinical studies, all of these factors have a profound impact on data collection and analysis.

Other aspects of our clinical trials are common to all such trials. For each study group, a definite diagnosis is made using internationally accepted parameters, such as blood pressure for hypertension and blood sugar level for diabetes mellitus. A complete biochemical profile is usually obtained at the same time to rule out other medical problems. Similar data are collected for both the study and control groups. All clinical trials require a great deal of human labor and other resources, making them extremely expensive. This problem is compounded in our case because research in alternative medicine is, in general, grossly under funded.

Ethics are another critical issue for all clinical studies. For treatment studies, it is usually necessary to withhold other treatments or continue traditional ones. The control group might receive ineffective or no treatment at all, which could cause discomfort or much worse. In our studies, the EDST is often used in conjunction with alternative practices such as acupuncture, Chinese herbal remedies, or homeopathic remedies. Both the device and the treatments are non-standard and some

Table 1: Glossary of Measurement Points

Abbreviation	Name	Location
AL-cmp-L	Allergy CMP	left hand *
AL-cmp-R	Allergy CMP	right hand *
AL-lc-L	Vascular sclerosis	left hand *
AL-1c-R	Vascular sclerosis	right hand *
AR-cmp-L	Joints CMP	left foot
AR-cmp-R	Joints CMP	right foot
BL-cmp-L	Urinary bladder CMP	left foot
BL-cmp-R	Urinary bladder CMP	right foot
CI-cmp-L	Circulation CMP	left hand *
CI-cmp-R	Circulation CMP	right hand *
CI-7-L	Coronary vessels	left hand *
CI-7-R	Coronary vessels	right hand *
CI-9-L	Arteries	left hand *
CI-9-R	Arteries	right hand *
FA-cmp-L	Fatty degeneration CMP	left foot
FA-cmp-R	Fatty degeneration CMP	right foot
FI-cmp-L	Fibroid degeneration CMP	left foot
FI-cmp-R	Fibroid degeneration CMP	right foot
GB-cmp-L	Gallbladder CMP	left foot
GB-cmp-R	Gallbladder CMP	right foot
HT-cmp-L	Heart CMP	left hand *
HT-cmp-R	Heart CMP	righthand *
HT-9-L	Pulmonary valve	left hand *
HT-9-R	Aortic Valve	right hand *
KI-cmp-L	Kidney CMP	left foot +
KI-cmp-R	Kidney CMP	right foot +
KI-2a-L	Renal medulla	left foot *
KI-2a-R	Renal medulla	right hand *
LI-cmp-L	Large intestine CMP	left hand
LI-cmp-R	Large Intestine CMP	right hand
LU-cmp-L	Lung CMP	left hand
LU-cmp-R	Lung CMP	right hand
LV-cmp-L	Liver CMP	left foot
LV-cmp-R	Liver CMP	right foot
LY-cmp-L	Lymph CMP	left hand
LY-cmp-R	Lymph CMP	right hand
ND-cmp-L	Nervous system (degeneration) CMP	left hand +
ND-cmp-R	Nervous system (degeneration) CMP	right hand +
ND-la-L	Autonomic nervous system	right hand *
ND-la-R	Autonomic nervous system	right hand *
OD-cmp-L	Organ degeneration (cellular metabolism) CMP	left hand
OD-cmp-R	Organ degeneration (cellular metabolism) CMP	right hand
PA-cmp	Pancreas CMP	right foot +
PA-1	Function of protease formation and protein metabolism	right foot +
PA-2	Function of nuclease formaton and nuclo-protein metabolism	right foot +
PA-3	Function of carbohydrate enzymes and metabolism of carbohydrates	right foot +
PA-4	Function of esterase and lipase and fat metabolism	right foot +
SI-cmp-L	Small intestine CMP	left hand
SI-cmp-R	Small Intestine CMP	right hand
SI-lc-L	Peritoneum in the region of the duodenum I-III and the terminal ileium	left hand +
SI-lc-R	Peritoneum in the region of the duodenum I-III; jejunum; and ileum	right hand +
SK-cmp-L	Skin CMP	left foot
SK-cmp-R	Skin CMP	right foot
SP-cmp	Spleen CMP	left foot +
SP-3-L	Spleen function of red pulp	left foot
ST-cmp-L	Stomach CMP	left foot
ST-cmp-R	Stomach CMP	right foot
TW-cmp-L	Endocrine (Triple Warmer) CMP	left hand +
TW-cmp-R	Endocrine (Triple Warmer) CMP	right hand +
TW-1-L	Gonad and adrenal	left hand +
TW-1-R	Gonad and adrenal	right hand +
TW-ld-L	Endocrine; pancreas function	left hand
TW-ld-R	Endocrine; pancreas function	right hand

All points designated CMP are control measurement points and all other points are branch points. Readings at CMPs can be used to ascertain the general bioenergetic condition of a complete system. Branch points usually offer more specific information on one organ or function, as their names suggest. The far right column shows the special set of cardiovascular related (*) and non-related ( ) points used in the second hypertension study [15] and one of the chikung studies [20]. The ones not marked include both cardiovascular related and non-related points that were not examined in those two studies.

Table 2: Bioenergy of healthy subjects, analysis of variance of whole-body (quadrant) measurements

Source of Variation	Mean Squares				
	d.f.	HH	LHF	RHF	FF
Gender	1	2712.5*	1455.9*	1838.8*	262.9
Age	2	3026.1*	2931.7*	3187.9*	3379.9*
Tester	2	666.0	1962.9*	1243.5*	7.8
Residual	458	238.2	160.5	173.5	191.2

*Highly significant ($p<0.01$)

Table 3: Bioenergy of healthy subjects, least-squares means and standard errors of whole-body measurements, Chin values (1 Chin values 0.5 standard EDST value).

	HH	LHF	RHF	FF
Gender				
Males	168.39±0.87	158.99±0.71	157.24±0.74	170.67±0.78
Females	2.77±1.44	154.87±1.18	52.62±1.23	1688.93±1.29
Age				
Young	170.38±1.49	162.68±1.22	160.84±1.27	175.55±1.33
Middle	166.81±0.99	156.00±0.81	154.26±0.84	170.01±0.88
Old	159.54±1.66	152.10±1.36	149.66±1.41	163.85±1.49
Tester				
A	163.65±1.35	160.86±1.11	155.72±1.15	169.92±1.21
B	165.28±1.31	153.70±1.08	151.84±1.12	169.55±1.18
C	167.80±1.29	156.22±1.06	157.24±1.10	169.94±1.16

Table 4: Bioenergy of healthy subjects, analysis of variance of point measurements

Source of Variation	Mean Squares					
	d.f.	RLIcmp	RAcmp	LAcmp	RPcmp	LScmp
Gender	1	0.6	667.5	862.3	4.5	1437.6
Age	2	461.1	667.5	1542.9	793.8	643.5
Tester	2	1841.6†	485.3	1330.3	1352.0*	5003.5*
Residual	458	478.3	459.0	524.1	613.1	644.1

*Highly significant ($p<0.01$), †Significant ($p<0.05$)

risk might be involved, so finding study participants can be extremely difficult.

In case-control studies, data from healthy and sick individuals are analyzed and compared, increasing the possible accuracy of EDST readings in describing actual conditions. With the EDST, this type of analysis is needed because there are many variables involved in interpretation of readings. For example, no measurment decrease at a specific organ-related point means, theoretically, that the organ probably is healthy, but this is not certain. All we really "know" from this finding is that the structure and function of the systems tested are balanced at the time of the measurement. In most cases, an indicator drop (ID) of less than two points might be due to either a minor condition or a technical error. This ID may be negligible, but depends on the system being measured as well as the suspected condition. An ID of more than two points may imply a medium to major problem. One attempts to clarify such findings by noting the speed and extent of the ID and by medicine testing. There will always be an amount of "art" involved in the process, if only because of the complexity of the full-body system being measured. However, through much proper research, it is possible to continually structure and standardize the EDST.

There are some elements of clinical study structure that work in our favor, particularly because ours are studies of a screening process, not a therapy. Unlike the studies of acupuncture therapeutics described by Jobst, studies of screening effectiveness allows the easy comparison of different study populations and the testing of multiple, control-selected points and meridians, which reduces confounding factors.

The twin Foundations for East-West Medicine were established in 1989, though a number of people, particularly Julia Tsuei and Fred Lam, have cooperated in traditional Chinese medicine research projects for many years previously. The foundations are located in Honolulu, Hawaii and Taipei, Taiwan. We have done cooperative research with two major universities: the University of Hawaii (John A. Burns School of Medicine, Center for East-West Medicine Project) in Honolulu and National Yang-Ming University School of Medicine in Taipei. To date, we have completed over 20 studies on bio-energy and the EDSS. These studies offer proof of a significant co-relationship between meridians and organs and demonstrate that knowledge of this connection has practical implications. These are not the only clinical studies of electrodermal diagnostics, but they constitute the largest body of data on this subject collected by one research group. Other interesting studies include cancer detection using EAV [3] and the Ryodoraku technique [4].

Our research, which began in 1982, was designed in accordance with the accepted steps for scientific approval. Due to its complexity, all research planning was done with the assistance of experts in clinical study design. These experts in-

cluded Elisa T. Lee, a former member of the Committee of Clinical Trials of the United States National Institutes of Health. She has written on the challenges of conducting research of traditional medicine according to modern scientific standards, and we have followed her suggested protocol structure [5]. Not only did we demonstrate the safety and efficacy of a new medical device, we also demonstrated the efficacy of a complicated testing procedure.

Overview of Our Research

We began with two observational studies (both available in English) designed to establish the untested impression that EDST diagnostic results matched those of standard diagnostic tests. In the first study, 11 clinical cases treated in a family practitioner's office were observed, including peptic ulcer, appendicitis, chronic chorea, and cancer of the colon, breast, and uterus. In every case, readings taken with the EDSD matched standard diagnostic tests [6]. This study was essentially just a set of case finding reports, but the results were very convincing and we decided to proceed.

We had heard from many practitioners that the EDSD was particularly useful to determine the causes of allergies. In the second study, allergic symptoms in 30 volunteers were analyzed using 5 standard diagnostic methods (history, skin test, RAST, IgE tests, and food rechallenge) along with the EDST. EDST results correlated strongly with the results of the other five, particularly the food rechallenge test, which is considered by allergists to be the most reliable method of testing for food allergies [7].

The observational studies were followed with a series of descriptive studies (total of seven, with two currently available in English). This series included theoretical studies, studies designed to refine the EDST and standardize the EDSD, and studies designed to demonstrate the EDSD's general effectiveness as a diagnostic tool. During this phase of research, 16 different devices with electrodermal screening capabilities were used and their electronic specifics compared [8]. The following parameters were noted: meter scale units, battery voltage, current (micro-amps, full scale), 100kilo-ohm phantom-load meter units, mid-scale kilo-ohms, ID at 80% phantom load, and rise time to full scale. These data clarify which devices would generate equivalent data, allowing researchers to analyze and compare results from different studies. Such standardization is necessary for proper EDSD research and device development.

It is possible to define much of the meridian system with the electrodermal screening device (EDSD)

In 1987, the first in a continuing series of comparative/descriptive studies was completed (total of six, two currently available in English). In these studies, the bio-energy of varying population groups was analyzed, such as those exposed or not exposed to dangerous materials such as pesticides at the workplace [9], those who had or had not received metal dental fillings [10], and those who did or did not perform a specific activity (such as chikung, see below). These studies were followed by major clinical research projects on electrodermal screening for diabetes mellitus and hypertension (also discussed below).

The study of the effect of metal dental fillings involved 160 subjects [10]. Statistically significant relationships were found that suggest (a) a relationship between the major meridians and galvanic resistance of the teeth and (b) a substantial negative effect of dental fillings on dental galvanic properties, which by extension can effect the primary meridian associated with that tooth and other parts of the body associated with that meridian. For example, we found a statistically significant relationship between metal fillings in any of the third molars and problems in the small intestines and the heart. In this study, diagnosis was done using both standard Western and traditional Chinese procedures.

In the study of pesticide exposure [9] there were a total of 120 subjects, employees at a factory that produced organo phosphate (DDVP). Of these, 60 were workers who came in regular contact with DDVP and its components. The 60 control subjects were office workers who did not come in direct contact with the finished product or the materials used. The 40 control measurement points (points that show the general condition of an organ or sys-

Table 5: Hypertension screening, 7 groupings of points.

Group	Left Ventricle Mass	Systolic Pressure	Diastolic Pressure
1	0.097*	0.013	0.034
2	0.041	0.078*	0.072*
3	0.059†	0.016	0.021
4	0.044	0.007	0.028
5	0.001	0.001	0.005
6	0.000	0.010	0.030*
7	0.006	0.003†	0.022*
1 ID	0.049	0.106*	0.107*
2 ID	0.035	0.046	0.023
3 ID	0.041	0.038	0.042
4 ID	0.018	0.023	0.019
5 ID	0.008	0.003	0.007
6 ID	0.003	0.009	0.002
7 ID	0.004	0.017	0.007

Regression analysis R2 values.
*Highly significant ($p<0.01$), †Significant ($p<0.05$)

Table 6: The positive effect of chikung meditation (16-person chikung study)

Measurement Point	Positive Sign Rank	Probability > ISI
Ly-cmp-L	90.0	0.0260
Ly-cmp-R	98.0	0.0184
Lu-cmp-L	118.0	0.0040
Lu-cmp-R	104.0	0.0202
LI-cmp-L	108.0	0.0070
LI-cmp-R	126.0	0.0010
Ci-cmp-R	70.0	0.0244
AL-cmp-L	111.0	0.0118
AL-cmp-R	86.5	0.0410
Or-cmp-L	70.0	0.0258
SI-cmp-L	96.5	0.0208
SI-cmp-R	91.0	0.0202
Sp-cmp-L	89.5	0.0264
Sp-cmp-R	115.0	0.0022
Lv-cmp-R	119.0	0.0030
BL-cmp-L	124.5	0.0020
BL-cmp-R	121.0	0.0014

Wilcoxon sign rank test of the difference between ID values measured before and after 30 minutes of chikung meditation (statistically significant 17 of 40 control measurement points). In case of a tie, the following adjustment was made:

$$E_H(V_s^*) = \frac{N(N-H) - d_o(d_o+1)}{4}, \quad \textbf{where } N\textbf{: sample size}$$

$$Varu(V_s^*) = \frac{1}{24}[N(N+1)(2N+1) - d_o(d_o+1)(2d_o+1)] - \frac{1}{48}\sum_{i=1}^{c}[(d_i)(d_i-1)(d_i+1)],$$

where d_o: difference among number

tem) were tested with the EDST. Readings from seven points showed a statistically significant correspondence (P 0.05) separating study and control groups. In general, measurements from people in the study group had a higher initial reading and a larger indicator drop at those seven points. Readings from the same seven points also corresponded with blood ACHE (acetyl cholinesterase) levels. This was also statistically significant (P 0.05), particularly for readings from the right nervous system point (ND-cmp-R, P 0.01).

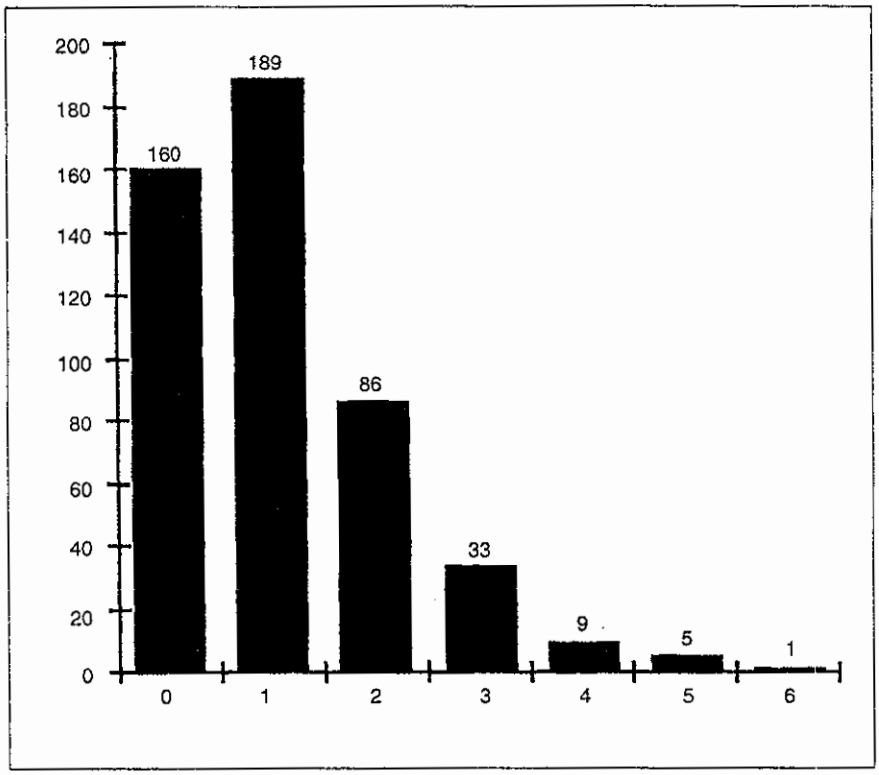
Healthy Subjects Study

The most important of the observational studies was one in which the bio-energy of 483 healthy subjects was measured and analyzed. The body of data that was created is extremely important for a number or reasons. We can now more clearly define norms for EDST measurements including acceptable ranges for inconsistency and natural variations. The data also taught us much about human bio-energy in general. Two reports have been written on this study, one based on the initial readings data [11], and one which emphasizes indicator drop (ID) values but also compares this to initial readings [unpublished, Zhao Z, Tsuei JJ, Lam Jr F: Study of Bioenergy in Healthy Subjects, Analysis of Indicator Drop Values, 1990]. The two studies are in agreement in all major points despite using different measurement parameters, which is further proof of the consistency of human bio-energetic properties, in general. Both studies analyzed reading distributions, which is particularly important for determining measurement norms. (Figs. 1-4)

The data were analyzed statistically according to age and sex to determine, in general, what effect these two parameters have on bio-energy. Quadrant measurements (hand to hand, foot to foot, right hand to foot, and left hand to foot) were found to be related to age and sex, though individual point measurements showed no such relationship. Younger males generally had the highest quadrant readings, but quadrant readings were found to decrease steadily with age for males. Quadrant readings for females were more consistent for all age groups. (Tables 1-3)

The difference between whole-body (quadrant) measurements and point measurements is an important topic that is discussed in both articles. Quadrant measurements measure general biological energy levels, which could conceivably vary among age groups and sexes. Point measurements represent the energy and balance of an individual organ or system at the time of measurement. There appears to be a basic difference between the two types of energy being measured, i.e., different levels of the body's energy are being measured. Zhou, et al., noted that ID values in whole-body measurements were significantly lower (average 0.61 to 1.48) than those found during acupuncture point readings (average 6.60 to 7.69).

It became clear to us during this study that the presence of individual testers can have an effect on readings, and that this must be treated as a possible confounding factor. As mentioned above, the magnetic fields of the subject and technician often intermingle during a measurement and the learned technique is important, but there are other ways in which the presence of the technician can effect the readings. There were three technicians participating in the healthy subjects study, and one of them had a statistically significant negative effect on the readings taken on males but not females. As we were analyzing the data, still blinded to the identity of the technicians, one of us joked that it must be an attractive female. We later found out that the technicians were all female and that the one in question was much more attractive than the others. This finding suggests that physical attraction also effects bioenergy, though much more re-



3. Bioenergy in healthy subjects, quadrant ID values. The frequency distribution of ID values for left hand-foot quadrant measurements in Chin values (1 Chin value ≈ 0.5 standard EDST value).

search is needed before anything definitive can be said. More important, it is an example of possible confounding factors specific to this type of research.

Diabetes Mellitus Case Control Studies

We have completed four case control studies, two of diabetes mellitus (DM) and two of hypertension (see below). These two conditions were chosen because both have strict, universally accepted World Health Organization (WHO) criteria. All four studies clearly show that by measuring the electrical resistance of a few specific points on the skin, it is possible to differentiate normal from abnormal function of internal organs and systems.

The first study was done in Honolulu in 1987 with a total of 55 DM cases and 95 people in the control group [12]. The diabetics generally had lower quadrant measurement values (hand/foot measurements p 0.01), but point measurements proved more useful in screening for DM. Ten points were chosen for study because of their possible association with diabetes according to traditional acupuncture theory or the theories of Reinhold Voll. There was a highly statistically significant difference (p 0.01) between the ID values of diabetics and non-diabetics for all ten points. The mean ID values for diabetics for the points TW-1d-L and TW-1d-R, respectively were 7.4 and 8.2 times that of the control group. The ID at PA-3 (which was identified by Voll as the carbohydrate metabolism point) was the most significant of all. (Refer to Table 1 for a listing of all specific points mentioned throughout this article.)

Statistical analysis of all readings was done to determine which were particularly effected by DM. Nine readings were isolated (initial reading for PA-2 and PA-3; ID values for PA-2, PA-3, OD-cmp-R, OD-cmp-L, PA-cmp, TW-1d-L, and TW-1d-R) and used to create a discriminant function to screen for DM. All study subjects and control group members were screened very successfully (+95% agreement with standard diagnostic procedures).

The second study was done in 1988-89 with diabetic patients (total 50) and healthy people coming for standard physical checkups (total 50) at Veterans General Hospital, Taipei [13]. This time, measurements were taken at the 4 quadrants, all 40 control measurement points, and 4 branch points (PA-3, SP-3, TW-1d-L, and TW-1d-R). Once again, it was found that quadrant measurements were lower and point measurement ID values larger among those with DM. Using the Wilcoxon sign rank test and logistic regression analysis, the following three ID values were found to be the most significant in DM: PA-3, ND-cmp-L, and LV-cmp-L (Kappa value = 0.3409, p = 0.0006). Screening done using these three values resulted in sensitivity of 59.1%, specificity 75%, positive predictability 0.703, and negative predictability 0.647.

Two Hypertension Case Control Studies

We have completed two studies of electrodermal screening for hypertension, one in 1992 [14] and one in 1955 [15]. The results were similar, though the following discussion will center on the second study, in which we did more thorough statistical analysis. Participants totaled 336, age range 20-83, 171 normal-tensive and 165 hypertensive. Measurement points were selected based on either traditional meridian theory or Voll's theories. Forty control points and sixteen branch points were measured on each individual. Of the total of 56 points, 18 represented cardiovascular function and 38 measured the general condition of organs or systems not part of the cardiovascular system (Table 1). The non-cardiovascular points were measured because hypertension is a systemic condition, which most likely would have an effect on various body organs and systems.

Through factor analysis and regression analysis it was possible to divide the 56 points into 7 groups, according to the relationship between the readings and hypertension:

1. Major points on the two hands except left lung and left large intestine
2. Branch points on the hands
3. 11 secondary points on the feet
4. 9 major measuring points on the feet
5. left lung and left large intestine
6. 2 foot branch points
7. Coronary measuring points on both hands

Groups 3-5 were all non-cardiovascular, groups 6 and 7 were cardiovascular, and groups 1 and 2 included both cardiovascular and non-cardiovascular related points. In these statistically-based groupings, both foot and hand points were separated from each other, as were control and branch points.

We then compared the data from all seven groups with standard medical meas-

urements (ultrasound heart mass measurements and systolic and diastolic blood pressures). Group 1's initial reading correlated with left ventricular mass, and ID value related to both systolic and diastolic blood pressure. For group 2, the significant relationships were between the initial reading and systolic and diastolic pressures. Group 3's initial reading related to left ventricular mass. The initial reading of group 6's points related to diastolic pressure. Group 7's initial reading related to diastolic pressure, but the drop rate related to systolic pressure (Table 5). The nature of the groupings and their relationships with data from standard diagnostic procedures are good examples of the coherency of the meridian system.

Discriminant analysis was used to determine if the seven groupings could be used to successfully screen for hypertension and its various effects. To separate normal from hypertensive cases, the most useful measurements were group 1's ID values and group 2's initial readings. To differentiate borderline hypertensive from normal, the most useful measurements were different: the initial readings of groups 2 & 7 and the ID values of groups 1-5 & 7. Most standard diagnostic tests for hypertension were related to groups 6 and 7, which are mostly cardiovascular related, but these are also mixed with some non-related points. There is a very good reason for this. These relationships are examples of those between the various organs and systems. For example, group 6 includes the left & right renal points, and it is not at all surprising that hypertension would have an effect on renal function.

Chikung Studies

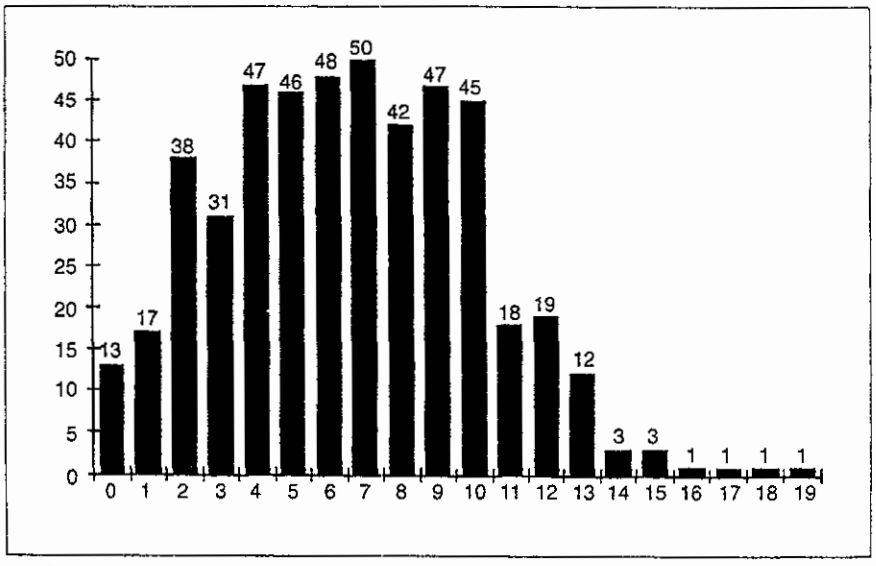
Like acupuncture, the ancient practice of chikung (also spelled *qigong*) meditation is also based on meridian theory. Chikung meditation is usually done sitting still with "regulation" (a relaxed concentration on) of breath. This practice supposedly improves the circulation of both blood and chi energy. Intermediate practitioners of chikung begin to learn how to consciously monitor the flow of chi through their bodies. Advanced practitioners can control the flow of chi within their bodies. Very advanced practitioners and masters can emit chi that can be measured by some scientific devices. Emitted chi is said to have curative powers and can be used therapeutically.

We have had numerous clinical experiences involving the EDSD and chikung masters and practitioners. Many masters are able to effect the readings of a sick person by emitting chi toward them during the test. In effect, they are using their own chi to affect the chi of the patient and improve the patient's reading, at least temporarily. We also suggest chikung meditation to many of our patients and often see a definite improvement after they have practiced for a period of time. Data for a study of this phenomenon is still being collected, but we feel very safe at this time in asserting that there is a connection between chikung, the meridian system, and the energy measured with the EDSD. Chikung practice seems to strengthen and increase the body's energetic properties. Chikung practitioners make particularly good subjects for bioenergetics research. We believe that scientific validation of chikung and emitted chi are valuable for many reasons, including the fact that this is another expression of meridian energy and constitutes part of their proof.

A series of studies have been conducted attempting to define better emitted chi. Studies by Lee [16] and Chien, et al. [17], have isolated infrared light as part of the energy present in emitted chi. In both studies, an InSb detector was used to measure the level of infrared radiation (3 to 5 μm) at the palms of advanced chikung practitioners. Both studies noted that two type of emitted chi produced opposite results. "Facilitating chi" increased infrared levels, while "inhibiting chi" reduced infrared levels. Chien, et al., [17] also studied the effect of the two types of emitted chi on human fibroblast FS-4 cells and boar sperm. Facilitating chi increased DNA synthesis, protein synthesis, and cell growth in human cells, while inhibiting chi decreased all three. In the case of boar sperm, facilitating chi increased the respiration rate 12.5-13.0%, while inhibiting chi decreased it 45-48%. A similar study by Hwang [18] offers photographic proof of the negative effect inhibiting chi has on influenza A/Taiwan/H1N1 virus reproduction.

We have completed two studies on the effect of chikung meditation on EDST measurements. The first was a study of 16 relatively advanced practitioners (age 35-68, mean 49.6), all of whom had practiced the *Ta Mo Cheng Kung* style of chikung meditation for at least 30 minutes daily for 3 years or more [19]. Quadrant measurements and all 40 control measurement points were measured before and after a 30 minute meditation session. All quadrant measurements become more evenly distributed and all initial reading values of specific points came closer to the standard value of 50. The mean ID value of 17 of the 40 specific points measured showed positive significant change, i.e., became more balanced (Table 6).

A larger comparative study was completed with a group of 72 beginning to intermediate chikung meditation practitioners [20]. Stratified randomization was used to divided the 72 into a study group (mean age 42) and a control group (mean age 39). EDST measurements were taken



4. Bioenergy in healthy subjects, specific point ID values. The frequency distribution of ID values at the right large intestine measurement point (LI-cmp-R) in Chin values (1 Chin values ≈ 0.5 standard EDST value).

before and after a 30 minute session, during which the study group meditated and the control group just sat and waited. A total of 34 acupuncture points were measured on each individual, including 18 believed related to cardiovascular function and 16 believed to represent most other body functions. (The same points as used in the hypertension study, Table 1.) Measurement readings, in particular skin points representing circulation, improved significantly after just half an hour of chikung meditation. The whole body benefits from chikung meditation, though there is an immediate clear effect on circulation. All bodily systems are interrelated, and positive and negative effects on one system eventual effect other parts of the body, such as the negative effect hypertension on renal function.

Conclusion

The acupuncture and meridian system of traditional Chinese medicine is an important, real biophysical aspect of the living body. With the electrodermal screening device (EDSD), it is possible to define, both quantitatively and qualitatively, much of the meridian system. The meridian system is essential to most or possibly all bodily functions. The EDSD, which reads meridian information, is capable of delivering valuable information on nearly every facet of body function. The EDST could serve as the standard "ruler" by which biological energy is measured, similar to body temperature and blood pressure. In other words, it is conceivable that someday the EDSD will be as commonplace as the thermometer and sphygmomanometer.

The EDSD is non-invasive and economical. With its further refinement and acceptance, along with that of the associated testing methodology (EDST) and health management system (EDSS), it may be possible to chart even the higher functions, including emotional, cognitive, and psychosomatic. The EDST has the potential of developing into a truly complete test of the body, making possible levels of international medical standardization and meta-analysis unknown today. The device, test, and system may prove to be the greatest set of tools against disease created this century. But now what is needed is much more research. It is the authors' sincere hope that many others in the medical-scientific community will see the EDST's potential and initiate further research projects.

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References

1. **Becker RO, Reichmanis M, Marino A:** Electrophysiological correlates of acupuncture points and meridians. *Psychoenergetic Systems* 1(105):195-212, 1976.

2. **Jobst K:** A critical analysis of acupuncture in pulmonary disease: efficacy and safety of the acupuncture needle. *J Alternative Complementary Med* 1:57-85, 1995.

3. **Sullivan SG, Eggleston DW, Martinoff JT, Kroening RJ:** Evoked electrical conductivity on the lung acupuncture points in healthy individuals and confirmed lung cancer patients. *Am J Acupunct* 13:261-6, 1985.

4. **Kobayashi T:** Early diagnosis of microcancer by cancer check of related acupuncture meridian. *Am J Acupunct* 13:63-8, 1985.

5. **Lee ET:** Clinical trials in traditional medicine. In: International Congress On Traditional Medicine (Beijing '91). Modern Interpretations of Qi and Blood. Bioenergetic Medicine (2nd printing, this is not stated on the English title page). Foundation for East-West Medicine. Taipei, pp 98-115, 1991.

6. **Tsuei JJ, Lam F, Jr:** Case findings from a family practitioner's office using electroacupuncture according to Voll. *Am J Acupunct* 11:23-9, 1983.

7. **Tsuei JJ, Lehman CW, Lam F, Jr, Zhu D:** A food allergy study utilizing the EAV acupuncture technique. *Am J Acupunct* 12:105-16, 1984.

8. **Lam Jr. F, Tsuei JJ, Zhao Z:** Studies in Bioenergetic Correlations—Bioenergetic Regulatory Measurement Instruments and Devices. *Am J Acupunct* 16:345-9, 1988.

9. **Tsuei JJ, Chun C, Lu CY:** Study of pesticide residues in the bodies of workers at a chemical factory by bioenergetic measurements. *R.O.C. National Science Council Reports* March, 1989.

10. **Chen SY, Liu CC:** The influence of metal prosthetics to the meridian system expressed by electric potential measurement *R.O.C. National Science Council Reports*, August 1993

11. **Tsuei JJ, Chung C, Lam F, Jr, Mi M:** Studies of bioenergy in healthy subjects. *Am J Acupunct* 16:125-34, 1988.

12. **Tsuei JJ, Chun C:** Controlled study of diabetes mellitus by bioenergetic measurement. *R.O.C. National Science Council Reports* March, 1989.

13. **Tsuei JJ, Lam F, Jr, Mi M, Zhao Z:** Studies in bioenergetic correlations—study on bioenergy in diabetes mellitus patients. *Am J Acupunct* 17:31-8, 1989.

14. **Tsuei JJ, Wang WK, Yang PT:** The study of bioenergetic screening model for hypertension. *R.O.C. National Science Council Reports* November, 1993.

15. **Chou P, Tsuei JJ, Chen CH:** Clinical application of bioenergy in the cardiovascular system, report to the *ROC National Research Institute of Chinese Medicine*, NRICM-84-103, 1995.

16. **Lee SC:** The Qi-Kung States and the Infrared Spectra of External "Qi". *Bulletin of the College of Engineering, National Taiwan University*, June 1990;49:97-108.

17. **Chien CH, Tsuei JJ, Lee SC, Huang YC, Wei YH:** Effect of emitted bioenergy on biochemical functions of cells. *American Journal of Chinese Medicine* 1991;19(3-4):285-92.

18. **Hwang ST:** The Impact of Qi on the Human Promonocyte Cell Line HL-CZ and Influenza A Virus. Masters Thesis, National Yang-Ming University Institute of Traditional Medicine, June 1995.

19. **Chang Y, Tsuei JJ, Chun C:** Bioenergetic measurement of chi-kung practitioners. Paper presented at International Conference of Chi-Kung and Marshall Arts, July 5-7, 1988.

20. **Tsao W, Tsuei JJ:** The effect of meditation on the electrical properties of the human meridian system, report to the ROC National College of Physical Education and Sports, No. 8205, 1993.

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