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# **Bioenergetics, Information and Acupuncture:**

# An Exploration of the Links between Acupuncture

# Information, and Bio-electromagnetism

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## (iii) Abbreviations used

AC Alternating Current
ACTH Adreno Cortico Tropic Hormone
Ag-AgCl
AlCl3 Aluminium Chloride
ARIMA Autoregressive Integrated Moving Average
BC Before Christ
BPBlood Pressure
CaCl
CNS Central Nervous System
CO2Carbon Dioxide
CSF Cerebro Spinal Fluid
DC
DNIC
EAVElectro Acupuncture according to Voll
ECG Electro Cardio Gram
EDSD Electro Dermal Screening Device
EDST Electro Dermal Screening Test
EEG Electro Encephalo Gram
ELF Extremely Low Frequency
EMR Electro Magnetic Radiation
FFT Fast Fourier Transform
fMR1functional Magnetic Resonance Imaging
GSR Galvanic Skin Response
GV Governing Vessel 20
HR Heart Rate
IASP International Association for the Study of Pain
KCl
Li 11 Large Intestine 11
Li 4

NHMRC	National Health and Medical Research Council
NIH	National Institute of Health
NOAA	National Oceanographic and Atmospheric Administration
PC	Personal Computer
PRISM	Psychiatric Records Information Systems Manager
PSM	Propagated Sensation along a Meridian
SQUID	Superconducting Quantum Interference Device
ТСМ	Traditional Chinese Medicine
TENS	Transcutaneous Electro Neuro Stimulation
TF	
UT	Universal Time
VLF	Very Low Frequency
WHO	World Health Organisation

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#### (iv) Summary

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Acupuncture has been used as a therapeutic modality since the beginning of recorded history and is currently used by over one quarter of the world population. While acupuncture can be explained by Chinese medicine theory and the idea that life is dependent on a subtle form of energy, this theory is couched in terms of Chinese cosmology and mysticism and has not yet been reconciled with Western science. A comprehensive 'scientific theory of acupuncture' therefore remains elusive. Although the theories of Chinese medicine and bioenergetic medicine are not yet integrated with Western science, there are suggestions that the investigation of interactions between electromagnetic and biological systems may help in the understanding of acupuncture and other bioenergetic techniques.

The following thesis attempts to explore the phenomenon of acupuncture and to examine how electromagnetic interactions may be involved. Furthermore, it attempts to explore the integration of Eastern and Western ideas using the concepts of information theory. After briefly reviewing the Eastern and Western literature on acupuncture, the nature of acupuncture points and meridians is discussed, along with the influence of electromagnetic fields and the direct current control theory of acupuncture. A series of experiments exploring the properties of acupuncture points and meridians and the electrical effects of needling is then presented.

The experimental reports begin with a consideration of the energetic exchange involved in needling and laser therapy. These describe for the first time the measurement of the potential difference produced by temperature gradients induced in acupuncture needles, as well as the finding of distinct infrared absorption properties of acupuncture points. This is followed by studies looking at the properties of the points and meridians and a field plot of the skin's DC resistance using a multicentre probe is described that reveals a low resistance pattern in the region of an acupuncture point and meridian. The DC resistance between points along an acupuncture meridian is then examined demonstrating a low resistance pathway along a meridian and the dynamic behaviour of the measurements. The transfer

function of an acupuncture meridian is then reported. This leads to the observation that the resonant frequencies of an acupuncture meridian share spectral characteristics with the Earth-ionosphere Schumann resonance and the human EEG. This is the first report of such a relationship and is followed by a discussion of Schumann resonance and possible interactions with biological systems. Finally, the possibility of subtle interactions between environmental electromagnetic fields and health is confirmed by demonstrating a correlation between solar activity and psychiatric hospital admissions.

These studies suggest that electromagnetic interactions play an essential role in biological communication systems and that natural environmental electromagnetic fields are important for human health. Furthermore, it is suggested that an understanding of Eastern medicine and acupuncture in terms of information processes and entropy, may help to integrate these fields with other areas of Western science. This leads to an exploration of the parallels between Eastern and Western concepts and a discussion of acupuncture and the Eastern concept of 'Qi' in terms of information and entropy.

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## (v) Disclaimer

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university or other institution. To the best of my knowledge, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.



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# **<u>1.0 An introduction to bioenergetics, acupuncture and the</u>** <u>**division between Eastern and Western medicine**</u>

#### **1.1 Introduction to bioenergetic medicine**

Bio-energetic medicine encompasses a number of different therapeutic approaches that share common underlying principles. The basic premise of bio-energetic medicine is that energetic processes, including electrical and magnetic processes are essential to life, and that 'bio-energy' acts as a carrier for information that is crucial to biological selfregulation. (Tsuei 1996)

The concept of 'bio-energy' is based on the idea that life is dependent on a subtle form of energy. This energy has been described by many different healing traditions and has been termed '*life energy*', '*vital force*', '*life force*', '*prana*, '*chi*', or '*Qi*'. This energy is described as flowing throughout an organism in order to animate living processes and maintain physical and psychological responses. In this view, pain and disease are said to be produced when the energetic flow is disrupted or blocked and healing is said to occur when the natural flow is restored. (Manning & Vanrenen 1988)

Based on this view, bio-energetic therapies are aimed at restoring the natural energetic flow and thus aiding natural homeostatic responses. These therapies include many different approaches including the approach utilised by acupuncture within the framework of Traditional Chinese Medicine (TCM) as well as various forms of electrotherapy and homoeopathy. (Manning & Vanrenen 1988) In order to restore energetic harmony, bioenergetic therapies often pay considerable attention to the patient's emotional and physical state and the therapeutic act usually involves relatively small, yet very specific, energetic or physical stimuli in which the timing is often important. Thus, bio-energetic therapies are often also referred to as vibrational or informational medicine. (Manning & Vanrenen 1988; Gerber 1996)

As Western science is yet to recognise a form of energy specific to living systems, many of the concepts underlying bio-energetic medicine have been criticised as being unscientific. (NCAHF 1991; Skrabanek 1984) There is no doubt however, that life has evolved bathed in a constant stream of energy. While much of this energy is obvious to us in kinetic, chemical, gravitational and thermal forms, other forms of energy appear to be more subtle. (Davidson 1987) Except for the visible and infrared regions, most of the electromagnetic spectrum is not obvious to living organisms unless specific receivers (such as radios, mobile phones, televisions or photographic plates) are used. The 'invisible' parts of the electromagnetic spectrum however can be found to have profound effects on living systems that may result in either gross or subtle changes. (Presman 1970)

The possibility that electromagnetic energy may underlie acupuncture and other bioenergetic approaches is a common suggestion. (Becker 1991; Bensoussan 1991a; Maxey 1976) This suggestion is supported by the discovery of the electromagnetic spectrum and the solid state properties of biological tissues, as well as evidence provided by practical experimentation and clinical trials. However, while modern attempts to measure and influence electromagnetic pathways in living systems have met with considerable success, there is still much that needs to be learned before bioenergetic approaches such as acupuncture are integrated with Western science.

#### 1.2 The study of acupuncture

Counter-irritation techniques that involve stimulating one area of the body in order to reduce pain in another are as old as recorded history. The use of sharpened bone and stone implements for skin stimulation has been recorded in diverse geographical locations and amongst widely separated cultures including, the Bantus in South Africa, the Singhalese in Sri Lanka, the Eskimos in Alaska, as well as in China, Northern Europe and South America (Mann 1978). It was the ancient Chinese however that elaborated on these techniques and developed the practice of acupuncture that incorporated counter-irritation techniques into a sophisticated belief system that includes philosophical beliefs and empirical principles.

To date, there has been a vast amount of research on acupuncture reported in the Western scientific literature. Most of this focuses on clinical trials, or research into establishing a plausible physiological basis for acupuncture based on neuro-humoral theories invoking complex nerve pathways and neurotransmitter release. (Filshie & White 1998) However, while it is accepted that acupuncture has a sound physiological basis, there are many aspects of traditional acupuncture that cannot be accounted for such as the specificity of acupuncture point and the complex practical rules that guides its use.

Not only do Western attempts to explain acupuncture generally fail to explain the nature of acupuncture points and meridians, these explanations either ignore, or blatantly dismiss the philosophy and principles upon which acupuncture was developed. Thus, while acupuncture has proven to be a relatively safe and effective therapy in clinical practice a comprehensive theoretical framework explaining acupuncture based on scientific principles is yet to be described. The integration of acupuncture into Western medicine therefore is currently based on clinical rather than scientific grounds.

The failure of Western accounts of acupuncture to take into consideration the philosophy and principles upon which acupuncture was developed is not surprising for the origins of acupuncture are often considered to detract from its legitimacy. Thus, it is not uncommon for scientific reviews of acupuncture to begin with sentiments such as the following: "We should realise that one of the great disadvantages of acupuncture –an impediment to its acceptance among scientists in the United States – is that it is often associated with the philosophy, mysticism, and magic of the East." (Dornette 1975)

While Western attempts to explain acupuncture remain incomplete, traditional Chinese medicine theory does provide a comprehensive account of acupuncture and its uses. This theory however, as stated above, is based on empirical observations as well as a philosophy and mysticism that has not yet been integrated into the Western scientific framework. TCM theory therefore remains incomplete from a scientific viewpoint. Yet, while Western scientific attempts at understanding acupuncture need to be based on scientific principles

rather than esoteric philosophy, it is also important to realise that there is valuable knowledge contained in the ancient Chinese concepts and traditional practices. As Prance et al. state; "If traditional Chinese acupuncture is to be applied in the context of Western medicine a rational 'translation' of the procedure is necessary, but this should not mean discarding the traditional Chinese explanations." (Prance, Dresser et al. 1988)

#### **1.3 The division between Eastern and Western medicine**

The lack of integration between Eastern and Western explanations for acupuncture can be seen to be due to a number of reasons that include historical, conceptual and semantic aspects. The division between Eastern and Western ideas is reflected in their different approaches which parallel the two complementary modes of human consciousness, represented by the rational and intuitive, or top down and bottom up approaches to knowledge. Thus, the evolution of medicine has seen the claboration of two distinct yet complementary approaches, with Eastern medicine based on holistic thinking that maintains a cosmological perspective outlining a philosophy of life, and Western medicine based on a reductionist approaches have led to the development of different schools of thought based on different world-views and separated by different languages and terminologies that prevent the exchange of ideas between disciplines.

The use of different conceptual languages is a major barrier to the integration of Eastern and Western medicine for when one group is talking about 'Qi, and 'yin' and 'yang' and another about 'receptor transmitter interactions' and 'neuro-humoral regulation', it is difficult to find a common ground, even though the common goal of understanding and reducing pain and disease is shared. Thus, while much work remains to be done on a clinical level to demonstrate the efficacy of different diagnostic and therapeutic techniques, perhaps the most challenging task is to integrate modalities on a theoretical level. In order for these different disciplines to be rationally compared and integrated however, it is first necessary to develop a common language. Furthermore, any common language must include a framework that includes scientific terminology, as it is in the light of rational scientific inquiry that modern medical practices are ultimately assessed.

The practice of acupuncture is based on the idea of energy flow through an intricate biological communication network. It therefore seems appropriate to attempt to understand the conceptual basis for acupuncture from an engineering perspective, for the concepts of energy and communication fall within the domain of engineering. The applicability of engineering principles to the study of acupuncture is evident when it is realised that the language of information theory and the principles of thermodynamics may provide a common language with which to begin understanding Eastern ideas in terms of Western science.

Information theory has been referred to as the "the language of language". (Weaver 1949) The ability of information theory to bridge discussions between diverse disciplines is discussed by Young, who states in the preface to his text on information theory; "There is one major achievement of information theory . . . the theory has helped in the process of cross-fertilisation of ideas from one discipline to another. It provides a common language, and definable quantities, for use on many different fields of endevour." (Young 1971)

The applicability of information theory to an understanding of acupuncture has not been widely explored yet this seems a fruitful area for further work. Before this suggestion is followed however, it seems appropriate to review the literature on the conceptual and practical basis for acupuncture from both an Eastern and Western perspective. This will be followed by an exploration of the nature of acupuncture points and meridians and the influence of electromagnetic interactions. Supporting experimental evidence for the role of electromagnetism in acupuncture will then be presented and the findings will be discussed in terms of information processes. Finally, the parallels between the basic concepts of Western science and Traditional Chinese Medicine will be explored and an attempt will be made to describe pain and the Eastern concept of Qi in terms of thermodynamics and information theory

#### 2.1 An introduction to traditional Chinese medicine concepts

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Traditional Chinese Medical theory provides a comprehensive explanation of acupuncture based on a functional view of the world and a long history of astute observations. This theory however is couched in the terms of Chinese cosmology and philosophy which employs such concepts as; *"Tao"* (universal order), *"Chi"* (vital energy), *"Wusieng"* (five evolutive phases), *"ko"* and *"sheng"* cycles (constructive and controlling cycles) and *"Yin"* and *"Yang"* (complementary opposites) and other concepts and principles that are not readily accepted by Western science.

The inability of Western science to recognise the basic concepts underlying Eastern medicine prevents the integration of Eastern and Western medical theory and thus in order to begin integrating these world-views it is first necessary to translate Eastern concepts into the language of science and vice versa. This process has already commenced within the realms of modern physics and Eastern mysticism and has been popularised by many authors who have outlined the parallels between the views of Eastern mystics and modern-day, quantum physicists. (Capra 1983; Talbot 1993; Zukav 1979) These discussions however have remained focused on the realms of medicine.

When expressed in the Chinese language it is difficult for Western minds to appreciate the significance of many of the concepts of Chinese Medicine, thus a brief explanation of them is necessary in order to determine how they might be translated into, or integrated with, Western thought. When discussing the principles behind ancient concepts it is difficult to surpass the comments provided by past scholars, or improve upon the wisdom provided by the ancient philosophers, therefore the following section makes extensive use of quotations.

#### 2.2 The historical basis of traditional Chinese medicine

Chinese medicine is based on a comprehensive theory that includes general cosmological and philosophical principles that are applied to human health and disease. The basic principles of Chinese medicine are recorded in the Canon of Internal Medicine called the (The Yellow Emperors Classic of Internal Medicine) which is said to be the oldest extant medical book in the world. This book is said to have been authored by Huang Ti, also known as the Yellow Emperor, who reigned from 2696-2598 BC and is accredited with the invention of wheeled vehicles, armour, ships, pottery, and other useful appliances, as we<sup>11</sup> the invention of the art of writing. (Veith 1966)

The *Nei Ching Su Wen* develops the basic philosophical tenets of Chinese medicine and remains the theoretical foundation for Chinese medicine to this day. As Ilza Veith states in the introduction to her translation of the *Nei Ching Su Wen*:

"The Nei Ching, the Classic of Internal Medicine, attributed to Huang Ti, the Yellow Emperor, is indeed a very important if not the most important early Chinese medical book. ..., particularly its first part, Su Wen, "Familiar Conversations" between the Emperor and his physician Ch'i Po. It is important because it develops in a lucid and attractive way a theory of man in health and disease and a theory of medicine.... The theory expounded in the Nei Ching Su Wen has remained the dominating theory of Chinese indigenous medicine to the present day." (Veith 1966)

#### 2.2.1 The concept of Tao

The Nei Ching is unusual for a medical text in that it emphasises preventative measures rather than empirical treatments and expounds on a natural philosophy that views the world as having a universal order. This order is encapsulated by the concept of 'Tao' (pronounced 'Dow'). As Veith states: "The essence of the universalistic Chinese philosophy is the concept of Tao. It is difficult to translate the exact meaning of this word. The "Way" is probably the closest equivalent. All the ideas of Chinese philosophy converge in Tao. Tao has been described as "formless, nameless, the motive force of all movements and actions, and the mother of all substances." (Veith 1966)

The concept of *Tao* is a difficult concept to grasp, as it is, almost by definition, indescribable; "*the Tao that can be spoken of is not the real Tao*" (Lao Tsu 1989) yet in addition to having important philosophical and religious meanings, the concept of *Tao* also has important practical and medical connotations. 'To be at one with the *Tao*', is considered by the Chinese as being the ultimate state of health. This encompasses a dynamic process that implies being in harmony with all of the continually changing cycles of nature and any separation from this universal order is considered as a source of pain and disease. The concept of the Tao for the Chinese is therefore more than a theoretical concept. It is a way of defining an ultimate state of existence providing an ideal that can be used to guide everyday life, as well as being a central concept within medicine. "*Those who disobey the laws of Heaven and Earth have a lifetime of calamities, while those who follow the laws remain free from dangerous illness*" (Veith 1966)

#### 2.2.2 Yin and yang

While Chinese cosmology views the universe as manifesting as cosmic order or 'Tao', this manifestation is seen to happen through the interplay of two opposite, but inter-dependant and complementary, forces: 'Yin' and 'Yang'. As the ancient philosopher Chuang-Tzu states: "One Yin and one Yang is called the Tao. The passionate union of Yin and Yang is the eternal pattern of the Universe". In direct translation, the ideogram for yin means the shady side of a hill and yang means the sunny side of a hill, thus yin and yang indicate polarity as well as cyclic transformations of one into another. As described by Jayasuriya: "Yin is conceptualized as being cold, dark and female. Yang is warm, light and male. Yin is passive and signifies that which is deep and hidden. Yang is active and signifies that which is deep and hidden. Yang is active and signifies that which is deep of the translation of the relationship to each other, one cannot exist, materially or conceptually, without the other." (Jayasuriya 1991)

The dual concepts of *yin* and *yang* encompass a range of philosophical principles that imply a dynamic process of cyclic change as well as the idea of harmony which is obtained through the interplay of polar opposites. This interplay of opposites is represented in the familiar *yin-yang* symbol. (Figure 1) These principles are seen to apply not only to natural and cosmic phenomenon, but also to human activities, illness and disease. As Veith states:

"The central concept of Chinese cosmology since classical times has been the dual forces of yin and yang, whose continuous interaction lies behind all natural phenomena, including the constitution and functioning of the human body. The Su-Wen section of the Nei-Ching explains how maintenance of the proper balance of yin and yang within the body is essential for good health, and discusses the ways of obtaining this equilibrium. These range from proper conduct and mental hygiene-adumbrations of psychotherapy, but also traces of religious concepts - to dietary rules and acupuncture."



Figure 1 Yin and Yang symbol representing the interplay of interdependent opposites

It is difficult to overstate the importance of the *yin-yang* concept for Chinese medicine as life processes are seen to result directly from *yin-yang* harmony and disease is seen to result from an imbalance of these forces. This principle encompasses the idea of balance, harmony and dynamic equilibrium and can be applied not only to physiological and psychological processes but also to social and cosmic processes as well as forming one of the most fundamental principles in medical theorising.

#### 2.2.3 Qi

After the concepts of *Tao* and *yin* and *yang*, the next most fundamental principle : Chinese medicine is the idea that life is dependent on a subtle form of energy. This subtle energy, often termed 'vital force', 'life energy', 'life force', 'prana', 'chi', or 'Qi', is deemed to flow throughout living systems along defined pathways or meridians. Thus while the dual forces of '*yin*' and '*yang*' are in constant flux, this flux is seen to manifest by the movement of "Qi" that is present throughout the environment and flows through and animates living systems.

The Eastern conception of Qi is a subtle one that may be seen to relate to the concept of flow rather than a material substance. As Capra states: "Qi is not a substance, nor does it have the purely quantitative meaning of our scientific concept of energy. It is used in Chinese medicine in a very subtle way to describe the various patterns of flow and fluctuation in the human organism and environment. Chi does not refer to the flow of any particular substance but rather to the principle of flow as such, which, in the Chinese view, is always cyclical." (Capra 1983)

According to Chinese medical theory, Qi is said to come in various forms that animate life. Thus, there is the Qi that is present at birth through the process of heredity, Qi that is derived from food and Qi that results when the products of digestion are mixed with air. Qienergy is believed to be in constant flux and to circulate throughout the body in welldefined cycles and through defined meridians. Furthermore, the Qi is the body, or in a particular part of the body, may be in either excess ("Bu") or deficiency ("Xi") and this may result in aberrant Qi that may give rise to pain, discomfort, and hype- or hyperfunction of an organ that may then give rise to disease. (Jayasuriya 1991) Thus, it is the flow of Qi throughout the body that maintains both physical and psychological processes and the functional integrity of the system. Therapies are best directed at restoring the natural energetic flow, which in turn restores the bodies homoeostatic responses. (Omura 1982)

#### 2.2.4 Five phases

Throughout its cyclic flow, *Qi* is subject to different influences or 'phases' (wu-hsing) that determine its characteristics at particular stages of its cycle. These phases have been commonly termed the "5 elements" although it is certainly more correct to label these as 'phases' rather than 'elements' as the Chinese 'hsing' or 'xing' denotes movement and activity and literally meaning, "passage" or "passing through". (Liao 1992) The Chinese Medicine scholar Manfred Porkert has coined the term "evolutive phases" to emphasise that the 5 phases are more correctly described as processes rather than defined entities; "The Five Evolutive Phases define conventionally and unequivocally energetic qualities changing in the course of time" (Porkert 1974)

The principle of cyclic transformations and the description of different qualities throughout a cycle may be applied to many different aspects of life. Within the sphere of Traditional Chinese Medicine this system is applied to the qualities of the organs, tissue types, emotions, senses, tastes, food types, colors as well as to the seasons, directions, and other natural phenomena. (Jayasuriya 1991) The five phases are commonly depicted in geometric arrangements to emphasise different aspects of this control system and an elaborate set of rules by which the phases may regulate each other is described.

The division of energy flow into five phases allows for a sophisticated description of a system of feedback and control processes within an organism and between an organism and the environment. This system includes constructive ('Ko') and controlling ('Sheng') cycles that together comprise positive and negative feedback cycles that interact through the continual flow of Qi. The theory of five phases therefore represents a stylised control theory whereby the flow of Qi contributes to the maintenance of homeostasis through achieving balance between the forces of *yin* and *yang*. Within the framework of traditional Chinese medicine these basic principles are directly applied to the consideration of biological function and dysfunction and it is from these principles that the theory and practice of acupuncture has been developed.

#### 2.3 Traditional Chinese medicine concepts and acupuncture

The treatment of disease using acupuncture relies on the detection of energetic imbalances and the restoration of harmony through the stimulation of specific points on the body that are believed to be gateways linking the internal and external environments. These points, called 'acupuncture points' or 'acupoints', are used to assess and influence the internal energy and the practice of acupuncture includes many sophisticated techniques and principles through which this may be achieved. Before commencing acupuncture treatment, the traditional Chinese medicine practitioner needs to assess a person's energetic balance based on a clinical history and examination. This includes careful palpation of the subject's pulse, as well as observation of the subject's tongue, complexion and smell. (Kaptchuk 1983) Palpation of specific acupuncture points also plays a role in the clinical assessment of traditional Chinese medicine, as it is believed that in certain disorders specific acupuncture points would become tender. (Jayasuriya 1991)

The procedure of acupuncture involves the introduction of a fine piece of metal, usually stainless steel, into the skin, subcutaneous tissue, or muscle. Typically an acupuncture needle has a diameter of about  $50\mu$ m at the tip and the shaft has a diameter of over  $300\mu$ . (Fleck 1975) however nine different types of needles are described and different techniques are employed with different types of needles at different body sites. The stimulation applied with the use of needles may be quite intricate and can be modified by many factors. Thus, needle stimulation can be modified by altering the needle length, diameter, shape and construction with gold or silver being traditionally used. Furthermore, the needles may be inserted at different angles and to different depths within the tissue. Specific manipulations can also be carried out on the needles such as repeated rapid insertion and withdrawal, twirling the needles back and forth, rubbing the ribbed handle to cause vibrations along the needle shaft, as well as heating or cooling the handle of the needle once it has been inserted. (Jayasuriya 1991)

In addition to stimulating points with needles, the use of heat is commonly employed and the practice of acupuncture is intricately linked to the practice of moxibustion, which involves the application of the burning leaves of the *artemisia vulgaris* (mugwort) plant to specific points on the body. (Omura 1982) Thus, different stimulation techniques could be used depending on the particular clinical condition or energetic imbalance to be treated. There are also many ways to alter these stimulation parameters and different forms and preparations of moxa can be used as well as techniques that serve to alter the frequency of stimulation such as 'sparrow pecking', which involves applying a burning moxa stick close to the skin and then removing it in a rhythmic fashion.

To achieve the desired therapeutic effects stimulation may be applied at different points (or combination of points) and the precise location of applying acupuncture stimulation is said to be of the greatest importance. (Bossy 1984) Drawings and figurines describing acupuncture points and meridians have been used by traditional Chinese physicians for centuries and are still used by modern acupuncturists as a guide to therapy. (Figure 2)

Acupuncture points are defined by anatomical landmarks, body posture, surface markings and creases and as well as measurement of the body called the "cun" which is based on the relative dimensions of an individual's anatomy. The description of acupuncture points is not limited to human anatomy and descriptions of points on animals exist that are thousands of years old (Yu, Zhang et al. 1994) (Jayasuriya 1991)

As well as having specific locations, acupuncture points are said to have specific functions with certain acupuncture points being related to specific internal organs. Points with related functions are said to be joined by pathways or meridians that are named according to the internal organ with which they are associated. The concept of meridians that link related acupuncture points into a functional network has been developed into a sophisticated system of channels and collaterals, with 12 major meridians being connected to the internal organs through 8 extra meridians and various collateral channels. (Tsuei 1998) (Figure 2)



Figure 1 Acupuncture charts depicting traditionally described acupuncture points and meridians.

The functional relationships of acupuncture points and meridians are described in detail with references being made to *yin* and *yang*, five-phase theory and other conceptual constructs of traditional Chinese medicine. (Beinfield & Korngold 1991; Kaptchuk 1983) In addition to acupuncture points being related to each other through the meridian system, a topographical mapping of points is described on various areas such as the ears, hands, feet or face or scalp. These areas are said to contain 'microsystems' that represent the entire body thus providing an example of the philosophical position that the macrocosm reflects the microcosm. (Oleson & Kroening 1983)

The idea that functionally related points are joined by meridians relates back to the concept of Qi, for the meridians are supposedly a series of pathways along which Qi preferentially flows. As well as being described conceptually, the meridians may also be practically described as the path of a distinct sensation called "deqi" or "the acupuncture sensation". This sensation consists of soreness, numbress, distention and fullness, and is commonly felt to radiate along a meridian pathway due to needling an acupuncture point. (Borwankar 1988)

The sensation of deqi is traditionally related to the therapeutic effect of needling and in some individuals who are considered particularly sensitive to acupuncture this feeling is particularly strong and is termed "Propagated Sensation along a Meridian" (PSM). (Bensoussan 1991b) As well as being produced by needle insertion it is often stated that an experienced acupuncturist can feel the sensation of deqi through the needle as a tightening and slight jerking of the needle, or the feeling of the needle being 'sucked' into the tissue. (Chang 1976)

In determining which point to puncture there are many principles are used drawing on the complex relationships between the points, meridians and the conceptual constructs of traditional Chinese medicine. In addition to utilising traditional Chinese medicine theory, point selection also has a large practical and empirical component. It is generally acknowledged that any point that is able to reproduce the patient's symptoms will produce the best therapeutic effect and that any acupuncture point that is particularly painful is also

deemed to be worthy of puncture. (Baldry 1993) Thus, while there are classically defined acupuncture points described in ancient texts, any tender point on the body may be deemed an acupuncture point. Supposedly, the best therapeutic effect is obtained when deqi is elicited and when the most specific points are used. Thus it is said that the master acupuncturist will use the fewest points yet obtain the most dramatic results. (Borwankar 1988)

Based on the traditional acupuncture principles there are many factors that are taken into consideration when deciding on the parameters for a particular acupuncture treatment. These factors include the type, depth and rate of stimulation, the specific points used, including the number and combination of points, as well as the number and frequency of treatments given, as well as the time of day, or even time of year that they are administered. In addition, the training of the acupuncturist along with considerations based on traditional Chinese medicine theory combine to determine the treatment parameters.

While the above discussion has focussed on the therapeutic use of acupuncture points, these same points and philosophical constructs are also described within the 'martial arts'. Therefore, in addition to enhancing physiological functioning, energy transfer at these points may be used to produce pain, numbness, and damage to the body's internal organs, unconsciousness or even death. (Yang 1987) Thus, the conceptual constructs of traditional Chinese medicine appear to provide a sophisticated analysis of the biological engineering of the body that may be related to general cosmological principles.

The traditional Chinese account of acupuncture is detailed and sophisticated however, many questions remain. How can the principles outlined in traditional Chinese medicine be applied to our Western understanding of science and biology? Are there parallel concepts within Western science? Can Western cosmological principles be equally applied to biology and the study of pain? Can the constructs of traditional Chinese medicine be used to inform Western science? How can the useful and practical concepts within Chinese medicine be extracted from the ineffective and useless ideas? To begin to answer these questions requires an ability to translate Eastern concepts into the language of Western science.

## **3.0 Western explanations for acupuncture**

### 3.1 Acupuncture in the West and the development of electrostimulation

Acupuncture reached Japan in the sixth century BC and from there was introduced into Europe in the 1600s by the Dutch physician Ten Rhijne (Hsu 1989). This was followed by other reports from travelling doctors and Jesuit missionaries and during the 18<sup>th</sup> and 19<sup>th</sup> centuries and the practice of acupuncture enjoyed a short period of use in Europe. It wasn't until the early 1970s however, that a report in the New York Times (Reston 1971) prompted serious discussion of acupuncture by Western clinicians. (Porkert 1982).

This 'rediscovery' of acupuncture in the West was somewhat preceded by the development of modern acupuncture techniques within China. The use of acupuncture in China was promoted as a political measure in the 1950s and it is claimed that this served to alter the practice of traditional Chinese medicine. (Porkert 1982) Thus it has been suggested that it is difficult to analyse the role of traditional acupuncture as this has been replaced by new methods that involve constant manipulation of the needle and electrical stimulation techniques. (Dimond 1971)

While the use of electrical stimulation as an acupuncture technique is generally considered a modern day phenomenon, the use of electricity for therapeutic purposes is as old as recorded history. The first electro-therapy treatments were applied with species of fish that produce electric charge and this is depicted by stone carvings in tombs from the Fifth Dynasty of ancient Egypt (2500BC).(Walsh 1997) Electric fish were also used by Roman physicians and their use are described for the treatment of gout by the Roman Physician Scribonius Largus (AD 46) (Kellaway 1946) in his book Compositiones Medicae, which is one of the earliest texts describing electrotherapy and includes the passage;

" For any type of gout a live black torpedo should, when the pain begins, be placed under the feet. The patient must stand on a moist shore washed by the sea and he should stay like this until his whole foot and leg up to the knee is numb. This takes away present pain and prevents pain from coming on if it has not already arisen." (Walsh 1997)

The technology involved in electrotherapy did not improve greatly until the advent of the Leyden jar which could generate and store electrical charge in the mid 1700s at which time electrical stimulation enjoyed an increasing popularity with proponents such as Benjamin Franklin. (Kahn 1994) The use of electrical stimulation applied to acupuncture was first reported by Gennai Hiraga in Japan in 1764, (Omura 1975) yet it wasn't until the 1950s that electrostimulation began to be systematically studied and used for surgical anaesthesia in China.

Modern electro-stimulation techniques involve the use of specially designed electrostimulators, which provide voltages of the order of milliVolts and currents in the range of micro to milliAmps. These devices permit the application of positive or negative potentials to acupuncture points either through skin electrodes or through the direct connection with acupuncture needles. Generally a biphasic pulsed waveform is used that has a zero net DC component so as to avoid the build up of charges around the electrodes. (Walsh 1997) The pulse width is usually between 10 and 200  $\mu$ s and pulse frequencies may be modulated from 1 Hz to 10 kHz with low frequencies of the range 2 to 20 Hz being used to produce an acupuncture-like effect. (Walsh 1997)

The parameters of electrical stimulation are generally adjusted to produce a mild sensation of current without pain and without inducing excessive muscular contraction. The parameters however are largely adjusted based on clinical experience and empirical observations and there are very few principles to guide clinical practice. Despite this, the use of electrical stimulation is extremely common in practice and electroacupuncture has been found more effective than manual acupuncture for producing analgesia (Ulett, Han et al. 1998a)

In addition to the development of electrostimulation techniques, the adoption of acupuncture in the West has led other novel techniques. Currently the practice of acupuncture includes the use of electrical stimulation, laser, microwaves, ultrasound, and

magnetism, as well as the use of implantable electrodes and dorsal column stimulation. (Bensoussan 1991b; Jayasuriya 1991) It is uncertain however, to what degree these techniques can be considered congruent with the practice of traditional acupuncture as they may be employed without reference to the philosophical principles or practical guidelines outlined by traditional Chinese medicine theory. (Ulett, Han et al. 1998b) Thus, while the practice of acupuncture usually involves needles, the definition of acupuncture may be considered to be quite broad and includes other stimulation techniques such as low level laser, moxibustion, cupping, transcutaneous electrical neural stimulation (TENS), trigger point therapy and dorsal column stimulation. (Bensoussan 1991b)

In general, acupuncture has proven to be a cheap, safe and effective therapy, the main use of which is in treatment of pain and addictions. (Cohen 1994) In addition to treating pain, acupuncture has been shown effective in systemic conditions and for surgical analgesia. (Stux & Pomeranz 1990) However, its efficacy is such that there would appear no justification for the use of acupuncture in competition with orthodox anaesthetic techniques. (NHMRC 1989)

The relative safety and efficacy of acupuncture compared to other treatment modalities suggests that in many conditions, acupuncture should be used as a 'first line therapy', thus keeping with the Hippocratic ethic of "*first do no harm*". Acupuncture however, is a medical procedure and like any other procedure, does have associated risks if used without appropriate skills and knowledge. (Carron, Epstein et al. 1974) These risks include transmission of infections from contaminated needles, injury to vital structures by misguided needle placement, and the masking of symptoms preventing early detection and diagnosis. While the risk of infection can be easily prevented with disposable needles or low level laser, the risk of injury can only be prevented through adequate training in anatomy and pathology.

The World Health Organisation estimated that in 1979 acupuncture was a major mode of therapy for one third of the world's population (Bannerman, 1980) and as a guideline for practitioners drew up a provisional list of disorders that lend themselves to acupuncture treatment. (NHMRC 1989) In Australia at present, acupuncture is offered by a variety of

providers including doctors, dentists, veterinary surgeons, physiotherapists, chiropractors, and various lay practitioners. At least 15% of Australian general practitioners currently practice acupuncture (Easthope, Beilby et al. 1998) and over 20% have received some acupuncture training. (Pirotta, Cohen et al. 2000) The extent to which general practitioners practice acupuncture however, appears to be extremely varied ranging from a few consultations to full time practice.

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Neurological disorders	Mouth disorders	Eye disorders
Headache and migraine	Toothache	Acute conjunctivitis
Trigeminal neuralgia	Post extraction pain	Central retinitis
Facial paralysis	Gingivitis	Myopia in children
Peripheral neuropathy	Acute or chronic pharyngitis	Uncomplicated cataract
Post-poliomyelitis paralysis		
Meniere's syndrome	Upper respiratory tract	Gastrointestinal disorders
Neurogenic bladder	Acute sinusitis	Oesophageal and cardia
Nocturnal enuresis	Acute rhinitis	spasm
Intercostal neuralgia	Common cold	Hiccough
_	Acute tonsillitis	Acute and chronic gastritis
Musculoskeletal disorders		Gastric hyperacidity
Acute/ chronic muscle strains	Respiratory system	Uncomplicated duodenal
Frozen shoulder	Acute bronchitis	ulcer
Tennis elbow	Bronchial asthma	Acute and chronic colitis
Lumbar pain and sciatica		Acute bacterial dysentery
Degenerative arthritis		Constipation and Diarrhoea
Inflammatory polyarthritis.		Paralytic ileus
		-

Table 1 World Health Organisation List of Indications for Acupuncture

## 3.2 Scientific research into Acupuncture

The research literature into acupuncture is vast and can be divided into many different areas of study with different degrees of scientific and experimental rigor. While there is a vast and rigorous literature on the physiological effects and the neuro-humoral mechanisms behind acupuncture, the clinical literature is generally of poorer quality. Perhaps even less rigorous and coherent is the literature into the biophysical and electro-physiological nature of acupuncture points and meridians.

The widely disparate nature of the acupuncture literature may be seen to arise from the fact that there is no general agreement as to how to define acupuncture. Thus, many studies attempt to divorce themselves as much as possible from the historical and cultural basis of acupuncture and aim to merely examine the effects of 'dry needling of musculoskeletal trigger points', 'electro-stimulation' or other forms of 'acupuncture-like stimulation'. The research literature is therefore divided into work that generally denies the historical and conceptual basis of traditional Chinese medicine and literature that accepts the basic traditional Chinese medicine principles from the outset.

Due to the widely different conceptions of acupuncture within the literature, there is no general agreement as to point location, nomenclature or meridian anatomy. While some in roads have been made in this area with international committees attempting to standardise the nomenclature used, (The WHO Scientific Group to Adopt a Standard International Acupuncture Nomenclature 1993) acupuncture points are defined differently by different studies. For example point are commonly located by locating low resistance points, tender points, or points located by an experienced acupuncturist or described on traditional acupuncture charts.

The lack of an agreed standard by which to define acupuncture points greatly hinders the development of quality research and this is further hindered by the lack of any standards in the many stimulation parameters. Studies are therefore widely heterogeneous with regard to stimulation techniques, depth and angle of insertion, stimulation frequencies, amplitudes, duration, and points used, as well as with regard to the use of traditional Chinese medicine principles. The wide variations in definitions for acupuncture, along with the lack of standardisation for acupuncture techniques, makes it difficult for comparisons to be made between studies. The research literature therefore lacks coherence and this is compounded by a lack of a general theoretical framework with which to explain experimental findings. Most of the scientific literature therefore can be seen to merely validate the acupuncture phenomena and demonstrate *how* it may work, rather than provide an understanding of *why* it works. The following chapters attempt to review the clinical and

physiological literature on acupuncture, before discussing the nature of acupuncture points and meridians and the role of electromagnetic interactions.

#### **3.3 Clinical acupuncture research**

Western studies generally accept the premise that the theories underlying traditional acupuncture are implausible and irrelevant to modern medicine but that the treatment may be effective whether or not the theory is valid. Thus questions about the efficacy of acupuncture are often asked without considering traditional ideas. (Lewith & Vincent 1998) When applied in this manner the term 'medical acupuncture' or 'scientific acupuncture' is commonly used to differentiate it from traditional Chinese medicine, which is intricately linked to its philosophical and cultural history.

This approach has led to many clinical trials of acupuncture and a vast literature on its clinical effects that have been reviewed previously. (Filshie & White 1998) While it is beyond the scope of the present work to review the research literature on the clinical applications of acupuncture, this literature can be categorised into different groups according to the methodology used. Thus, clinical research can be divided into trials that include anecdotal or uncontrolled studies, trials using a no-treatment control group, trials using a alternative treatment control group, and placebo-controlled trials which may either use a non-acupuncture placebo group such as bogus TENS, or a 'sham acupuncture' placebo group, where needles are placed in points considered to be 'non-acupuncture points'. (Lewith & Machin 1983; Prance, Dresser et al. 1988; Richardson & Vincent 1986)

While the clinical research literature is vast, few studies are able to meet the gold standard for clinical trials that includes double-blinded, randomised, placebo-controlled trials with defined outcome criteria and sufficient statistical power. (Vincent & Richardson 1986) Thus, it is acknowledged that the clinical research into acupuncture is generally of poor quality. (Lewith & Vincent 1998; NIH Consensus Development Panel on Acupuncture 1998; Prance, Dresser et al. 1988) The paucity of high-quality clinical research into acupuncture can be seen to be due to the many inherent methodological problems that arise

in this type of research. These methodological problems include poor design, inadequate statistical analysis, difficulties in defining the diagnosis of conditions to be treated and problems with the choice of suitable placebo interventions and control groups (Lewith & Vincent 1998).

In order to have reproducible results in clinical trials, a standardised treatment approach is needed. Acupuncture however is a 'holistic' therapy, and most acupuncturists tailor their treatments to the needs of individual patients and may use different points as treatment progresses. (Bensoussan 1991a) Furthermore, due to the nature of the treatment, doubleblind conditions are virtually impossible to achieve. Other methodological problems include the choice of treatment parameters, agreement as to the location of 'true' acupuncture points, the need for sample sizes to be sufficient to provide adequate statistical power and the requirement of having objective yet multidimensional measures of outcome. (Lewith & Vincent 1998; Richardson & Vincent 1986)

Perhaps the most perplexing problem in acupuncture research is the choice of a suitable placebo. Randomised controlled trials were originally developed to assess the efficacy of pharmaceutical interventions and pose many difficulties when being applied to physical therapies such as acupuncture. A review of randomised trials on acupuncture (Lewith & Machin 1983) has shown that response rates vary from 30% for placebo groups, to 50% for sham acupuncture groups, and 70% for true acupuncture groups. These results suggests that sham acupuncture cannot be considered an adequate placebo, but rather a "poor form of acupuncture" (Lewith & Machin 1983). The use of a sham acupuncture group therefore requires a larger numbers of subjects to be able to detect significant treatment effects. As most trials do not employ large numbers of subjects, the authors were forced to conclude: *"The majority of published reports have a very low power for distinguishing statistical differences between treatment groups" (and hence) "one cannot necessarily conclude from trials which produce statistically non-significant results that acupuncture (when compared with placebo for example) is ineffective." (Lewith & Machin 1983).*
It is perhaps surprising that despite the difficulties associated with the clinical evaluation of acupuncture, there are numerous trials that can attest to its efficacy. A recent United States National Institute of Health Consensus Conference reviewed the status of acupuncture and drafted a consensus statement that acknowledged the paucity of high quality clinical research into the clinical uses of acupuncture as well as the inherent methodological difficulties, yet concluded that:

"Promising results have emerged", and; "the data in support of acupuncture are as strong as those for many accepted Western medical therapies." The panel went on to conclude that; "there is sufficient evidence of acupuncture's value to expand its use into conventional medicine and to encourage further studies of its physiology and clinical value."(NIH Consensus Development Panel on Acupuncture 1998)

## **3.4 Physiological effects of acupuncture**

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The effects of acupuncture include subjective sensations and psychological effects as well as physiological effects that include analgesia, homoeostasis, immune enhancement and motor recovery. (Jayasuriya 1991) In addition to these effects, which are generally well accepted, it is often claimed that acupuncture may have more subtle effects by acting on 'subtle energies' within the acupuncture meridian system and that these are primary to the more gross physiological effects. (Tiller 1997) Most research into the physiological research into acupuncture however denies any energetic processes into the body and merely emphasises the needle effect. This however may not be essential. (Tsuei 1998) Whether or not this is the case, the existence of the physiological effects of acupuncture is generally not disputed. (Andersson & Lundeberg 1995)

In addition to obviously producing physiological changes, acupuncture also has profound psychological effects. The strong psychological component with acupuncture has led to the suggestion that its action is purely placebo. (NCAHF 1991) The ability of acupuncture to induce psychological changes, which can then go on to produce physiological effects, is evident in people who exhibit nervous laughter, sweating, feelings of nausea, and light headedness with just the thought of a needle being inserted into their body.

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The debate over the placebo status of acupuncture is clouded by the complexities of clinical trials research and the difficulties in devising an adequate placebos for use in randomised controlled trials makes it difficult to draw firm conclusions. (Lewith & Vincent 1998) However, while it is likely that acupuncture does indeed have a powerful placebo effect, (Ernst 1994) the numerous physiological changes demonstrated with acupuncture in both animals and humans make it seem unlikely that acupuncture is purely placebo.

#### 3.4.1 Analgesia,

By far the most extensive literature on the physiological effects of acupuncture centres on acupuncture analgesia and the many neuronal and humoral effects that may be associated with it. The extent of this literature has led to different authors pointing out that there is more known about acupuncture analgesia than there is about many chemical drugs in routine use (Jayasuriya 1982; Stux & Pomeranz 1990).

Certainly, the neurophysiological basis of acupuncture analgesia is well established. This has been primarily based on the gate control theory of pain mechanisms (Melzak and Wall, 1965) which describes a competition between large and small diameter fibres for transmission of pain signals to the brain (Figure 3) and the discovery of the endogenous opioid and other neurotransmitter involvement.

In 1989 after investigating the scientific basis of acupuncture, the executive committee of the National Health and Medical Research Council concluded that:

"the relief of pain by acupuncture can be explained in terms of neurophysiological mechanisms. These mechanisms depend on an intact and functioning peripheral and central nervous system, can be induced without using the full range of traditional acupuncture points and are similar in mechanisms associated with narcotic analgesia. In addition to a neurophysiological effect on pain, acupuncture has a powerful placebo effect."(NHMRC 1989)



Figure 3 The Gate control theory of pain mechanisms.

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Large and small diameter fibres are seen to project to the substantia gelatinosa (SG) and the first central transmission cell (T). (+ excitation – inhibition). The inhibitory effect exerted by the substantia gelatinosa on the transmission cell is seen to be increased by large fibre activity and decreased by small fibre activity. Thus small fibres open and large fibres close the physiological pain gate. (Melzak and Wall, 1965)

Evidence to date certainly suggests that acupuncture analgesia is a real phenomenon. The basic pathway by which acupuncture analgesia is produced appears to begin with the stimulation of small diameter nerves in muscles which send impulses to the spinal cord, and then to centres in the spinal cord, midbrain and pituitary that release endorphins and monoamines which block pain messages. (Stux & Pomeranz 1990).

The acceptance of acupuncture by the scientific community has been greatly enhanced by the discovery of the endogenous opioids or endorphins and the finding that these were increased during acupuncture analgesia. Since their discovery there has been intense and rigorous research into the role of the endorphins in acupuncture analgesia. Stux and Pomeranz summarise the research on the role of the endorphins in acupuncture and identify at least ten different lines of experimental evidence that has emerged to support their role. (Stux & Pomeranz 1990)

Most of this research into establishing the neurological basis for acupuncture has been done using electrical stimulation in addition to traditional needling. Electrical stimulation may be applied via a needle or transcutaneously using a surface electrode in which case the procedure is termed Transcutaneous Electrical Nerve Stimulation (TENS). (Walsh 1997) Ulett et al. have determined that electroacupuncture is more effective than manual acupuncture for producing analgesia and that electrical stimulation via skin patch electrodes is as effective as electro-acupuncture using needles. (Ulett, Han et al. 1998a) Despite these differences, acupuncture, electro-acupuncture and TENS are generally considered similar and are not commonly distinguished in the academic literature.

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The use of electrical stimulation has somewhat standardised acupuncture research by allowing stimulation parameters to be quantified into values such as voltage, current, amplitude and frequency. The use of TENS and direct electrical stimulation has therefore gone a long way to making the field of acupuncture research acceptable. This research however, has raised many more questions than it has answered for it has revealed that the electrophysiological and neuro-humoral mechanisms behind acupuncture analgesia are extremely complex. The complexity of the neuro-humoral mechanisms of acupuncture analgesia is evident when it is realised that different types of stimulation produce different types of analgesia. For example Takeshige found that analgesia caused by direct acupuncture point stimulation is naloxone reversible, while that caused by stimulation at non-acupuncture points is dexamethasone reversible. (Takeshige 1985)

The complexity of acupuncture analgesia is also evident when viewing the research from Professor Han's team from Beijing University in China. His team has produced a wealth of rigorous research indicating that stimulation at different frequencies produces different and distinct physiological effects including the differential release of neuropeptides. (Han, Chen et al. 1991; Han, Xie et al. 1984). For example they have reported that different opioid peptides are released by different stimulation frequencies (Han, Xie et al. 1984) and that low-frequency (2 Hz) electrical stimulation on the hand and leg results in raised met-enkephalin levels in CSF without changing the levels of dynorphin A, while high-

frequency stimulation (100 Hz) causes increased Dynorphin A in CSF with no change in met-enkephalin. (Han, Chen et al. 1991)

The finding that different frequencies of electrical stimulation produce different effects has led to the classification of different modes of TENS, the main modes being low-frequency (1-4 Hz) or 'acupuncture-like' TENS and high frequency (>100 Hz) or 'conventional' TENS. (Kahn 1994; Walsh 1997) These two modes appear to produce different types of analgesia. (Andersson & Lundeberg 1995) Acupuncture-like TENS produces analgesia that has a relatively slow onset and long duration with cumulative effects. This type of analgesia is thought to involve endorphin release from the spinal cord midbrain and pituitary and is blocked by naloxone. Conventional TENS on the other hand produces analgesia that has a rapid onset, a short duration and does not have cumulative effects. This type of analgesia produces a strong segmental effect that is not blocked by naloxone and is thought to activate the midbrain and spinal cord and involve the release of monoamines. (Stux & Pomeranz 1990)

The frequency dependant nature of the effects produced by electrical stimulation suggests that it is more than just the simple stimulation at certain points that influence pain perception. However while there is a vast amount of information that can be transmitted via the frequency component of electrical signals, to date research has only divided the stimulation parameters into broad categories of 'low' (0-100Hz) or 'high' (100Hz–10kHz) frequency.

Surely there is a lot more to be learned from this research, and many questions remain unanswered, such as: why does the body respond to different frequencies? What is the nature of the information that may be transferred through the acupuncture meridian system? How does the body distinguish between frequencies? Do resonances occur with specific frequencies? Are particular frequencies unique to a particular individual, anatomical region, acupuncture meridian or clinical condition? Furthermore, the question of the relationship between frequency and pain remains relatively unanswered.

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### 3.4.2 Homeostasis and immune enhancement

In addition to producing analgesia, acupuncture has many other physiological effects and this is reflected in its traditional uses. Perhaps the most clinically important effect of acupuncture is its effect on homoeostasis, which is commonly used clinically. Thus needling at similar points may be used to relieve hypo or hypertension, or hypo or hyperglycaemia (Jayasuriya 1991) and acupuncture has been found to enhance cardiovascular homoeostasis in healthy people. (Ballegaard, Muteki et al. 1993)

It has been suggested that one of the ways in which acupuncture is able to affect organ systems is by the stimulation of the autonomic nervous system via the cutaneo-visceral reflexes. These reflexes along with viscero-cutaneous reflexes permit stimulation of the skin to effect the internal organs and vise-versa. (Kuntz 1945; Mann 1980) Thus acupuncture has been shown to affect the sympathetic nervous system in anesthetized rats (Lin, Fu et al. 1998) and humans, (Knardahl, Elam et al. 1998) as well as produce reflex responses in gastric motility, (Sato, Sato et al. 1975a; Sato, Sato et al. 1993) contraction of the urinary bladder, (Sato, Sato et al. 1975b; Sato, Sato et al. 1992) as well changes in carotid arterial pressure, stroke volume and peripheral vascular resistance. (Clifford, Lee et al. 1976; Lee, Lee et al. 1976)

While the effects of acupuncture on the autonomic nervous system are well documented, they are extremely varied and have not been the subject of systematic study. Many different effects have been reported including the ability of electroacupuncture to produce a transient increase in muscle sympathetic activity (Knardahl, Elam et al. 1998) and stimulation to points on the hand and leg to producing changes in facial temperature. (Zhang, Wen et al. 1990) Acupuncture has also been shown to influence brain function as evidenced by changes in the electroencephalogram (EEG).

The EEG changes produced by acupuncture are of particular interest as the role of the brain may be considered of primary importance in the processing of information from the periphery. Furthermore, the EEG changes observed with acupuncture are suggestive of a generalised homoeostatic effect. EEG changes that are characterised by a significant increase in EEG alpha (8-12 Hz) activity have been found to be produced with both laser acupuncture (Wang, Huang et al. 1992) and electroacupuncture. (Rosenblatt 1982a; Saito, Sim et al. 1983; Varrassi, Manna et al. 1986) This increase in EEG alpha wave activity is similar to that seen during meditation (Banquet 1973; Orme-Johnson 1973; Wallace 1970) which has been reported to correspond to generalised homoeostatic effects on physiological processes. (Benson 1975) Similar changes have also been reported during *Qi*-Gong. (Zhang, Zhao et al. 1988)

In addition to physiological effects that are obviously neuronally mediated, acupuncture has also been reported to influence other internal states. Thus there are reports of acupuncture increasing secretion of salivary neuropeptides, (Dawidson, Angmar et al. 1998) plasma growth hormone (Debreceni 1991), and free fatty acids, (Doenicke, Kamipik et al. 1976) as well as reducing serum albumin, haematocrit and serum cholinesterase. (Doenicke, Kamipik et al. 1976) In addition to the above physiological effects, acupuncture has been found to have a homoeostatic effect on the immune system in animals (Chu & Affronti 1975) and humans. (Bossy 1990; Bossy 1994; Cui 1992)

The ability of acupuncture to modulate that immune system is used clinically to treat infectious or autoimmune diseases. While the mechanisms by which acupuncture produces these effects is not well understood the role of ACTH may be of importance. ACTH has a significant effect on inflammatory responses through the release of cortisol and is produced in the pituitary from the precursor pro-opiomelancortin in equimolar amounts to  $\beta$ -endorphin. (Andersson & Lundeberg 1995) Furthermore  $\beta$ -endorphin itself has been shown to have immunomodulatory effects with  $\beta$ -endorphin receptors existing on immune cells. (McDaniel 1992)

In addition to centrally mediated effects on the immune system through ACTH and  $\beta$ endorphin, it is possible that there is a direct effect of needling on the immune system. Certainly needling does produce some cell damage with a corresponding release of inflammatory markers. Thus, substances such as bradykinin and histamine may play a role in modulating the immune responses in acupuncture. (Popkin 1972) An interesting observation that supports the possibility of immune enhancement by the direct effects of needling is the observation that despite its common use in clinical practice, skin preparation with alcohol swabs to reduce microbiological contamination is unnecessary before routine injection. (Dann 1969; Koivisto 1978) A possible reason for this observation is that the needle effect produced by the injection is sufficient to produce local immuno-stimulation that counters any slight tendency towards infection. The apparently low rate of infection at acupuncture sites further supports this.

The role of acupuncture in enhancing homoeostasis has been extended from considerations of general physiological functioning to include the concept of bio-electric homoeostasis with the exchange of energy between meridians being compared to the exchange of electricity between closed electrical circuits in the body. (Maxey 1976; Zukauskas, Dapsys et al. 1988) This suggestion builds on the work of Bjorn Nordenstrom who maintains that there are "biologically closed electric circuits" that constitute a complex electrical system that regulates the activity of the internal organs. (Nordenstrom 1983) This idea is supported by experiments in animals and humans that found that electrophysiological parameters in different points and zones of an organism remain practically constant, while the changes in separate organs or skin points vary widely. (Zukauskas, Dapsys et al. 1988) Despite some experimental verification, this theory is not widely recognised in the scientific literature. (Becker 1991)

While there is much research to demonstrate the different physiological effects of acupuncture, (Reichmanis & Becker 1978) this research is not as coherent as the research on acupuncture analgesia and many of the above findings await further collaboration along with elucidation of the mechanisms involved. Certainly the mechanisms by which particular acupuncture points may have specific effects is not fully explained by cutaneo-visceral pathways and many of the clinical effects of acupuncture await further elucidation. Many questions remain such as: What is the nature of the relationship between specific points and organs? How is this relationship mediated? What is the nature of acupuncture points and how are they able to mediate the exchange or energy and information between the internal and external environment?

# **4.0 The anatomy of acupuncture**

### **4.1** The nature of acupuncture points

Traditional Chinese sources identify 365 acupuncture points on the body (Dornette 1975) and modern authors have extended this number to over 2000. (Jayasuriya 1991) Despite these claims, the existence of acupuncture points is a widely disputed. Some authors such as Bossy suggests that the accurate anatomical localisation of the point is indispensable to get satisfactory therapeutic results, as is the correct puncture of the point in terms of location, direction and depth. (Bossy 1984) Other authors others contend that acupuncture points are a myth and that puncturing in the general area is sufficient. (Mann 1992).

The fact that acupuncture points are located on the skin links them to a sophisticated organ that not only covers and protects an organism, but also serves functions such as breathing, elimination, heat exchange and transduction of impinging external forces. (Fleck 1975) The skin is a specialised form of epithelium and is a complex tissue that consists of three layers, the epidermal, the dermal and the subcutaneous tissue. The outermost epidermis consists of five layers. The deepest layer where new keratinocytes are produced is termed the stratum germinativum or stratum basalis. This layer is bound to the underlying basal membrane and dermis by hemidesmosomes, which are plaque-like attachments on the basal membrane of epithelial cells that are also attached to tonofilaments that help to constitute the cellular cytoskeleton. (Hopkins 1978) The cells of the basal layer are also attached to each other and to the cells of the overlying stratum spinosum by numerous desmosomes thus forming a connective tissue network between the layers of the dermis. Above the stratum basalis, are the stratum spinosum, stratum granulosum, stratum lucidium and stratum corneum.

The layers of the skin contain cells of increasing degrees of keratinization and the epidermis is avascular and is nourished by the underlying dermis. This nourishment however, is only sufficient to sustain the deeper layers of the epidermis. Thus by the time the more superficial cells reach the body surface, they are nothing more than dead flakes of

keratin that are being continually worn off and replaced by new cells from underneath. (Cormack 1984) While the epidermis may appear relatively inactive, epidermally derived skin appendages extend down into the dermis, some reaching the superficial fascia which comprise the subcutaneous tissue. (Cormack 1984)

In addition to being connected through their respective cytoskeletons, epithelial cells are also served by an extensive intercommunication network consisting of series of gap junctions. These junctions consist of a narrow gap between adjacent cells that is traversed by tubular passageways that allow the passage of chemical and electrical signals between cells by allowing the passage of low molecular weight molecules and ions. (Cormack 1984; Hopkins 1978) Gap junctions have a primary role in the heart and visceral smooth muscle in propagating waves of electrical excitation throughout the tissue and low electrical resistance pathways between cells may be related to the relative distribution of gap junctions. (Guthrie 1984) Yet, while gap junctions are widely distributed throughout most tissues of the body, their specific role in intercellular communication in the epithelium is not well understood. (Hopkins 1978)

While it is the skin that acts as the interface between external and internal forces, most of the work involving acupuncture has focused on the actions of the nervous system. The sensory nerve supply of the skin is derived from many sources and varies from thickly myelinated sensory fibres with large diameters, to nonmyelinated sensory and autonomic fibres with extremely small diameters. The myelinated fibres eventually lose their myelin sheaths and terminate in naked axons that are in close relation to the epidermal cells and collagen fibres (Fleck 1975) as well as forming a variety of end-organs, such as Merkel's disks, Golgi's tendon organs, neuromuscular spindles and corpuscles of Ruffini, Meissner, Golgi-Manzoni and Pacini. (Cormack 1984; Fleck 1975) These various elements form an extensive and overlapping network and the skin entire skin surface forms a sense organ that continually transforms external energy such as heat and mechanical deformation into information that can be transmitted and processed by the peripheral nervous system.

There is certainly a relationship between acupuncture points and the nervous system. This is evident by the ability of local anaesthetic agents to prevent the effects of acupuncture (Jayasuriya 1982; Kaada 1976) and the fact that acupuncture analgesia fails to develop on the affected side in hemiplegic patients. (Kaada 1976) The acupuncture sensation or *deqi*, which manifests as soreness, fullness, distention and numbness, can also be considered to be neurogenic and involve both the somatic and autonomic nervous system. (Dornette 1975) The link between the nervous system and acupuncture points is further supported by the observation that motor points have been found to consequent with acupuncture points. (Liao 1975) This correspondence has been demonstrated by Liu *et al* in a double blind study that found an excellent correspondence between motor points as determined by electro-diagnosis and acupuncture points as determined by an experienced acupuncturist. (Liu, Varela et al. 1975)

The association between the effects of acupuncture and the nervous system has led to the suggestion that acupuncture points tend to have higher concentrations of neural and vascular elements. It has been noted that acupuncture points appear to correspond to concentrations of sensory receptors, (Dornette 1975; Fleck 1975; Funakoshi & Kawakita 1980; Matsumoto 1972) or Golgi tendon organs. (Gunn 1976; Hwang 1992) The link between the acupuncture points and the nervous system is also strengthened by the observation that acupuncture points tend to coincide with cutaneous nerve branches (Kaada 1976) and the points where small nerve bundles penetrate the fascia. (Bowsher 1998)

While there are many studies that are suggestive of an anatomical basis for acupuncture points, these studies await reproduction by others before they are generally accepted. Most authors therefore contend that there are no consistent anatomical correlates for acupuncture points. Furthermore, while the role of the nervous system in acupuncture has been widely confirmed, there are many authors that believe that the nervous system does not account for all observed phenomena and that a more basic substrates for the actions of acupuncture exist such as gap junctions (Shang 1989) or the fascia and connective tissue. (Matsumoto & Birch 1988)

## 4.2 The role of the fascia

While the existence of specific anatomical entities that can mediate the effect of acupuncture is not yet confirmed, it has been proposed that an anatomical substrate for the action of acupuncture may be the fascia and connective tissue. Matsumoto and Birch discuss the properties of the fascia in detail and suggest that there is evidence to show that connective tissue is capable of communication, connection, and energy conduction in the form of electron and proton transmission as well as having thermoelectric and piezoelectric properties.(Matsumoto & Birch 1988)

The fascia is certainly well placed to be a substrate for communications within the body. The superficial fascia is continuous with the dermis and lies one or two millimeters below the surface of the skin while the deep fascia covers the musculature and is continuous with the subserous fascia that line the abdominal and thoracic cavities providing connections with the organ systems of the body. The fascia also provides connection to the autonomic nervous system with the autonomic ganglia being embedded in fascial planes.

James Oschman from Woodshole Marine Biological Laboratory discusses the role of the fascia and states: "In principle it would be possible to trace the fascial connections between any point within the body and any other. . . At any particular level in the body the connective tissues form a continuous network ensheathing muscles, bones, nerves, blood vessels, and extending down microscopically onto the surface of cells and even into the cells themselves."(Oschman 1985)

Fascia and connective tissue fibers are certainly pervasive throughout the body. Connective tissue fibers extend into every cell in the body and are contiguous with the microfilaments and microtubules that make up the cellular cytoskeleton and intracellular matrix. There is even the suggestion that these connective tissue fibers extend to the surface of the body. Electronmicrograph evidence has revealed that the anchoring filaments of hemidesmosomes extend through the dermal-epidermal junction thus allowing continuity from the collagenous filament system of the dermis through the epidermis to the surface of

the body. (Ellison & Garrod 1984) This connection is not only an anatomical and mechanical one for the fascia may communicate bioelectric as well as mechanical forces. (Matsumoto & Birch 1988)

James Oschman summarises the properties of connective tissue and fascia and suggests that this network does indeed constitute the anatomical basis for the acupuncture meridian system:

"The connective tissue and fascia form a mechanical continuum, extending throughout the animal body, even to the innermost parts of each cell. All the great systems of the body – the circulation, the nervous system, the musculoskeletal system, the digestive tract, the various organs – are ensheathed in connective tissue. This matrix determines the overall shape of the organism as will as the detailed architecture of its parts. All movements of the body as a whole or of its smallest parts are created by tensions created through the connective tissue fabric. Each tension, each compression, each movement causes crystalline lattices of connective tissue to generate bioelectric signals that are precisely characteristic of those tensions, compressions and movements. The fabric is a semiconducting communication network that can convey the bioelectric signals between every part of the body and every other part. This communication network is no other than the meridian system of traditional Oriental medicine." (Oschman 1985)

The suggestion that the fascia may be the anatomical substrate for acupuncture is supported by experimental evidence. Kimura et al performed electron microscopy of transparent material that was found to bind to acupuncture needles after twisting-needle manipulation. This revealed that the material corresponded to injured fascia and consisted of collagen fibres, elastic fibres, fibroblasts, adipocytes and mast cells. Only rarely did the authors find nerve fibre like structures. (Kimura, Tohya et al. 1992)

The possibility of the fascia being important in mediating the effects of acupuncture is also suggested by Kawakita et al who performed an elegant study using an insulated needle electrode and electrical stimulation in order to determine pain threshold at different depths of insertion. They found that the minimum pain threshold under a tender point occurred at

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the depth at where stiffness against the needle exertion could be felt and that this depth coincided with the fascia on ultrasonic tomography. (Kawakita, Miura et al. 1991)

Further support for the role of the fascia in acupuncture comes from Lin et al. who studied the depth of needling in modern and ancient texts and compared the 'cun' measures in cadavers and live subjects using CT scans. This sudy revealed that the depth at which *deqi* is obtained corresponds to body thickness. (Lin 1997) In another study using human cadavers, Omura et al. found that the connective tissue network between the skin layer and the fascia on the muscle tissue at acupuncture points is more dense that surrounding areas. (Omura, Takeshige et al. 1988) The relationship between the fascial layers and acupuncture is also supported by the subjective observation that the feeling of deqi may be felt by experienced acupuncturists just as the needle is penetrating the deep fascia and that this corresponds with the patient's subjective sensation of 'deqi'.

While there is still much to learn about the role of the fascia in the body, it does appear that the fascia is well placed to mediate the effects of acupuncture. The fascia certainly provides a continuous network that links the organs and tissues of the body and maintains structural and possibly electrical continuity. The fascial system within the body may therefore provide the basis for a direct current control system that underlies healing and regeneration. The existence of such a system has been proposed by Becker (Becker, Bachman et al. 1962a) and evidence for this system will be discussed further in subsequent chapters.

# **4.3 Acupuncture and trigger points**

While the ancient Chinese had a reasonable understanding of gross anatomy and were able to describe the circulation of blood thousands of years before this was acknowledged in the West, the Chinese view of anatomy is centered more on functional relationships between bodily structures than structure. Similarly, it seems that acupuncture points may best be considered as functional, rather than structural entities. The functional nature of acupuncture points is evident from the fact that there is an extremely high correlation between acupuncture points and myofascial trigger points. Myofascial trigger points are characterised clinically as points of focal muscle tenderness that can be identified using a pressure algometer or palpation, and which are found to have a local twitch response to mechanical stimulation (Baldry 1993; Melzak, Stillwell et al. 1977; Reeves, Jaeger et al. 1986; Travell & Simons 1983). When 'active', trigger points are painful to palpation and refer pain, tenderness, and autonomic symptoms such as redness, swelling and sweating to remote structures in predictable and reproducible patterns characteristic for each point (Baldry 1993; Travell 1976). When 'latent', trigger points are still tender and may show a twitch response but do not produce any referred phenomena. (Reeves, Jaeger et al. 1986)

Trigger points are used in Western medical practice for the diagnosis and treatment of pathological pain and their use has been widely adopted in Western medicine since a classic study by Travell and Rinzler described a large number of spatial patterns of pain associated with specific trigger points. (Travell & Rinzler 1952) The therapeutic use of trigger points centers around the finding that local anesthetic administration to trigger points often produce prolonged, sometimes permanent relief of some forms of myofascial or visceral pain (Baldry 1993; Bonica 1954; Travell & Rinzler 1952). In addition to injecting trigger points with local anesthetic, it has been found that brief intense stimulation of trigger points by dry needling, intense cold, injection of normal saline or transcutaneous electrical stimulation may have similar effects. (Baldry 1993; Travell & Rinzler 1952)

The effects of intense stimulation, which have been labeled as 'hyperstimulation analgesia' closely resemble the effects of acupuncture and it has been suggested that trigger points and acupuncture points, though discovered independently and labeled differently, represent the same phenomenon (Vanderschot 1976). Indeed when examining the correlation between the location of trigger points and traditional acupuncture points, Melzak et al. revealed that every trigger point has a corresponding acupuncture point and that there is a greater than 70% correspondence between the pain syndromes treated by these points. (Melzak, Stillwell et al. 1977)

The correspondence between the location of myofascial trigger points and acupuncture points, as well as the ability for stimulation of these points to produce desirable clinical outcomes, gives support to the suggestion that acupuncture points are distinct functional entities, even though they may not demonstrable by consistent anatomical findings.

# 4.4 The nature of the meridians

In addition to the debate as to the anatomical existence of acupuncture points, the existence of the acupuncture meridians is also questioned. Skeptics often point out that morphological research has not reached any firm conclusions regarding physical evidence for the acupuncture meridians and thus they are a fiction. These criticisms are countered by some authors with the suggestion that acupuncture meridians may be likened to contour lines on topographical maps and are thus conceptual tools rather than distinct physical entities. (Gunn 1998; Mann 1992). Felix Mann, one of the most renowned teachers of acupuncture in the West states in his lectures: "The meridians of acupuncture are no more real than the meridians of geography. If someone were to get a spade and tried to dig up the Greenwich meridian, he might end up in a lunatic asylum. Perhaps the same fate should await those doctors who believe in meridians." (Mann 1992)

It seems that the original depiction of the meridians was as functional and physiological rather than as physical channels, with empirical evidence of their existence provided by the description of radiated soreness, distention and numbness or Propagated Sensation along a Meridian (PSM). (Xie, Li et al. 1996; Xue 1986; You 1992; Yu, Zhang et al. 1981; Zhu, Yan et al. 1981) Traditionally the appearance of PSM indicated an increased likelihood of a beneficial effect from needling and recently this has been demonstrated in patients with cardiovascular disease. (You 1992) The appearance of PSM has also been described in amputees along with its cessation after total section of the spinal cord thus implicating neuraxial participation in its production (Bossy 1984; Xue 1986)

While the exact physical substrate for the acupuncture meridians is disputed, recently there has been the suggestion of objectively defining the meridians using techniques capable of imaging functional, rather than structural relationships. One particular technique for

visualising the acupuncture meridians is described by Macdonald whereby the entire body is covered in a reflective substance such as oil or water to make the skin shiny and then illuminated by a single light source. When the body is placed in particular poses similar to those found in Ming dynasty (1368-1644) paintings of acupuncture meridians the meridians appear as highlights on the skin surface. (Macdonald 1982)

It has also been suggested that acupuncture points and meridians maybe visualised using computerised thermography. (Zhang 1992a) Zhang et al used infrared thermography demonstrated a high temperature line along the path of an acupuncture meridian on the face. (Zhang 1992b; Zhang, Gao et al. 1990) These authors were also able to shown that the high temperature line, which was between 1-1.5cm wide, could be made more prominent after acupuncture stimulation. (Zhang, Gao et al. 1992) This demonstration of isothermal meridian lines is disputed with the suggestion that these lines simply conform to the laws of temperature diffusion on the body surface and are not related to the classical acupuncture meridians. (Li 1996)

In addition to demonstrating the meridians on the skins surface there have been many modern attempts to distinguish unique biophysical properties of acupuncture meridians using techniques that include acoustic, (Yu, Zhang et al. 1994), luminescent, thermal, (Li 1996; Osipov, Glibitskii et al. 1996; Zhang 1992b; Zhang, Gao et al. 1990; Zhang, Gao et al. 1992) electrical, and isotopic.(Chen, Wu et al. 1994; De Vernejoul P., Albarède et al. 1992; Kovacs, Gotzens et al. 1992a; Lazorthes, Esquerré et al. 1990; Wu & Jong 1990; Zhu Z. 1990). Furthermore, meridians have not only been described in humans but also in animals (Yu, Zhang et al. 1994) and plants. (Hou, Dawitof et al. 1994; Hou & Li 1997a; Hou & Li 1997b; Hou, Luan et al. 1994; Hou, Re et al. 1994)

Chinese workers have demonstrated low impedance lines and high-percussion sound lines on the skin surface of animals that are said to correspond to the meridians. (Yu, Zhang et al. 1994) Another group has reported that combining electrical impulses with mechanical stimulation using light taps on the skin surface along lines perpendicular to the channels, a specific numb feeling could be elicited which they called latent propagated sensation along

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the meridian. When the skin conductance was measured over a channel they found a greater electrical conductance than at sites 1cm apart from the channel course indicating that the entire course of the propagated sensation and not just the acupuncture points have a higher electrical conductance. (Zhu, Yan et al. 1981) Similar studies by the same group revealed that the channel lines were around 0.5cm wide and that latent propagated sensation along meridians is a common meridian phenomenon in over two thirds of people. (Yu, Zhang et al. 1981)

Further support for the suggestion that the skin points along the course of acupuncture meridians are of low impedance is provided by Hu et al. who used a computerised plotting system to examine the impedance of points along meridians in 68 subjects. Using this system which they claim is accurate reliable and repeatable, the authors found that there were a series of low resistance points located that were stable over time and were within 5mm of the classically described acupuncture meridians. (Hu, Wu et al. 1992)

Yet another Chinese author has suggested that the meridians are "multi-layered, multifunctional, multimorphological structures that may be detected using a number of different biophysical approaches including acoustic, luminescent, thermal, electrical and isotopic migration" (Zhu Z. 1990) This author reports studies done pre and post-amputation in patient with osteoblastoma that revealed that the low impedance characteristics of the meridian were related directly to thinning of the stratum corneum over the meridian and not to other dermal structures. (Zhu Z. 1990) He goes on to report that there is a higher concentration of nerve bundles and vessels in the epidermis and dermis under the low impedance line as well as a higher concentration of mast cells. (Zhu Z. 1990) While this work is interesting, it is yet to be accepted by the wider scientific community and the results await confirmation by other authors.

The functional existence of the acupuncture points and meridians has also been supported by the finding that the injection of radioisotopes such as technetium-99m pertechnetate is preferentially absorbed at acupuncture points rather than "non-points" and that the isotopes migrate along distinct pathways. When studying the path of isotopic migration after subcutaneous injection in dogs, the isotope was found to migrate along a specific pathway that coincides with an acupuncture meridian rather that the path of a nerve, vein or lymphatic vessel. (Kovacs, Gotzens et al. 1992b; Kovacs, Gotzens et al. 1993) This finding however is in contradiction to the finding of Wu et al. that suggests that certain acupuncture points may be closely related to the venous drainage. (Wu, Chen et al. 1994)

In a series of experiments, Wu et al found that subcutaneous injection of technetium-99m pertechnetate at acupuncture points led to a better visualisation of the venous drainage than intravenous injection. This has led to the suggestion that this technique may offer an alternative method of radionuclide venography (Wu, Chen et al. 1994; Wu & Jong 1989; Wu & Jong 1990). This work has been confirmed by Lazorthes et al who have shown that the radioactive paths appearing after the injection of a radiotracer at acupuncture points correspond to vascular drainage of the radiotracer. (Lazorthes, Esquerré et al. 1990)

The suggestion that acupuncture meridians may be related to the migration of specific substances is supported by a series of experiments by Wu et al who describe the attenuation of the effects of acupuncture on the electrogastrogram and the electroretinogram by direct pressure over the stimulated meridian. (Wu, Hu et al. 1993b; Wu, Hu et al. 1993a; Xu, Huang et al. 1993) While the results of the radioisotope studies suggest that some acupuncture points play a role in drainage of tissue fluid from soft tissue into the veins, (Wu, Jong et al. 1990) it remains unclear as to whether the pathways of isotopic migration actually represent the meridians.

# 5.0 Electrical properties of the skin

### **5.1 Electro-dermal measurements**

The literature on the electrical properties of skin is extremely heterogeneous and may be divided between research that is specifically concerned with determining the existence and nature of acupuncture points, the psycho-physiological literature that is concerned with measuring the Galvanic Skin Response (GSR) and the literature concerned with examining the biophysical properties of biological tissue. The only sure conclusion that can be made from this literature is that the study of the electrical properties of the skin is complex and subject to many difficulties. Despite proposals for standardised methods of measurement (Lykken & Venables 1971) there are no generally accepted standards and studies differ widely with respect to the methodology and the equipment used. It is therefore extremely difficult to establish the precise limits of normality or compare the significance of results from different studies. (Pruna & Ionescu 1987)

Skin resistance is highly variable and may be influenced by factors that include temporal and environmental variables as well as a subject's physiological and psychological state and the choice of equipment. Furthermore the properties of the skin are nonlinear (Fraden & Gelman 1979) and the action of passing a current through the skin may alter its electrical properties (Bergsmann & Wooley-Hart 1973; Lykken & Venables 1971). The electrical properties of the skin may also alter with different intensity, duration, and frequency of stimulation. (Fraden & Gelman 1979)

When performing measurements of skin resistance, the timing and the surrounding environment appear to be important. This includes such factors as the time of day the measurements are taken, (Lykken & Venables 1971) the ambient environment including temperature, humidity, (Ionescu, Pruna et al. 1990; Schuldt 1977) and ambient electromagnetic activity, (Ryzhikov, Raevskaya et al. 1982; Schuldt 1977) as well as physiological and psychological state including physical and emotional activity and sleep. (Hálek, Opavský et al. 1984; Levy, Johnson et al. 1961) For example, while Comunetti found that there was good reproducibility of skin conductance measurements within time periods of around 20 minutes, these measurements changed considerably during the day depending on factors such as physical and physiological activity. (Comunetti, Laage et al. 1995)

The relationship between arousal and skin resistance is also variable and has been explored by Levy et al. who performed a series of experiments aimed to determine the ability of skin resistance measures to monitor the arousal level in pilots. The results of these experiments found that records of skin resistance were able to record sleep and wakefulness. Yet due to the many psychological, physical and physiological confounding factors, these measures were nor deemed accurate enough for the moment to moment monitoring of functioning in pilots. (Levy, Johnson et al. 1961)

The relationship between skin resistance and psychological state has also been examined in the context of polygraph testing. This testing involves many concurrent physiological measurements including GSR measures from the fingertips. These measures aim to determine a subject's psychological responses to questioning and thus help to judge whether the answers given are truthful. While the polygraph literature does not generally acknowledge the existence of acupuncture points, it has been suggested that the response and sensitivity of polygraph recordings can be enhanced by using an acupuncture point on the ear for GSR measurements rather than the fingertips. (Lee, Wu et al. 1993)

# **5.2 Electrode - skin interface**

The skin can be described by an electrical equivalent circuit consisting of a parallel resistor  $(R_e)$  and capacitor  $(C_e)$  along with a trans-epidermal potential difference  $(E_{se})$ . The underlying dermis can be considered as a pure resistance  $(R_u)$  with negligible DC components. In parallel with the epidermis, sweat glands and ducts also contribute to skin impedance and the addition of a gel or different types of polarisable or nonpolarisable electrodes to the skin adds to the complexity. (Neuman 1992) (Figure 4)



Figure 4 Circuit diagram of the skin - gel - electrode interface (Adapted from Neuman 1992)

Electrodermal measurements are very sensitive to the type of skin preparation performed. As the main impedance of the skin is produced from the stratum corneum of the epidermis, it is possible to minimize the effect of the stratum corneum by reducing or removing it. (Yamamoto 1994 ; Yamamoto 1976) This can be achieved by vigorous rubbing with a pad soaked in acetone, direct abrasion with sandpaper, stripping with adhesive tape or by direct puncture. (Neuman 1992) The use of needle electrodes may also be use to totally bypass the resistance of the stratum corneum and thus short out  $E_{se}$ ,  $C_e$  and  $R_e$ . Furthermore wetting the skin or the application of electrode gels can have a great effect on the recorded measurements.

The size, type, positioning, and pressure placed on the electrode may have a considerable influence on the recorded measurements. When examining the effect of different electrode types on skin resistance measurements, Nolan examined 25 different commercially available electrode types and found that measured skin impedance ranged from 1000 to

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7800  $\Omega$ . (Nolan 1991) Certainly skin resistance will vary inversely with the electrode area in contact with the skin. Thus for reliable measurements it is important to standardise the size of the electrode. (Lykken & Venables 1971) It is also important to recognise that different types of electrodes will influence the readings.

The function of an electrode is to serve as a transducer that can change ionic current into an electronic circuit. Different electrodes however, are limited in their ability to perform this function and the choice of electrode system must be made based on the specific application. For example, polarisable metallic electrodes are prone to motion artifact if the electrode is moved with respect to a surrounding electrolyte (Neuman 1992) and different metals may have different properties. (Hyvärinen & Karlsson 1977) The use of different metallic electrodes was examined by Comunetti et al who measured the GSR using an alternating, rectangular voltage of 0.4V and 10Hz and constant voltage steps of 0.4, 0.8, 1.2V. This current was applied to the skin for 2 seconds using electrodes composed of gold, graphite, silver or brass. After recording the current intensity at intervals of 1ms they found that conductance values were independent of applied voltage (between 0.4 and 1.2V applied for 2 seconds) and that chemically active electrodes (brass and silver) help to overcome the resistance of the epidermis. (Comunetti, Laage et al. 1995)

Generally nonpolarisable electrodes such as Ag-AgCl are considered more reliable, especially for electrical potential measurements and for measurements made over time. (McAdams & Jossinet 1991) The use of electrode gels is also often employed to ensure optimal electrical contact between the skin and the electrode. As the major proportion of ions in the tissue fluids and sweat are sodium, potassium and chloride, the electrolyte most commonly used in electrode gels is sodium chloride (NaCl) although other salts such as Ca CL, KCl and AlCl<sub>3</sub> are also used. (McAdams & Jossinet 1991) The use of these gels however, may reduce the skin impedance as the electrolyte permeates the epidermis and renders it more conductive. This effect may be enhanced when gels contain high salt concentrations. (McAdams & Jossinet 1991) Thus while gels are useful for measuring biopotentials they are less useful for measurements of skin resistance.

Due to the physical properties of skin and variations in contact area, the application of pressure to the skin surface via an applied electrode may alter the measured resistance. The measurement of skin resistance is therefore subject to significant electrode-pressure artifact and many studies are criticised for not controlling for this. (Noordergraaf & Silage 1973) The relationship between measured skin resistance and electrode pressure has been examined by Halek et. al. who found an exponential and inversely proportional dependence between pressure and resistance. (Hálek, Opavský et al. 1984)

As there is no accepted standardised methodology in electrodermal research, researchers have been prompted to develop different ways to control for electrode pressure and many different and innovative electrodes have been devised. Methods used to control for electrode pressure include the development of a specially designed wheel electrode (Reichmanis, Marino et al. 1975) as well as the use of a spring loaded probes, (Bergsmann & Wooley-Hart 1973; Oleson 1980) and systems whereby the weight of the electrode is used to exert constant pressure. (Bercker, Reichmanis et al. 1976) Other electrode systems that have been used to control for pressure effects include the use of solvent activated tape that obviates the need to apply any pressure to the skin, (Poon, Choy et al. 1980) the use of electrode conductive varnish consisting of a flake silver suspension in polyvinyl acetate, (Hálek, Opavský et al. 1984) the use of a saline bath in which the whole hand could be immersed (Poon, Choy et al. 1980; Schuldt 1977) as well as an electrode system whereby the searching and reference electrode consisted of concentric rings rigidly mounted together. (Bergsmann & Wooley-Hart 1973; Hyvärinen & Karlsson 1977; Yamamoto & Yamamoto 1986)

The positioning of the electrode on the body is another factor that may affect electrodermal measurements and this will largely depend on the subject of interest. Whereas the GSR literature is mainly concerned with measurements taken from the volar surface of the fingertips, (Lykken & Venables 1971) the acupuncture literature is concerned with the measurements of points over the limbs and the body in general, and in particular of the electrodermal characteristic of the acupuncture points.

## **5.3 Electrical impedance measures**

The response of biological tissue to different frequencies is largely due to the properties of the tissue fluid and cell membranes. In response to low frequencies, the cellular membrane has a high resistance and the current preferentially travels through the extracellular fluid, while at high frequency the capacitance of the cellular membrane shorts circuits the membrane resistance and the current may pass directly through the tissue. (Rabbat 1990) Skin is a complex structure and there are many factors that may influence measurements of skin impedance including the inhomogeneous and larninate structure of the cells as well as the frequency, and temperature. (Rabbat 1990; Yamamoto & Yamamoto 1976)

The frequency dependence of tissue can be separated into three main regions caused by the three dispersions observed in the dielectric permittivity ( $\epsilon$ ). These three dispersions are labeled  $\alpha$ ,  $\beta$ , and  $\gamma$ . The  $\alpha$  dispersion decreases  $\epsilon$  between 10Hz and 10kHz and is caused by interfacial counterion polarisations and surface ionic conduction at membrane boundaries. The  $\beta$  dispersion decreases  $\epsilon$  between 10MHz and is caused by the membrane capacitance short circuiting the membrane resistance. The  $\gamma$  dispersion is in the microwave frequency and is cause by the relaxation of water molecules in the intracellular fluid. (Foster & Schwan 1989; Rabbat 1990) In measuring the impedance of the skin, it has been suggested that the low frequency range is most important, as measurement at higher frequencies may be confounded by the dielectric properties of the underlying tissue. (Plutchik & Hirsch 1963)

On measuring the impedance of  $1 \text{ cm}^2$  of intact skin, Plutchik and Hirsch found that the impedance decreased from approximately 130 to 30 k $\Omega$  as the frequency of the AC input increased from 1 to 1000 Hz. (Plutchik & Hirsch 1963) In another series of measurements, Rosell et al. confirmed and extended these results with the finding that for  $1 \text{ cm}^2$  areas of unabraided skin at different body sites, impedance reduced from approximately 200 k $\Omega$  at 1Hz, to 200  $\Omega$  at 1 MHz. Furthermore, they found that impedance at lower frequencies was highly variable with the 1 Hz impedance varying from  $10 \text{k}\Omega$  to 1 M $\Omega$  while the 1 MHz impedance was tightly clustered about 120  $\Omega$ . (Figure 5). (Rosell, Colominas et al. 1988)

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Figure 5 The impedance of 1cm<sup>2</sup> of unabraided skin decreases and becomes clustered with increasing frequency (adapted from Rosell et al. 1988)

In skin, the main contribution to impedance measurements is from the outermost layers of the epidermis, which is found to have the highest impedance. Impedance measurements up to several kHz are also strongly influenced by the hydration of the stratum corneum. (Yamamoto 1994; Yamamoto & Yamamoto 1986) The importance of the outer epidermal layer is evident from measurements made after stepwise removal of the stratum corneum by cellulose tape stripping which revealed a decrease by more than 50% after the first stage of stripping. (Yamamoto & Yamamoto 1976)

The epidermal layer of the skin is found to have an electric impedance that behaves as a parallel RC circuit in series with the resistance of the underlying dermis. (Neuman 1992) (Figure 4) This may be represented in the series-equivalent form as complex series impedance (Z) or in parallel-equivalent form as complex parallel admittance (Y). (Rabbat 1990) The complex series impedance Z can be represented by the following equation:

$$Z = R + jX$$
$$= \frac{1}{Y}$$
$$= \frac{d}{(\sigma + j\omega\varepsilon\varepsilon_0)A}$$

**Equation 1** 

Where

R is the resistance ( $\Omega$ ) X is the reactance ( $\Omega$ ) Y is the admittance (S) A is the area of the specimen ( $m^2$ ) d is the depth of the specimen (m)  $\sigma$  is the conductivity (S/m)  $\epsilon$  is the relative permittivity (dielectric constant)  $\epsilon_0$  is the permittivity of vacuum (8.85 x 10<sup>-12</sup> (F/m)) (Rabbat 1990)

The complex series impedance can be represented graphically by a plot of the real component R versus the imaginary component X for the impedance at different frequencies. The corresponding plot is known as the Cole-Cole plot and for an impedance with a single time constant this appears as a semicircle centered on the real axis (Figure 6) and is given by the equation:

$$Z = R_{\infty} + \frac{R_0 - R_{\infty}}{1 + j\omega\tau}$$

**Equation 2** 

Where

R<sub>0</sub> is the resistance at f=0, R<sub> $\infty$ </sub> is the resistance at  $f=\infty$  $\tau$  is the time constant (Rabbat 1990)

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Figure 6 The Cole-Cole plot for impedance with a single time constant. (Adapted from Rabbat, 1990)

In most biological situations, the dielectric relaxation behaviour is more complicated than described by the Cole plot, for there may be multiple relaxation processes each with a different relaxation time, or the relaxation process may have kinetics that are not first-order such as counterion polarisation arising from diffusion. (Foster & Schwan 1989) In these situations, the corresponding plot may represent a semicircle with a centre that is depressed below the real axis (Figure 7). (Rabbat 1990)



Figure 7 The depressed Cole-Cole plot (adapted from Rabbat, 1990)

In addition to complex relaxation behaviour, further complexities in the dielectric properties of skin arise from the possibility of nonlinear effects, the threshold for which will vary according to the effect, the field strength and the frequency. Nonlinear behaviour of tissue to applied fields may be due to a number of factors including molecular phenomenon, creation of mechanical forces, counterion polarisation and cellular phenomena. Cellular responses may include active physiological responses such as the initiation of an action potential, changes in conductance due to field-induced conformational changes in membrane proteins, as well as responses due to breakdown of cell membrane structure. (Foster & Schwan 1989) These effects may be difficult to predict due to the high concentrations of suspended particles and the interaction between physiological, hydrodynamic and electrokinetic effects. (Foster & Schwan 1989)

In a study looking at the perturbing effects of electrical current on the lipid fine structure of human stratum corneum using freeze-fracture electron microscopy and X-ray diffusion analysis, Craane et al. found a series of changes that increased as the current was increased from 0.013 to 13 mAcm<sup>-2</sup>. These changes included an initial decrease in resistance followed by an increase in capacitance along with an increase in the stratum corneum hydration level. A disordering of the intercellular lipid structure was also noted that was suggested to arise from polarisation of the lipid head groups induced by the electric field, followed by mutual repulsion. (Craane Van Hinsberg, Verhoef et al. 1997)

While there are many biophysical factors that may effect skin impedance measurements only some of which can be rigorously analysed, these measurements are also prone to variation due to the choice of frequency, current density, electrode type and size, and skin preparation. (Webster 1990) Skin impedance measurements may also vary according to the site measured (Nicander, Rundquist et al. 1997) and may reflect the different composition of the tissue including the presence of any pathological changes. Thus, much of the work on skin impedance focuses on determinations of body composition (Webster 1990) yet there are suggestions that the interpretation of impedance data may provide useful for quantifying pathological changes such as skin reactions. (Ollmar & Nicander 1998)

# **5.4 Electrical properties of acupuncture points**

### 5.4.1 Low electrical resistance at acupuncture points

Despite the difficulties associated with electrodermal measurement techniques, it is now generally accepted that acupuncture points are in fact points of low electrical resistance compared to surrounding skin. Whereas dry skin is reported to have a DC resistance between 200 k $\Omega$  and 10 M $\Omega$ , the resistance at acupuncture points is reported to be orders of magnitude less than this. (Hyvärinen & Karlsson 1977; Ishchenko, Zubkov et al. 1990; Wolfsohn, Yoo et al. 1973) Furthermore acupuncture points have been reported to have a higher capacitance (0.1-1.0  $\mu$ F) and a higher skin potential (up to 350 mV) (Ishchenko, Zubkov et al. 1990)

While there are many studies reporting on the electrical properties of acupuncture points (Bergsmann & Wooley-Hart 1973; Chiou, Chao et al. 1998; Comunetti, Laage et al. 1995; Fraden 1979; Fraden & Gelman 1979; Hálek, Opavský et al. 1984; Hu, Wu et al. 1992; Hyvärinen & Karlsson 1977; McCarroll & Rowley 1979; Poon, Choy et al. 1980; Reichmanis, Marino et al. 1975; Reichmanis, Marino et al. 1976; Rosenblatt 1982b; Zhu 1981; Bergsmann & Wooley-Hart 1973) the quality of these studies appears to be extremely varied and hindered by the lack of any standardised equipment or stimulation parameters. Furthermore, the definition of the acupuncture points may also be variable.

While some studies into the electrical properties of the skin have examined differences between acupuncture points and surrounding tissue, other studies have merely examined the electrical properties of acupuncture points over time or in healthy and diseased individuals. (Hyvärinen & Karlsson 1977; Reichmanis, Marino et al. 1975; Reichmanis, Marino et al. 1976; Fraden 1979; Fraden & Gelman 1979; Hálek, Opavský et al. 1984; McCarroll & Rowley 1979; Poon, Choy et al. 1980; Rosenblatt 1982b) Other studies assume from the outset that acupuncture points have a relatively low resistance and use this as the criteria for defining these points. (Fraden 1979)

During the 1960s and early 1970s, Becker and Reichmanis et al. performed a series of well designed experiments to demonstrate that there are indeed distinct electrical correlates for acupuncture points and meridians. (Becker, Reichmanis et al. 1976; Reichmanis, Marino et al. 1975; Reichmanis, Marino et al. 1976; Reichmanis, Marino et al. 1977b; Reichmanis, Marino et al. 1979) Like most Western researchers, Becker and his team denied any reality to the philosophical system suggested by traditional Chinese medicine, even after proving that many of the principles of this system were valid. Instead, they were led to explore the reality of the electrical basis for acupuncture points and meridians while developing a theory about a biological direct current communication system. (Becker, Reichmanis et al. 1976)

In a series of elegant experiments using a Wheatstone bridge and an applied voltage of 2 Volts with a current density in the order of  $10\mu$ A/cm<sup>2</sup> applied through a specially designed stainless steel wheel electrode providing constant pressure, Becker's team demonstrated that there are reproducible and statistically significant conductance maxima at many of the acupuncture points on the arm. (Becker, Reichmanis et al. 1976; Reichmanis, Marino et al. 1975) (Figure 8) While all points were not found in all subjects, specific points could be consistently demonstrated in all subjects, while over half of the traditionally described acupuncture points were demonstrated in most subjects tested (n=7). (Reichmanis, Marino et al. 1975)

In addition to conductance measurements along meridians, Becker's team also studied the field distribution of skin conductance around acupuncture points on the arm using a multielectrode probe. The results of these studies revealed that the electrical resistance around acupuncture points was well-organised (Figure 9) and that "*remarkably precise and extremely well organised field plots have been found in all instances*". (Becker, Reichmanis et al. 1976) This finding further suggests that acupuncture points are discrete structures with highly specific electrical properties.



Figure 8 Three scans of the Large Intestine meridian demonstrating correspondence between resistance measures and acupuncture points. The dotted line connects each point to corresponding areas of the scan. The length of the scan varies slightly due to variation in the speed of the probe (adapted from Becker & Reichmanis, et a. 1976).



Figure 9 Field plots of the resistance around the Li 4 acupuncture point (adapted from Becker & Reichmanis, et a. 1976).

While Becker's research focused on acupuncture points of the arm, other authors have extended this to work to include points on other sites. In a survey of 27 acupuncture points at various sites on different subjects, Wolfsohn et al. found that the average resistance of acupuncture points was 794 k $\Omega$ , while the average in control areas was 1407  $k\Omega$ . (Wolfsohn, Yoo et al. 1973) In another study that attempted to systematically examine the electrical resistance of the skin of the hands, face and ears, Hyvärinen and Karlsson compared the resistance of small areas of skin (0.5mm<sup>2</sup>) with that of surrounding skin. Using a specially designed meter and measuring device employing negative 6.7 Volts DC and a dry metal electrode, they consistently found distinct low resistance points of around 10 k $\Omega$  compared to the surrounding skin with resistance of around 10 M $\Omega$ . (Hyvärinen & Karlsson 1977) Furthermore, these authors consistently found these points in characteristic loci that were symmetrical about the body midline and comparable in different individuals, with points on the ears being more distinct than points on the hands. Although the authors state they were not familiar with the location of classical acupuncture points, they found that the distribution of low resistance points they identified on the ears and hands coincided with the location of classical acupuncture points as identified on traditional charts.

To further map the difference in resistance between low-resistance points and surrounding skin these authors conducted repeated measurements using either DC or 500 Hz or 1000 Hz square waves as the measurement current and a silver wire electrode, 0.5mm in diameter. (Hyvärinen & Karlsson 1977) These measurements were taken across the region of the previously detected low (DC) resistance points in successive steps equal to the probe diameter. This study revealed that the shape of the low resistance points were roughly circular with a diameter of 1.5 (+/- 0.5) mm with abrupt borders and with resistance of around 10-100 k $\Omega$  in the centre and 2-3 M $\Omega$  in the surrounding skin.

In one another study that specifically examined point size, Halek et al. mapped the skin surface using an electrode 17mm x 17mm square with 36 mutually insulated conductive areas and a microelectrode of 2mm diameter with 30 micro-areas and a constant 1 kHz, of 1 microAmp, AC current supply with a sinusoidal waveform. Pressure effects were effectively eliminated by using an electroconductive varnish consisting of flake silver

suspension in a polyvinyl acetate. When using the microelectrodes they found that the points were generally circular in shape with a diameter of between 3 and 8mm<sup>2</sup>. (Hálek, Opavský et al. 1984) This finding is consistent with other author who have found that low electrical resistance points are punctate in nature and correlate with known acupuncture points. (Nansel & Jansen 1988) In addition to describing distinct electrical properties of acupuncture points in humans, similar properties have been found in other animals. For example in the rat, points corresponding to acupuncture points are reported to be bilaterally and symmetrically distributed and distinct from surrounding skin. (Chiou, Chao et al. 1998)

Not all studies on the electrical properties of acupuncture points have produced positive results. Noordergraaf and Silage reported that when electrode-pressure artifact is controlled they could find no evidence for resistance minima at acupuncture points on the fingers. (Noordergraaf & Silage 1973) This conclusion has been challenged however, by authors who point out that while Noordergraaf and Silage did not find acupuncture points to be absolute resistance minima, it does not exclude them from being local resistance minima. Furthermore, it is argued that a study limited to acupuncture points on the fingers can not necessarily be extrapolated to other body areas. (Reichmanis, Marino et al. 1975; Rosenblatt 1982b)

While most of the work on the electrical properties of acupuncture points has looked at DC resistance there have been a limited number of studies that have examined the impedance at acupuncture points at different frequencies although like other studies they vary widely in methodology and experimental rigor. (Zhu 1981) In a report of a study by Manaka that used 3.5 volts and 50Hz, it was determined that acupuncture points have a lower resistance and higher capacitance than control points and that the low resistance property extended along the course of the meridian. (Zhu 1981) This result has been confirmed by another study that employed a  $50\mu$ A current at 50kHz to examine the resistance and reactance of 25 points on the forearm in a 5 x 5cm grid after removal of the stratum corneum by stepwise cellulose stripping. This study found that the impedance was significantly different at acupuncture points and that the acupuncture meridian was evident as a low impedance line. (Suhariningsih & Kanai 1998) In a further series of studies examining the

impedance between two acupuncture points on the same meridian, Reichmanis et al. found that the resistance and capacitance between the acupuncture points differed significantly from control points. (Reichmanis, Marino et al. 1977a) (Reichmanis, Marino et al. 1977b)

In addition to performing direct electrical measurements of acupuncture points, other techniques have been employed to define the properties of these points. In an attempt to visualise the electroconductive points on the skin Dumitrescu developed a photographic technique termed electronography that utilise the Kirlian effect. This effect used a photographic technique to record the corona discharge that occurs when an electrically grounded object is placed in a high-frequency, high-voltage electric field. Using this technique Dumitrescu was able to visualise distinct points that corresponded to acupuncture points on the hands of subjects. (Dumitrescu 1983)

This work of Dumitrescu has been confirmed by Luciani who reports being able visualise the electroconductive points on the index finger photographically. Using an electric field produced by a Tesla coil operating at 25000 volts, 100 kHz and microamperage, to induce negative charge on the surface of objects along with a glass electrode and an inactive plate held against the skin, Luciani was able to demonstrate the existence of discrete points, which he claims are related to points along the Large Intestine meridian. (Luciani 1978)

### 5.4.2 Acupuncture point measurements

Recognition of the unique electrical properties of acupuncture points has led to devices being marketed as 'acupuncture point locators'. These devices generally utilise a metal locator probe and an indifferent reference electrode attached to an ohmmeter. An auditory output (usually a tone with a frequency proportional to the resistance being measured) is often produced when a point is located. These devices however, are open to criticism as they are unable to control for local variations in skin thickness, surface secretions, or pressure placed on the electrode. (Stux & Pomeranz 1990) While these devices are generally unsuitable for research purposes, the lack of any standard research methodology to measure skin resistance has led each group to design their own equipment. Generally however, two different systems are employed that utilise either constant current or constant voltage devices. In order to measure conductance directly, a voltage source and a resistance much smaller than the skin resistance is placed in series with the subject. In this case, the voltage across the skin electrodes (which may vary from 0.5 to 21V) remains relatively constant and the voltage drop across the small signal resistance is directly proportional to the current flowing in the circuit. This voltage drop can then amplified and recorded as a measure of conductance, (Lykken & Venables 1971) or it can be measured directly using a Wheatstone bridge. (Reichmanis, Marino et al. 1975) It has been suggested that this direct measurement of conductance using a constant voltage source is a more reliable method of measurement and is able to avoid high voltages that may damage the skin because the current density is independent of electrode area. (Lykken & Venables 1971)

With constant current systems, a circuit is used to pass a constant current through the skin producing a voltage drop across the electrodes. A constant current is obtained by including a resistance in series with the subject which is very large compared to the skin resistance. Changes in skin resistance will therefore produce relatively little change in the current level. The voltage drop across the electrodes in this case can the be amplified and recorded and is directly proportional to the resistance. Conductance can then be calculated from the resistance measures. (Lykken & Venables 1971)

### 5.4.3 Breakdown phenomenon

The electrical properties of the skin are nonlinear and when current is applied to the skin a point is reached where breakdown occurs and the electrical properties of the skin are altered due to the skin being damaged and allowing a greater passage of current. (Bergsmann & Wooley-Hart 1973; Fraden & Gelman 1979; Poon, Choy et al. 1980). This point of non-linearity has been reported to occur between 4 and 11 volts (Bergsmann & Wooley-Hart 1973; Poon, Choy et al. 1980) and is dependent on the current passed, occurring when the current density is over  $10\mu A \text{ cm}^2$ . (Fraden & Gelman 1979; Poon, Choy et al. 1980) Furthermore the nonlinearity has been found to be dependent on frequency (Cho & Chun 1994; Fraden & Gelman 1979) and the breakdown phenomena is reportedly to be more easily induced by negative than positive current (Fraden & Gelman 1979).
In the early 1950s the Japanese researcher Nakatani used the breakdown phenomenon to develop a method for measuring electrical resistance of the skin using a DC voltage of 12 to 21 volts and 200  $\mu$ A applied to the skin by a dry electrode of 1cm diameter. (Zhu 1981) Nakatani proposed internal organ pathology which manifests as changes in the electrical resistance on reflexly associated points on the skin and that this may be detected by eliciting breakdown phenomenon at specific reactive points. This idea has been elaborated on with the suggestion that acupuncture points have a lower threshold for the breakdown phenomena than surrounding areas. (Fraden & Gelman 1979; Poon, Choy et al. 1980)

In an experiment designed to determine the location of the breakdown points on the forearm, Poon et al. used a solvent activated tape electrode, to visualise the breakdown points by the black deposits left from the electrode after breakdown had occurred. With the application of increasing voltage, they found that a point is reached where a sudden flow of current occurs and the subject can feel a strong stinging sensation. This sensation is generally deemed to indicate the breakdown phenomena and is said to preferentially occur at sites that have a relatively high conductance. (Bergsmann & Wooley-Hart 1973; Fraden & Gelman 1979; Poon, Choy et al. 1980) The results of this experiment revealed that the breakdown points could indeed be visualised and that these points were consistently located along known acupuncture meridians although they did not necessarily correspond with classical acupuncture points. (Poon, Choy et al. 1980) Other studies on the breakdown phenomenon have found that after this phenomena occurs, the skins properties are altered and remain altered for a number of days. Thus, it has been suggested that achieving the breakdown phenomenon maybe useful clinically, as it destroys the skin tissue in a similar way to a needle and thus produces a treatment affect. (Fraden & Gelman 1979)

### 5.4.4 Currents of injury

The deep layers of the skin are similar to other tissues within the body and can be represented electrically by a simple resistance. (Neuman 1992) The epidermis however and in particular the stratum corneum is relatively nonconductive and presents a high impedance. Due to its dialectic properties and thinness, capacitive coupling is permitted between a metal electrode placed on the skin's surface and the underlying tissues. The

epidermis however is semi-permeable to ions and thus the flow of permeable ions can be represented electrically by a large resistance shunting the skin's capacitance. (McAdams & Jossinet 1991) Thus if there is a difference in ionic concentration across this membrane there is a potential difference which is given by the Nernst equation

$$E = \frac{RT}{nF} \ln \frac{(a1)}{(a2)}$$

#### **Equation 3**

#### Where

a1 and a2 are the concentrations of ions on each side of the membrane in moles per liter, R is the universal gas constant of 8.31 J/(mol.K),

T is absolute temperature in Kelvin,

F is the Faraday constant 96500 C/equivalent (equivalent = mole/valence),

n is the valence of the ions.

(Neuman 1992)

While there is considerable literature on the measurement of the bioelectric potentials of the skin, these measurements can be extremely difficult. Many sources of extraneous noise exist and distortion often appears at the skin electrode interface. (Fraden 1979) This noise may result from broadcasting and other electromagnetic and electrostatic fields as well as from electrode polarisation and offset potential due to the large differences in surface area between the measuring and reference electrodes. (Fraden 1979) The difficulties involved in performing experiments on bio-potentials have resulted in many studies not accounting for extraneous fields, noise sources and artifacts, (Bergsmann & Wooley-Hart 1973; Noordergraaf & Silage 1973; Stux & Pomeranz 1990) yet despite these methodological difficulties, there have been some rigorous studies done.

In a series of elegant studies Barker et al. found that in both guinea pigs and man there is a potential difference across the skin of the order of 30 to 100mV (inside positive) setting up a 'skin battery'. (Barker, Jaffe et al. 1982) The discovery of the 'skin battery' led to the

further finding that when an incision is made in the skin, a microampere current flows through each millimeter of the cut's edge. Thus these wound currents generate lateral intraepidermal voltage gradients or fields of about 100-200 mV/mm<sup>2</sup> near the cut which dissipate with distance from the cut with a space constant of 0.3-0.4mm. Thus, it has been determined that the epidermis near a cut drives up to  $300\mu$ A/cm<sup>2</sup> across itself. (Barker, Jaffe et al. 1982)

While currents of injury are insufficient to produce nerve impulses, it has been suggested that the potential difference across an epithelium may subserve epidermal wound healing (Lykken 1971) and that the lateral fields help to guide the cellular movements that close wounds. (Barker, Jaffe et al. 1982) This suggestion is supported by the finding that drying of wounds delays wound closure and that vertebrate cells respond to small steady fields. (Barker, Jaffe et al. 1982) Further support for the role of direct currents in healing is provided by findings that these currents may have profound biological effects including the stimulation of nerve growth, (Pomeranz, Mullen et al. 1984) limb regeneration, (Illingworth & Barker 1980) and bone healing, (Bassett, Pawlik et al. 1964) as well as being involved in embryogenesis, differentiation, and tumor growth.

The study of currents of injury has led to the suggestion that these currents may provide the basis for the effects produced by acupuncture. Indeed the insertion of an acupuncture needle has been shown to produce such currents that may last up to two days after needle insertion. (Stux & Pomeranz 1990) While the insertion of needles at acupuncture points would tend to produce currents of injury, the lowered electrical resistance at these points would also tend to short circuit the skin battery producing resting potentials more positive than surrounding skin. This has been confirmed by Becker's group, who reports that acupuncture points maintained a resting potential about 5mV above surrounding tissue. They also reported the detection of an overall proximo-distal negative gradient along meridian lines. (Becker, Reichmanis et al. 1976)

### 5.5 The significance of lowered skin resistance

The significance of the lowered electrical resistance at acupuncture points is uncertain and the subject of debate. Furthermore, the property of the skin that may contribute to the electrical resistance is also open to question. It has been suggested that the lowered resistance of acupuncture points is due to a thinner stratum corneum at these points (Rabischong, Niboyet et al. 1975; Zhu Z. 1990) or due to the presence of skin appendageal macropores (Chizmadzhev, Kuzmin et al. 1998). Other studies have suggested that there may be different concentrations of dermal nuclei and hair follicles at low resistance points. When examining guinea pig skin sections statistical analysis revealed that there was an increased density of hair follicles and decreased dermal nuclei at low-resistance skin points, which have been shown to correlate with acupuncture points. (Monteiro, Hwang et al. 1981) Light microscopy of these skin sections however was unable to distinguish any difference between these points and surrounding skin.

### 5.5.1 Sympathetic activity and electro-dermal measurements

Despite suggestions that there is a distinct anatomical or physiological basis for the altered resistance properties of acupuncture points at this time it remains unclear as to whether there is an anatomical substrate. Alternatively, it is often suggested that the lowered resistance of acupuncture points is merely a functional property of the skin that is a result of changes in regional sympathetic nervous system activity and sweating.

It is certainly widely accepted that increased sympathetic nervous system activity produces sweating and that this has profound effects on the skin resistance. This finding is used as the basis for lie detector tests and the GSR which represents a phasic increase in skin conductance primarily due to altered sympathetic activity and sweating that occurs in conjunction with psychological stress. (Lidberg & Wallin 1981) However, while the GSR has been shown to closely correlate with sweat production, the relationship between skin sympathetic nerve activity and sweat production has been shown to be a complex, nonlinear function. (Kirnö, Kunimoto et al. 1991) Thus, it has been proposed that GSR amplitudes do not provide reliable estimates of the level of, or even the direction of, changes in sympathetic nerve activity. (Kirnö, Kunimoto et al. 1991)

As well as producing the GSR, albeit in a complex way, it has been suggested that increase sympathetic activity also give rise to a lowered skin resistance in an area suffering from pain. (Bromm & Treede 1980; Riley & Richter 1975) This suggestion is supported by experiments that have abolished the skin resistance response to painful stimuli by sympathectomy or atropine nerve block. (Ionescu, Pruna et al. 1990; Kirnö, Kunimoto et al. 1991; Riley & Richter 1975; Kimo, Kunimoto et al. 1991) While there is good evidence to support the lowered skin resistance of painful areas being mediated by sympathetic activity, it remains uncertain as to the cause of the lowered resistance at acupuncture points.

To determine the role of sweating on skin resistance measures at active points Hálek, et al. performed measurements after preparing the skin by rubbing a 3% solution of formalin in water 4 days prior to the measurements, thus damaging the sweat glands and occluding exocrine sweat pathways. They found that while this preparation did increase overall skin resistance, the relationship between active and non-active skin points remained constant. The same authors also found that low resistance points retained their identity even when measurements were made under cold conditions that reduced sweating. (Hálek, Opavský et al. 1984)

Further support for the argument that sympathetic activity is not directly related to the low resistance at acupuncture points comes from their relative distribution. The finding that sweating occurs uniformly over the skin surface equally at acupuncture points and surrounding skin, (Stux & Pomeranz 1990) and that distinct low resistance points on the auricle of the ear may be detected (Kawakita, Kawamura et al. 1991; Oleson 1980) even though the ear is virtually devoid of sweat glands, suggests that factors other than sweating are important. This suggestion is further supported by the finding that low resistance points are found to be punctate in nature and of no greater than 1cm diameter (Nansel & Jansen 1988) rather than being patchy or diffuse, or involving substantial portions of a particular dermatome, as would be expected if they resulted from increased sympathetic activity.

Additional support for the suggestion that the resistance properties of acupuncture points are not dependent on sympathetically mediated sweat gland activity comes from the finding that acupuncture points may be detected after death. This has been demonstrated by a concordance between low resistance points in embalmed cadavers and live subjects. (Nansel & Jansen 1988) as well as the identification of specific low resistance points on Wistar rats up to thirty minutes after their death (Chiou, Chao et al. 1998).

Based on the above evidence, it appears that the low resistance properties of acupuncture points are not due to sympathetic activity, yet the factors that do give rise to these properties is not clear. Furthermore, it is unclear as to the significance of these properties, and how they change with physiological and pathological processes.

#### 5.5.2 Altered functions at acupuncture points

In addition to having distinct electrical properties, it has been reported that acupuncture points may be distinguished by other biophysical parameters. Distinct properties of acupuncture points have been demonstrated by Eõry who measured skin respiration using a supersensitive  $CO_2$  detecting instrument that is able to detect 0.01 millionth of a gram of  $CO_2$ . (Eõry 1984) These measurements revealed that the skin respiration at acupuncture points was significantly different from surrounding skin areas suggesting that there is a locally increased capillary p $CO_2$  at acupuncture points. Eõry uses these results to suggest a correlation between energy released from adenosine triphosphate and the *Qi* energy described by traditional Chinese medicine.

As well as reports of acupuncture points having different metabolic characteristics, it is often claimed that these points respond differently to pain either locally or in remote sites. Thus, when there is pain or a disease state in a given area of the body, the corresponding acupuncture points are said to become "active" making them increasingly tender and display an increased electrical conductance. (Bergsmann & Wooley-Hart 1973; Jayasuriya 1991; Oleson 1980; Zhu 1981) It is also claimed that at these times there may also be morphological changes in acupuncture points such as discolorations, pimples or papules (Oleson 1980) as well as changes in the electrical resistance of the bilateral acupoint. (Zhu 1981)

The relationship between skin conductivity and pain has been documented by Hampf (1990) who performed a study of 21 healthy volunteers in which acute pain was induced by cold exposure and skin impedance, heart rate and facial skin temperature were recorded. The findings of this study revealed that pain resulted in skin impedance increases of up to 24% and that this change was greater than changes induced in heart rate or skin temperature. (Hampf 1990)

As well as responding to pain, it has been reported that skin resistance at acupuncture points may be related to visceral function. Rosenblatt demonstrated that there is a correspondence between changes in heart rate and skin conductance at acupuncture points that lie along the heart meridian and hence are functionally related to the heart in traditional Chinese medicine. In a novel experimental design that utilised a completely noninvasive approach, Rosenblatt found that when subjects either increased or decreased their heart rate using biofeedback there was a corresponding increase or decrease in the skin conductance at an acupuncture point relating to the heart. Furthermore, when subjects were instructed to use biofeedback to alter their skin conductance at a point relating to the heart there was found to be a corresponding change in heart rate. In both cases significant changes were only seen in acupuncture points relating to the heart and no changes were seen in nearby placebo points. (Rosenblatt 1982b)

Further evidence of a relationship between visceral function and the cutaneous resistance of acupuncture points is provided by Zongxiang who found a relationship between stimulation of the gastric mucosa and skin conductance. In a series of experiments using monkeys and dogs, Zongxiang found that changes in the gastric mucosa produced by hot or cold water, and before or after food, corresponded to significant variations in skin conductance at an acupuncture point relating to the stomach. This relationship was also found in cases of peptic ulcer. (Zhu 1981)

# 6.0 Acupuncture and electromagnetism

### 6.1 'Life potential' and the diagnostic use of points

The fact that acupuncture points can be identified subjectively as tender points and are found to have characteristic electrical properties along with the altered function of these points suggests that they are functional entities. The functional properties of acupuncture points may be used diagnostically in a clinical setting whereby increased tenderness and altered electrical conductivity may indicate pathology in a 'corresponding' body location.

The ability of the electrical properties of acupuncture points to provide information about the functional status of the body has given rise to the development of many different electro-diagnostic devices that may be used to measure the electrical properties of acupuncture points and meridians. These instruments are commonly used to determine a person's energetic balance, as well as modify this balance with small but precise electrical stimulation. These devices are often termed Electro Dermal Screening Devices (EDSD) and the use of them is termed an Electro Dermal Screening Test (EDST) (Tsuei 1996) and include devices and systems such as the 'Mora', 'Vega', 'Biocom', 'Dermatron', 'Ryodoraku', 'Electro-acupuncture According to Voll (EAV)', and 'Listen' systems.

The construction of EDSDs generally consists of an ohmmeter designed to deliver around 10-12  $\mu$ A at around 1-1.25V. An active probe consisting of a metal-tipped electrode attached to the positive side of the circuit is then placed on the point to be examined and a reference electrode that has a much greater surface area attached to the negative side is held in the subject's hand. (Figure 10) A reading of resistance can then be made from the ohmmeter, which is usually calibrated according to a standard. This reading is usually described using two values, the initial reading obtained when the active probe first makes contact and an 'indictor drop', which represents whether or not a steady state is reached. (Lam, Tsuei et al. 1988)



Figure 10 Basic design of electro-acupuncture measurement instruments. (Adapted from Lam, Tsuei, & Zhao 1988)

In an attempt to standardise the equipment and measurement parameters used for electrodermal screening, Lam et al. examined 16 different devices with electrodermal screening capabilities. They found that all the instruments tested were similar in basic design with the main differences being the types of meters used and their respective calibrations. Thus, adjustments may be required when comparing results from different devices. (Lam, Tsuei et al. 1988)

It is claimed that many different types of information may be obtained from electrodermal screening procedures in the form of the magnitude of the initial reading, the presence of an indicator drop as well as information related to the particular point tested. Perhaps the most controversial aspect of electrodermal screening is the use of information based on the condition of the electrical circuit at the time of measurement. The circuit may be 'altered' by placing different substances on an aluminium plate in series with the subject and the initial reading and indicator drop may then be used to help assess whether these substances may enhance or diminish the body's homoeostatic responses. (Tsuei 1998)

Chen has attempted to explain the basis for EDST by including active elements in the description of the electrical properties of the body. Chen describes three types of responses of the body to applied small DC voltages; electrical conduction, dielectric polarization and defense regulation. Thus when voltage is applied to the body, initial current conduction is followed by polarization of the tissues. These passive processes then invoke an active response from the tissue whereby cells set up a defensive self-regulation of charge to oppose the induced polarisation. The net electrical gradient or polarisation produced by living tissue as an active response to externally applied voltages has been termed "*life potential*" by Chen. (Chen 1996) As this 'life potential' acts to oppose any externally applied voltage, the current passing through a living body can be represented by the equation

$$I(t) = [V + V_{LP}(t) - V_{POL}(t)]/R(t)$$

Equation 4

#### Where

V is the applied voltage

 $V_{\mbox{\tiny LP}}$  is the life potential produce by the active response of the tissues,

 $V_{\mbox{\scriptsize POL}}$  is the polarisation potential induced by the applied voltage V, and

R(t) is the tissue resistance.

(Chen 1996)

In practice it is only possible to measure the balance between polarisation potential and life potential and thus Chen has defined a balance potential  $V_{BAL}$  which represents the difference between these two measures. (Chen 1996) Thus, equation 2 can be rewritten as;

$$I(t) = [V + V_{BAL}(t)]/R(t)$$

#### **Equation 5**

Chen has determined that the relaxation time of the resistance function R(t) is usually less than 50ms while the relaxation time of the balance function  $V_{BAL}$  is several seconds, thus when current is applied to the body, the initial peak reading gives a measure of the resistance while the following steady state represents the balance function. Chen has further determined that acupuncture meridians have not only higher conductance but also lower polarisation and therefore faster electromagnetic wave propagation and patterns of preferential direction. (Chen 1996)

While Chen has gone further than other authors in establishing a scientific basis for electrodermal screening, the definitive analysis of electrodermal screening is yet to be performed. To date the development of the EDST as a clinical tool has been primarily based on clinical grounds and anecdotal reports and for this reason it has been criticised as lacking rigorous experimental evidence. (Katelande, Weiner et al. 1991; Stux & Pomeranz 1990) While it is true that electrodermal screening has developed from empirical observations, it is currently been used around the world in different clinical settings including veterinary practice and dentistry (Voll 1980) and there are a growing number of reports providing experimental validation of its use.

In a double-blind study by Krop et al. electrodermal testing was able to discriminate between allergic and non-allergic substances in a group of 24 subjects with up to a 96% success rate (p = 0.000002). (Krop, Lewith et al. 1997) In another double blind study Szopinski et al. compared the diagnostic results obtained by means of electrodermal diagnostics and clinical diagnoses in 70 patients with suspected pathology of one (or more) of the following organs: oesophagus, stomach, duodenum, biliary tract, pancreas, colon, kidneys and urinary tract. They found that the detection rate for the electrodermal screening was 90.6% with 91% sensitivity and 90% specificity. Furthermore, they found that the electrodermal screening measures were able to estimate the actual extent of the pathological process within particular organs. (Szopinski, Pantanowitz et al. 1998) Similarly, clinical diagnosis was compared with diagnosis made by electrodermal measurements in subjects with carcinoma of the lung using a blinded methodology by Sullivan et al. (1985). This study found a statistically significant correlation between cases of lung cancer and the electrical conductivity of acupuncture points corresponding to the lung and correct diagnoses were made in 87% of instances. (Sullivan, Eggleston et al. 1985)

In yet another rigorously designed 'double-blind' trial, Oleson et al. compared the diagnosis of musculoskeletal pain in 40 patients with assessments made by blinded examiners of the tenderness and electrical conductivity of acupuncture points on the patient's ears. The somatotopic mapping of the body onto ear acupuncture points has been described in detail by the Chinese and more recently by Paul Nogier (Nogier 1972) with only slight differences. (Oleson & Kroening 1983) Using these descriptions, it was found that there was greater than 75% concordance between established medical diagnosis and the diagnosis based on the functional state of the ear points. (Oleson 1980) The somatotopic mapping of organs on the ears was also investigated by Saku et al. who studied the electrical resistance of the ear in people with coronary artery disease. The found a positive correlation between altered electrical properties of points considered to be functionally related to the heart and the presence of angina and previous myocardial infarction. (Saku, Mukaino et al. 1993)

Further confirmation of the ability of electrodermal measures to provide clinically relevant information is provided by Tsuei et al. who have performed over 20 studies on bio-energy and electrodermal screening, constituting the largest body of data on this subject collected by one research group. (Tsuei, Lam et al. 1996) These studies include a series of case reports that positively correlated EDSD findings with standard diagnostic tests (Lam & Tsuei 1983) as well as a study that demonstrated a high correlation between the EDST and food allergy testing including food re-challenge testing. (Tsuei, Lehman et al. 1984) Further support for the accuracy and reliability of electrodermal screening was obtained from a series of studies in healthy subjects as well as in subjects performing *Qi*-gong and subjects who had been exposed to various substances such as organophosphates or dental amalgams. (Tsuei, Lam et al. 1996) Finally, in a series of case-controlled studies, EDST was found to correlate well with standard diagnostic procedures for diabetes (Tsuei, Lam et al. 1989) and hypertension. (Tsuei, Lam et al. 1996)

Based on the above findings these authors claim electrical measurements can be predicted based on the traditional organ-meridian relationships described by traditional Chinese medicine theory and that EDST has the potential of developing into a complete diagnostic screening tool. (Tsuei, Lam et al. 1996) However, while it is admitted that an intensive research effort with multiple clinical trials is required before this technique is adopted on a widespread basis, research activity in this area appears to be less than is warranted by the potential usefulness of this procedure. Perhaps the main reason that EDST has not enjoyed wider support from the mainstream medical community is that the bio-energetic basis for this system is not well accepted or understood.

#### 6.2 Direct current theory of acupuncture

In determining the significance of the electrical properties of acupuncture points, the work by Robert Becker's work is distinctive. Becker unlike other Western authors attempts to provide a framework within the context of Western science that could provide a theoretical tool with which to understand, rather than simply explain, the phenomenon of acupuncture. Becker's theory draws on cybernetics and solid state physics and centers on the description of a direct current control system that functions in concert with, but independent of, the nervous system. This theory builds on earlier suggestions by John Von Neumann that just as in the development of computer technology whereby analogue signaling predated digital communication, within the evolution of life there must be a more primitive analogue control system that antedates the development of the 'digital' all-or-nothing action potential. (Von Neumann 1958) Becker's theory also builds on previous work by Burr who postulated that naturally occurring DC potentials have a control function. (Burr 1935)

The theory of a direct current control system suggests that the mechanisms of healing and regeneration must be subject to control processes that initiate, monitor and terminate them. Furthermore, it is suggested that these processes are likely to be independent to the nervous system as the nervous system is not necessarily involved in the healing process and these processes also exist in life forms without a developed nervous system. (Becker, Reichmanis et al. 1976) Becker's direct current theory has led him to explore many different aspects of bio-electricity including acupuncture, currents of injury, the effects of environmental electromagnetic fields, the nature of charge carriage in animals, as well as the relationship between bio-electricity, levels of consciousness, wound healing and regeneration. This

work, which spans three decades is summarised in two volumes which also describe Becker's difficulty in performing research outside of the main scientific paradigm and his difficulties in having his work accepted by the wider scientific community. (Becker 1991; Becker & Seldon 1985)

Much of Becker's early work focuses on the problem of regeneration and measurements of the current of injury at the amputation sites of salamanders and frogs. In a series of experiments on regeneration Becker found that salamanders that are able to regenerate missing legs display a negative current of injury while the current of injury in frogs which heal amputations by fibrosis is positive. (Becker 1961a) Further research revealed that injury to living organisms results in a series of electrical events at the site of injury that are responsible for the process of dedifferentiation and mitotic activity and that electrical stimulation is able to stimulate regeneration in amphibians and at least partial regeneration in mammals. (Becker & Spadaro 1972)

In a remarkable series of experiments using silicon covered bimetallic implants consisting of silver and platinum with a carbon resistor between to produce current of the order of 1 - 3 nanoamps Becker was able to produce partial regeneration of amputated forelimbs in rats. Becker also found that de-differentiation could be induced in amphibian red blood cells *invitro* and that cells were able to respond to current levels ranging of the order of to pico  $(10^{-12})$  to nano  $(10^{-9})$  amperes. A distinct voltage and current window was also found for these effects. (Becker 1972) Thus while cellular changes could be produced by potentials of 0.3mV across each cell with current densities of the order of 1 picoamp/mm<sup>2</sup>, currents greater that nanoamperes were ineffective. (Becker & Murray 1970) Based on experiments of fracture healing in amphibians Becker was also able to demonstrate that fracture healing was dependent on electrical signals that were transmitted in the Schwann cells that support the peripheral neurons. (Becker 1974) This research led Becker to postulate that regeneration is a cellular process that is regulated by a precise control system utilising the solid-state and electrochemical properties of cells and tissues as control signals.

Becker theory proposes that a DC transmission system exists, based on the continuous passage of DC and that this system subserves the task of controlling phenomenon associated with healing and regeneration. (Becker, Bachman et al. 1962a) This DC system, while not able to carry the large volume of data carried by the 'digital' action potential system, is suggested to precisely control a few variables by transmitting information in the form of parameters such as polarity, magnitude, or specific low frequency waveforms. (Becker, Reichmanis et al. 1976) The DC control system theory is based on considerable experimental evidence including the finding that DC potentials on the surface of animals and humans exhibited field patterns are related to the nervous system (Becker 1962) and that spinal nerves exhibited longitudinal direct current gradients. (Becker, Bachman et al. 1962b) These findings along with measurements that revealed that sensory nerves posses gradients that are distal positive and motor nerves distal negative, led to the proposal that sensory and motor nerves not only complete a simple reflex arc through the conduction of actions potentials, they also complete a DC circuit. (Becker, Bachman et al. 1962a)

The medium for such a DC control system draws on work by Szent-Györgyi who proposed that solid state mechanisms such as semiconductivity and piezoelectricity play a role in living systems. (Szent-Györgyi 1960) Becker was able to expand on this idea by demonstrating that collagen molecules in addition to being piezoelectric behaved as N-type semiconductors while the mineral crystals in bone behaved as P-type semiconductors. (Becker 1972) Becker was also able to demonstrate the occurrence of semiconducting pathways in the limbs of salamanders. This was done by measuring Hall voltages (Figure 11) within the limb when it was placed in a perpendicular magnetic field. (Becker 1961b) In these experiments Becker was not only able to demonstrate that these voltages exist, he also demonstrated that the charge carriers concerned possessed a high mobility and were most likely electrons rather than ions and therefore due to semiconduction rather than ion movement. (Becker 1962)



Figure 11 The Hall effect (adapted from Becker 1974)

In addition to being confirmed by experimental evidence, the DC control theory has led suggested explanations for a variety of observed phenomena. The idea that sensory and motor nerves constitute a closed DC circuit has given rise to the suggestion that skin resistance and potential measures can be interpreted as variations in the DC flow at these points. (Becker 1974) Thus, it has been proposed that acapuncture meridians exist as DC communication channels and that acupuncture points are the sites of operational amplifiers that are necessary to overcome signal losses within the transmission line. Furthermore, being based on semiconduction with charge carriers with a high mobility and hence high susceptibility to perturbations by external electrical and magnetic fields, it is suggested that environmental electromagnetic fields may have significant effects on biological functions. (Becker 1972)

Becker supports this later suggestion with observations that geomagnetic disturbances alter human psychiatric behaviour (Friedman & Becker 1963; Friedman, Becker et al. 1965) leading Becker to conclude that: "the magnetic field of the Earth is an important physiologic factor for living organisms and that behavioural changes of an undesirable nature, either quite evident or subtle, may result from exposure to environments having lower or higher field strengths than "normal" or those having either no fluctuation or cyclic fluctuation at frequencies other than those to which we are adjusted" (Becker 1991) The idea that environmental electromagnetic activity may influence the acupuncture meridian system is supported by Sher (1996) who proposes that the effects of changing weather patterns on mood and behaviour may be mediated by electrical processes in acupuncture points. He suggests that acupuncture points may be affected by atmospheric electricity and that this may have an effect on neurotransmitter release in the CNS. (Sher 1996; Sher 1997) The suggestion that environmental electromagnetic activity may effect the activity of acupuncture points has also been widely investigated by Russian researchers who have demonstrated a connection between electrophysiological skin parameters and the state of the geomagnetic field. (Ryzhikov, Raevskaya et al. 1982)

While much of the Russian work has not been translated and remains inaccessible to Western readers, one study that has been translated, reports the measurement of electrical resistance of more than 12 acupuncture points using  $5\text{mm}^2$  Ag-AgCl search electrodes and a  $10\text{cm}^2$  reference electrode using two polarities of a  $1\mu$ A current. Twice daily measurements over a 53 day period revealed that while the mean 24-hourly value of electrical resistance at certain points was fairly stable under constant conditions, there was a correlation (correlation coefficient between 0.68-0.85) between an increase in resistance and high levels of simultaneous geomagnetic activity. (Ryzhikov, Raevskaya et al. 1982)

Over a period of three decades, rumerous lines of evidence have accumulated to suggest the existence of a biological DC control system. This evidence includes the presence of semiconducting properties of tissues (Becker 1972) and of semiconducting currents in the body, (Becker 1961b) the finding that currents of injury appear to influence regeneration and healing, (Becker 1961a; Becker & Spadaro 1972) demonstrations that the application of nanoamperes may cause dedifferentiation in cell cultures, (Becker 1972) the finding of an organised distribution of DC potentials over the body, (Becker, Reichmanis et al. 1976) along with the finding that environmental electromagnetic fields may influence human behaviour. (Friedman & Becker 1963; Friedman, Becker et al. 1965) Furthermore there is also considerable evidence to support the idea that such a system may provide an explanation for acupuncture including the demonstration of low resistance properties of

acupuncture points and meridians and the demonstration of well defined skin resistance patterns coinciding with the meridian network. (Becker, Reichmanis et al. 1976)

Despite the wealth of evidence, for an electromagnetic basis for acupuncture, it seems that the most research into acupuncture has been dominated by the exploration of neurohumoral mechanisms. This has been prompted by the discovery of the endogenous opioids in the mid-1970s, which seems to have led to the abandoning of much electromagnetic research into acupuncture in favour of neurophysiological research. The dominance of acupuncture research by the field of neurophysiology is perhaps not surprising, as electromagnetic explanations suggests an entirely new system of bio-communications whereas neurophysiological explanations do not involve such a radical change in perspective. It appears however, that an exploration of the electromagnetic basis for acupuncture is warranted for neurophysiological mechanisms are not able to provide a complete explanation or account of acupuncture phenomena.

While Becker's theory of a DC control system provides a framework with which to explain some of the electromagnetic phenomena associated with acupuncture, it does not provide an explanation of the organ-meridian relationships or provide an explanation for the therapeutic use of specific acupuncture points in specific conditions. Furthermore, this theory does not attempt to provide an account of the many practical and philosophical principles of traditional Chinese medicine upon which acupuncture was developed.

Thus while Becker's theory goes further than perhaps any other towards explaining acupuncture in terms that are accepted by Western science, any emerging explanations for acupuncture needs to be able to incorporate an explanation of both electromagnetic and neurophysiological phenomenon. It is also suggested that any future explanations will be incomplete without a consideration of traditional Chinese medicine theory upon which acupuncture was first developed.

### 6.3 An introduction to experimental work

After briefly reviewing the literature, it is evident that although acupuncture may produce significant physiological effects, there is still much that is unknown about its mechanism of action. It is also evident that there are many difficulties in performing research into acupuncture due to a lack of standard definitions for acupuncture points and meridians, as well as few standards for the experimental exploration of its basic mechanisms. Further difficulties arise from the lack of integration between Chinese concepts and Western science, which frustrates attempts by Western practitioners and researchers to learn from the traditional theoretical foundations of acupuncture.

Despite these difficulties there is good evidence that the stimulation of acupuncture points results in the release of neurochemicals and that this stimulation can mediate analgesia, produce immune enhancement and achieve alterations in autonomic nervous system and organ function. Furthermore, it is evident that acupuncture points can be identified as points of local tenderness as well as having distinct electrical properties. Although there is much work needed before these properties are fully characterised or understood, there is also evidence that acupuncture points may exhibit functional changes during pathological states, thus providing potentially useful diagnostic information

While current attempts at understanding acupuncture focus on either neuro-humoral or electromagnetic phenomena, both fall short of a complete explanation. Neuro-humoral explanations involve the evoking of viscero-cutaneous and cutaneo visceral reflexes as well as gating phenomenon in the spinal cord and the release of central neurotransmitters. While these processes help to explain some of the clinical effects of acupuncture, they do not account for the existence of points and meridians. Alternative explanations that focus on electromagnetic phenomena utilise the theory of a DC control system. This theory attempts to account for the electrical properties of acupuncture points and meridians and predicts biological effects from very low levels of stimulation including environmental electromagnetic fields. This theory however, does not explain the functional nature of the points or the various clinical effects.

In order to investigate some of the issues raised by the literature and to confirm and extend the results of previous studies, a broad series of investigations were undertaken that addressed the following questions.

- Does stimulation with acupuncture needles produce electrical effects?
- Do points have specific absorption properties?
- ♦ Can the DC properties of points and meridians be further characterised?
- Do meridians posses specific transfer functions?
- Is there a link between environmental fields and central nervous system functioning?
- Are there parallels between Eastern and Western concepts that may assist in understanding or explaining these phenomena?

The following chapters describe and discuss the outcomes of these investigations.

# 7.0 Acupuncture needles and the Seebeck effect

# 7.1 Introduction

While the use of electrical stimulation is commonly used in acupuncture research and practice, there is some evidence to suggest that the use of needles may also induce electrical changes and that traditional stimulation techniques may modify these effects. When an acupuncture needle is inserted into the body, a temperature differential of around 10 to 15 degrees is created between the handle of the needle at room temperature and the needle tip at body temperature. Based on theoretical considerations this temperature gradient is capable of inducing a potential difference due to the Seebeck effect. (Blatt, Schroeder et al. 1976; Pascoe 1973).

The Seebeck effect relies on the fact that electrons in the hotter parts of a conductor will naturally flow toward the cooler parts. Thus a current is produced which then maintains a charge separation and hence a potential difference driven by the temperature gradient. The traditional design of acupuncture needles appears well suited to maintaining such a temperature gradient because the classical coiling of copper around the handle of the needle acts to increase the surface area and thus acts as a thermal radiator. (Figure 12)

Based on these considerations it could be expected that the insertion of an acupuncture needle into the body would produce a potential difference across the needle with the needle tip being of negative potential compared to the more positive handle. The classical technique of heating the handle of an inserted needle with burning moxa (*artemesia vulgaris*) (Jayasuriya 1991) could then be seen to reverse this potential gradient causing the handle to be positive compared to the more negative tip, while cooling the needle handle would have the reverse effect.



#### Figure 12 Typical modern acupuncture needle construction

The above analysis suggests that the insertion of acupuncture needles into the body produces an electrical gradient induced through the Seebeck effect. The order of magnitude of this effect however, has not been reported. In order to determine the electrical potential produced in an acupuncture needle due to the temperature gradients between the environment and the body the following study was devised.

# 7.2 Method

Traditional 'Hwato<sup>TM</sup>' brand acupuncture needles 0.2 mm in diameter and 40 mm long, made in China from stainless steel with coiled copper handles were used (Figure 12). Needles were connected to a standard Biopac<sup>TM</sup> EEG, biopotential amplifier circuit (Biopac Systems Inc, Golenta, CA) in order to record potentials in the microVolt range. (Figure 13) The gain of the amplifier was set at 10 000 with the sampling rate set at 50 Hz. The EEG amplifier's built in 'alpha filter ' was used which consists of an analog 8-13 Hz band pass filter followed by a full wave rectifier and a 5 Hz two pole low pass filter. A 0.1 Hz low pass digital filter was also added to exclude low frequency noise and drift. This configuration was used to observe slow changes in the DC potential across the needle and was found to eliminate the majority of high frequency noise and to produce the cleanest signal with the available equipment. The needle was connected in series with a 2  $M\Omega$  resistor to match the input impedance with the impedance of the amplifier (2  $M\Omega$ ). The Biopac<sup>TM</sup> amplifier was interfaced with a PC through the associated MP100 data acquisition system and the related AcqKnowledge® software (Biopac Systems Inc, Golenta, CA) was used to display the output and to perform the digital filtering.

All measurements were carried out inside a Faraday cage to shield from the effects of low frequency electromagnetic radiation. The amplifier set-up and PC were kept outside the Faraday cage and shielded leads were used between the experimental set-up and the amplifier (Figure 13). An acupuncture needle was connected in series with a  $2M\Omega$  resistor to a Biopac<sup>TM</sup> EEG amplifier using shielded leads. All measurements were performed inside a Faraday cage and the cage and amplifier were connected to a common ground. The needle tip was heated to body temperature by holding it between thumb and forefinger. The handle was then heated using a naked flame.



Figure 13 Experimental Set-up for measurement of the Seebeck effect

Measurements were made on the needle alone to eliminate the effect of the transcutaneous potential difference. The ambient room temperature was maintained at a steady 22 °C. A temperature gradient of 13.4°C was maintained across the needle by heating the needle tip to a temperature of 35.4 degrees Celsius by grasping the end of the needle between two fingers. The temperature reading was confirmed using an electronic temperature probe accurate to 0.05°C. A temperature gradient of over 800 °C was maintained by heating the needle handle using a naked flame. All measurements were repeated five times on different occasions using the same type of needles to ensure consistency of results. (Cohen, Kwok et al. 1997)

## 7.3 Results

Figure 14a shows the recording needle potentials before, during and after heating the needle. Figure 14b shows the same data after digital filtering was applied. As can be seen from the figure, heating of either the tip or the handle of the needle produces an initial peak in measured potential which then drops after a period of about one second to a level above that recorded at room temperature. This indicates that there is an initial current flow in the needle after which equilibrium is maintained. The equilibrium is reached when a potential difference across the needle can balance the temperature gradient. The equilibrium potential for a heated needle occurs at around 20  $\mu$ V and is maintained for as long as the temperature gradient exists. When the needle is heated, a higher level of background noise is also seen. This is likely to be due to temperature effects.

The experimental procedure was performed ten times to ensure consistency of results and average values were taken. The average value for potentials across a needle at room temperature was 5  $\mu$ V. When the needle tip was heated to body temperature the average potential was 13  $\mu$ V, while after heating the needle handle with a flame the average potential was 18  $\mu$ V. The steady state current flow can be calculated from Ohms law;

I = V/R

**Equation 6** 

Where V is 13  $\mu$ V and R = 2 M $\Omega$ . The steady state current flow due to the temperature gradient between the body and the environment is therefore of the order of 6.5 pA (6.5 x 10<sup>-12</sup>). The average peak voltage recorded due to the initial heating was 270  $\mu$ V, which gives a value of 135 pA for the initial current flow.

## 7.4 Discussion

The above results suggest that the temperature gradient across an acupuncture needle is able to produce an electrical current of the order of picoAmps and a potential difference of the order of microVolts. This effect was consistently observed whenever heating was applied and was independent of any high frequency interference. The initial effect of heating the tip of the handle is to create a current of 135 pA. This may have been due to the transfer of static charge from the investigators fingers to the needle as well as due to initial electron movement from the cooler to warmer region. This initial current flows for less than 1 second after which equilibrium is reached and a steady potential difference of around  $15\mu$ V is maintained. These findings are consistent with previous reports the potential difference due to the Seebeck effect for copper-iron thermocouple pair is approximately linear in the range from 0°C to 200°C after which it plateaus and drops. (Pascoe 1973)

The traditional design of acupuncture needles seems to be well suited to enhance the Seebeck effect with the coiled copper handle acting as a thermal radiator. This effect however may be reduced by the modern trend of replacing copper handles with plastics that may have an insulating effect. The use of two different metals in needle construction may also act to produce electrical effects due to the Peltier effect, which describes the generation of a potential difference due to the temperature differential at the interface of the two metals. (Blatt, Schroeder et al. 1976; Pascoe 1973) This effect however would be minimal as the temperature gradient at the bimetallic interface would be small and the effect would be limited to the region of the needle's handle and would not extend down the shaft into the patient's body.



Figure 14 Results of Seebeck effect measurements

(a) Raw data of recording across a needle: at room temperature, with the needle tip heated to body temperature using investigator's fingers, 3) after the fingers were removed, 4) when the needle handle was heated with a naked flame, and 5) after the flame was removed.

- (b) The same results after filtering with a 0.1 Hz low pass digital filter.
- (c) Averaged results taken over five different recordings. (Cohen, Kwok et al. 1997)

In addition to the design of acupuncture needles enhancing the Seebeck effect, it seems significant that there are many traditional manipulations to acupuncture needles that may act to modulate the Seebeck effect and possibly enhance its therapeutic role. The classical technique of heating the handle of an acupuncture needle placed *in situ* with burning moxa, (Jayasuriya 1991) would act to reverse the normal temperature gradient by making the handle of the needle hotter compared to the tip and hence would reverse any current flow caused by the Seebeck effect. This would provide acupuncture practitioners with a technique for applying either a positive of negative potential and thus creating current flow either to, or from, the body. Another traditional manipulation that may modulate the Seebeck effect and enhance its therapeutic role is the technique of lifting and thrusting an acupuncture needle in and out of the skin. (Jayasuriya 1991) This technique would cause alternate heating and cooling of the needle and produce an alternating current of between 2 to 10 Hz, which is the frequency range used by modern electro-stimulation devices to maximise endorphin release. (Stux & Pomeranz 1990)

The electrical stimulation generated from the Seebeck effect appear to be extremely small and it is difficult to imagine how such small inputs may have biological effects. Certainly the measured potentials may be of no biological consequence whatsoever, yet these inputs are of the same order of magnitude that have been previously found to produce significant changes in biological tissues including de-differentiation and healing. (Becker 1972; Becker 1974; Becker & Murray 1970) Thus, it appears that due to the nonlinear nature of biological systems, the application of charge to specific sites may be amplified to produce significant biological effects. The application of extremely low levels of current to the body via acupuncture needles may therefore be seen as a technique that applies extremely small yet specific charge to specific body sites.

While the results presented here only apply to the electrical effects produced by a temperature gradient across an acupuncture needle, in clinical situations there is the possibility for many other effects. The short circuiting of the transcutaneous potential difference, the production of currents of injury as well as the creation of a half cell

potential between the needle and the body fluids and electromagnetic induction and may all contribute to electrical effects of needling and play a role in the mechanism of action of acupuncture. Nevertheless, it seems significant that the ancient Chinese, should develop techniques that can modulate current flow to and from the body. The above results suggest that the technique of acupuncture may modify bioelectric events without external electrostimulation equipment through the Seebeck effect. While the significance of this effect is unclear, it adds weight to the suggestion that acupuncture may influence an internal electrical control system.

# **8.0 Optical properties of acupuncture points**

# **8.1 Introduction**

The traditional depiction of acupuncture points suggests that they are sites of energetic exchange and the practice of acupuncture acts to apply external energy to these points. The application of infrared radiation to acupuncture points through the practice of moxibustion is a traditional method of stimulating acupuncture points and this technique has been extended in modern day practice through the use of low-level laser therapy. These techniques are based on the premise that there will be different clinical effects produced when infrared radiation is applied to acupuncture points rather than other areas.

While the low electrical resistance and increased pressure sensitivity at acupuncture points suggests they are points that preferentially transfer electrical and mechanical energy, the response of these points to infrared radiation has been less well explored. In order to investigate these properties further, experiments on the absorption of near infrared laser at acupuncture points were performed.

# 8.2 Method

An experimental procedure was designed and performed by Lazoura (Lazoura, Cohen et al. 1998; Lazoura, Cohen et al. 1997) (Figure 15). The experimental set-up included a single mode laser diode producing near infrared laser at 780nm, with a regulated output of 3.0 mW and pulse repetition frequencies between 1 and 20 Hz. The pulse repetition frequency was controlled by a frequency generator that produced pulses with a 50/50 duty cycle and frequencies of 1, 2, 5, 10, 15 Hz.

The beam produced was focused to produce a spot size of 1mm diameter and was directed at the Li 4 point, or a point 1.5-2.0cm lateral to this from a constant distance of 150mm. The point Li 4 was defined anatomically based on traditional charts as well as electrically by locating points of low electrical resistance using a multimeter (Philips PM2517x, Philips Corporation, Holland). Care was taken to ensure to avoid skin blemishes or discolorations that may have altered the skin's reflective properties. The reflected radiation was collected and focused onto an infrared sensitive receiver via a protected gold plated mirror. The output of the receiver was then sent to the Biopac<sup>TM</sup> biopotential amplifier and data acquisition system. (Biopac Systems Inc., Golenta, CA 1994) Signal analysis was performed using the accompanying AcqKnowledge® software.



Figure 15 Set-up of laser absorption study (Adapted from Lazoura, Cohen, Srekovic, & Cosic, 1997)

### 8.3 Results

The results demonstrate that the Li 4 may be distinguished from a 'non-acupuncture point' by the absorption of near infrared laser as indicated by less reflected radiation from the Li 4 point compared to a control point 1-2 cm distant. (Lazoura, Cohen et al. 1998; Lazoura, Cohen et al. 1997) The differential absorption between the two points was also found to vary with different pulse repetition frequencies with the difference being greatest at a pulse repetition frequency of 1 Hz. This difference was found to decrease with increasing pulse repetition frequencies in a linear fashion. At pulse repetition rates above 10 Hz there was no detectable difference between the two signals. (Lazoura, Cohen et al. 1998) (Figure 16)



Figure 16 Voltage versus time of reflected infrared radiation from acupuncture points and nonpoints at pulse repetition frequencies of a) 1Hz, b) 2HZ, c) 5 Hz, d) 10 Hz (adapted from Lazoura, Cohen, Sreckovic, & Cosic 1997)

# 8.4 Discussion

The finding of a difference in the infrared absorption characteristics between an acupuncture point and a nearby 'nonpoint', suggests that acupuncture points are points of preferential energy absorption and that there is a correlation between the skin's electrical and optical properties. While the biophysical or physiological basis for this correlation is unclear, the results of this study suggest that there is a greater transfer of energy from infrared radiation to an acupuncture point than surrounding tissue and that this difference is dependent on the pulse repetition frequency of the applied radiation.

The absorption of laser into tissue is dependent on a number of different parameters. These include the frequency and power of the laser radiation and the nature of the tissue irradiated. (Chow 1994) When laser is used to stimulate acupuncture points the major part of this energy is absorbed by the microcirculation and the deeper tissues. (Chow 1994) The applied energy density can be calculated from the equation;

$$E = \frac{Pt}{A} \qquad J/cm^2$$

**Equation 7** 

Where E = energy of laser radiation in Joules/cm<sup>2</sup> P = the power output of the laser in Watts t = the time that the radiation is applied in seconds A = area of the spot size in cm<sup>2</sup>

In the case of the above experiment, when a 50/50 duty cycle was used, the energy density delivered to the skin each second is;

$$\frac{0.003 \times 0.5}{0.1} = 0.015 \ J/cm^2$$

This value can be compared to the amount of energy delivered to an acupuncture point during low level laser therapy, which may vary between 0.1 and 4 Joules/ $cm^2$ . Thus the laser used in the above experiment would need to be applied between approximately 7 seconds and 4 minutes to provide a similar energy to that applied during low level laser therapy.

While the total energy density delivered to a point is often used for determining the length of time a laser is applied in therapy, it is the power density that determines the possibility of thermal effects in the tissue. Thermal damage is reported at power densities in excess of 0.5W/cm<sup>2</sup>. (Kert & Rose 1989) Power density in Watts/cm<sup>2</sup> may be calculated from the equation;

Power Density = 
$$\frac{Power}{Area}$$

### Equation 8

In the above experiment the power density = 0.003/0.1 = 0.03W/cm<sup>2</sup>, which is considerably less than the power required to produce significant heating of the tissue. However, the finding of a greater absorption of infrared laser at acupuncture points at pulse frequencies below 10 Hz suggests that there may be some feature of acupuncture points that is able to absorb infrared radiation that is saturated above this frequency. This may be due to short-term alteration in the microcirculation at these points, or the ability of the microcirculation to transmit radiant energy. It is also possible that these points have distinct microarchitecture with increase numbers of desmosomes, tonofilaments or gap junctions that may contribute to an enhanced conduction of both infrared radiation and electrical charge.

It is interesting to observe that the ancient Chinese developed a technique of applying infrared radiation to acupuncture points through the practice of moxibustion and that this technique often involves pulsing the applied radiation at a frequency of around 1 Hz. This is traditionally achieved through the technique of 'sparrow pecking' whereby burning moxa is alternatively placed in close proximity to an acupuncture point and then removed. (Jayasuriya 1991) However, while the finding of unique absorption properties of acupuncture points adds support to the suggestion that they are points of preferential energy exchange between the living body and the environment, the reasons for this are unclear. This finding therefore raises many questions and opens the way for further research into the anatomical or physiological properties that may underlie this phenomenon as well as research into the frequency dependence of the effect.

# 9.0 DC characteristics of an acupuncture meridian

# **9.1 Introduction**

While many studies have examined the electrical resistance properties of acupuncture points compared to surrounding skin, few studies have examined the DC resistance properties between acupuncture points along an acupuncture meridian. Furthermore, while studies involving electrodermal screening have examined the time course of electrical resistance measures over the course of a few secones the dynamic behaviour of resistance measures have not been reported over the course of longer periods. Assessment of the dynamic behaviour of resistance measurements is important however when considering the reliability of these measurements and may provide details of how physiological and psychological responses may influence the electrical properties.

In order to explore the DC resistance between acupuncture points along a meridian, a series of preliminary experiments were performed whereby the resistance between points along a meridian both unilaterally and bilaterally were compared with the resistance between a meridian point and a surrounding 'non-point'. Furthermore in order to determine the reliability and reproducibility of the results, it was decided to examine the stability of resistance measurements over fifteen minute intervals as well as during different manipulations such as during exercise and psychological stress and distraction. (Cohen, Voumard et al. 1995)

# 9.2 Methods

Electrical resistance measurements were performed along the Large Intestine meridian in healthy human subjects (1 female, 3 male). The large intestine meridian was chosen due to its accessibility and the fact that 'major points' that may be easily identified are located along this meridian. Measurements were made using a constant current source of 10  $\mu$  amps and adhesive, 1cm square, AgCl-gel electrodes that did not require any contact

pressure other than the initial pressure used to apply them. Electrodes were placed on the Hegu (Li 4) point over the first dorsal interosseus muscle on either hand, as well as on a point along the same channel situated over the common extensor origin at the elbow (Li 11).

Points were identified using an acupuncture point locator (MME 501 Acupuncture Point Locator & Stimulator, Myer Medical Electronics, Melbourne) and standard acupuncture charts. Electrodes were also placed on nearby 'nonpoints' located greater than 1.5cm from the nearest point or meridian (Figure 17). It was noted that the choice of the 'nonpoint' may have coincided with an acupuncture point in some cases, as the adhesive electrodes covered an areas of 1 cm<sup>2</sup> and there are many acupuncture points that are described on the dorsum of the hand. Every effort was made however, to place the non-point electrode clear of any 'major' meridian points as well as clear of any surface cuts and abrasions.



Figure 17 Points used for measurement (Li 4, Li 11, nonpoint (np)) and location of the Large Intestine meridian (dotted line)

Resistance measurements were made between points along the meridian both unilaterally and bilaterally, as well as between meridian points and nonpoints. Measurements were also performed between the points Li 4 - Li 11 on the same side over 15-minute intervals with readings plotted at 10-second intervals in order to determine the stability of these measurements over time. These measurements were also repeated on different days and under different experimental conditions such as during aerobic exercise (stepping) or during periods of mental distraction caused by asking subjects to perform mental arithmetic. (Cohen, Voumard et al. 1995)

# 9.3 Results

Resistance values ranged from around 50  $\Omega$  to over 4 M  $\Omega$  and were found to vary for different subjects as well as for the same subject at different times although there was some consistency within subjects when measurements were made on subsequent days. Results showed that the electrical resistance between unilaterally located acupuncture points was consistently less than the resistance between an acupoint and a nearby 'nonpoint' even though the distance between the point and nonpoint was significantly shorter than between the two meridian points. (Figure 18) When measurements were made between points on opposite sides of the body, it was found that the resistance between the two Li 4 points bilaterally was less than the resistance between Li 4 and a contralateral nonpoint. These measurements were also consistent when performed on subsequent days. (Figure 19)

Time dependence of resistance measurements are plotted in figures 20-22. From these measurements, three general trends are noted. When resistance values were found to be initially high (greater than 5 k $\Omega$ ) they would remain fairly stable (Figure 20). When the resistance was found to be initially low, (between  $1 - 4k\Omega$ ) it would either remain fairly stable (Figure 21) or tend to increase in a linear fashion. Dramatic drops in the resistance were recorded when subjects were made to undertake vigorous exercise and lesser drops were noted when a subject was unexpectedly distracted or was made to laugh. (Figure 22)


### Figure 2 Unilateral measurements

Measurements showing that between points along the meridian (Li 4 - Li 11) the resistance was less than between a meridian point and a nonpoint (np)



### Figure 3 Bilateral measurements

Measurements showing that despite being the furthest apart, the resistance between the bilateral Li 4 points was less than between meridian points and nonpoints (np) or between the two Li 11 points



Figure 20 Resistance measurements over time. Examples of constant resistance measures showing dramatic decreases with exercise



Figure 21 Resistance measurements over time. Examples of resistance measures showing a gradual decrease over time



Figure 22 Resistance measurements over time. Examples of initially low resistance measures that initially increased and then displayed dramatic decreases with exercise and distraction

## 9.4 Discussion

The results of this study tends to confirm the results of other studies that demonstrate that acupuncture points are of a lower electrical resistance compared to surrounding areas. The finding that the resistance between acupuncture points was less than between a point and a 'nonpoint' even though the path length was greater, may also suggest that there is a high conductance pathway occurring along the meridian. It is unclear from these measures however, if this finding is due to a low resistance pathway along the meridian or simply due to the acupuncture points being of low resistance and providing a current pathway through the epidermis and into the sub-dermal tissue.

Certainly the finding that the resistance between Li 4 - Li 4 bilaterally was less than the resistance between points along the same meridian both unilaterally and bilaterally even though the Li 4 - Li 4 distance was considerably greater may be explained by a particularly low local resistance at both Li 4 points. As these relationships were consistent across

subjects, these results demonstrate that the resistance along the Large Intestine meridian is indeed less than the resistance between the Li 4 meridian point and surrounding skin. The presence of a particularly low resistance at these points is consistent with the view in traditional Chinese medicine that Li 4 is a 'major point'. It may be possible therefore to draw a relationship between points of very low resistance and their relative 'importance' in terms of traditional Chinese medicine.

The dramatic reduction in the measured resistance with exercise and altered attention are likely to be related to the increased blood flow, sweating and greater ionic permeability associated with alterations in sympathetic activity. The slower changes however, may be due to other factors. The measurement procedure involved exposing subjects to constant stimulation by a DC current of  $10\mu$ A produced by the ohmmeter. The slow changes in resistance observed in some subjects may therefore provide an indication of the effects of tissue polarisation as well as the influences of the body's active response to constant stimulation. It is possible therefore that the observed rises and falls in measured resistance reflect subject's state of health or physiological functioning at the time of measurement, however, there is no indication of how this may be interpreted and all subjects were apparently healthy at the time of measurement.

It should be noted that while subjects did receive stimulation from the measuring current, in most cases there was no subjective awareness of any current flow. Some subjects however did experience a sensation of heaviness similar to the feeling of 'deqi' that persisted for some time after the session. It is likely that these sensations were due to polarisation effects leading to an active tissue response producing the deqi sensation.

While this initial study is of an exploratory nature and does not provide enough information to draw firm conclusions, it does suggest that there are distinct resistance phenomena along the Large Intestine acupuncture meridian and that this phenomena displays some dynamic behaviour.

# **10.0 Field plots of skin resistance at acupuncture points**

## **10.1 Introduction**

The clinical assessment of acupuncture points is generally accomplished using palpation or an electronic 'point locator', which measure the DC resistance of points compared to surrounding skin. Commercially available point locators however, are only able to measure a single point at a time, making them time consuming to use and subjective to user bias in point selection. Furthermore these devices do not store data and are therefore unsuitable for producing a field map of skin resistance.

While it is possible to use a multielectrode probe to create a field plot of surface resistance, to date there is only one published study reporting on such a field plot. (Becker, Reichmanis et al. 1976) This study utilised measurements made by rapidly scanning between 36 stainless steel electrodes 0.2cm in diameter placed 0.4cm part in a grid pattern covering a 3.5cm by 2.5cm area of skin. (Reichmanis, Marino et al. 1976) In this study, the authors reported finding conductance maxima at many acupuncture points as well as well-organised field plots around the points. The field plots described were generally ovoid in shape with the long axis roughly parallel to the meridian line and where the meridian line changed direction, the field plot showed a definite lobe along the changed meridian line. (Becker, Reichmanis et al. 1976) (Figure 9)

Despite the dramatic results reported by Becker et al., this study does not appear to have been repeated or confirmed by other researchers. In order to confirm and extend the findings of Becker et al., and to overcome some of the limitations of currently available single probe devices, a multi-channel probe capable of mapping the skin resistance of multiple points was designed. (Kwok 1998; Kwok, Cohen et al. 1998) Field plots of acupuncture points of the forearm were then plotted.

### 10.2 Method

The experimental probe was designed that consisted of 128 pins in a precise 16 x 8 square grid pattern over an 8 x  $4\text{cm}^2$  area. (Kwok 1998) The probe was placed on the skin so that the pins slide freely allowing the weight of each pin allowed to apply constant pressure at each contact point. After cleaning and dampening the skin with moist cotton, the probe was positioned on the anterior surface of the arm two finger breadths (1.5 cun) from the antecubital crease. This position minimised the curvature of the body under the probe and ensured that at least one known acupuncture point (Pericardium 4) was located in the area of interest (Figure 23).



Figure 23 Placement of the multi-electrode probe showing the position in relation to the Pericardium acupuncture meridian (adapted from Kwok, Cohen et al. 1998)

Once positioned, the probe was connected to a 16 x 16 multiplexer configuration. The output of the multiplexer went to a Wheatstone bridge that also had a connection to the posterior surface of the arm to act as a reference resistance. A regulated five volts DC was used to power the two branches and the voltage difference taken from the midpoint of the two branches was then passed to an analog to digital converter (ADC) and on to a PC for display. The whole process was controlled by dedicated software designed for the purpose. (Kwok 1998; Kwok, Cohen et al. 1998) The output produced a shaded contour plot with darker areas showing points of low electrical resistance on the skin.

### **10.3 Results**

Figure 24 shows an example of a skin resistance map produced by the multi-channel probe on the anterior surface of the arm of one subject averaged over three repeated measurements. Similar plots made with the same experimental setup have been previously described. (Kwok 1998) The field plot appears well organised and nonrandom with at least four specific areas of low resistance (darker areas) being easily identified. The distribution of the low resistance regions also appears to follow a longitudinal path, with a low resistance line extending along the length of the plot. (Figure 24)



Figure 24 A field plot of surface skin resistance on the forearm with darker areas representing regions of lower resistance. (adapted from Kwok, Cohen & Cosic, 1998)

## **10.4 Discussion**

The current findings confirm the finding of Becker et al and suggest that the surface skin resistance is well organised, with focal points of low resistance appearing within longitudinal bands of lesser resistance. While the longitudinal band of low resistance may correspond with an acupuncture meridian, it is unlikely that all of the focal low resistance points correspond with the traditionally described acupuncture points. Within the 8 x 4 cm<sup>2</sup> area of the forearm examined in this study only one traditional acupuncture point is well described (Pericardium 4), yet from the field plot it is evident that there are at least four

distinct focal points of low resistance. These four points however, do appear to be situated along a longitudinal band that can be seen to correspond with the pericardium meridian.

The finding of low resistance bands in the region of the acupuncture meridians suggests that the entire meridian has low resistance properties and that the acupuncture points are merely specific low resistance foci along these pathways. This suggestion is supported by the work of Becker et al. who describe field plots with ovoid shapes around acupuncture points and a longitudinal axis along the meridian. (Becker, Reichmanis et al. 1976) These suggestion is also consistent with the finding of low impedance lines on the skin surface of animals (Yu, Zhang et al. 1994) as well as with reports of a greater electrical conductance over the entire course of a meridian compared with sites 1cm distant. (Hu, Wu et al. 1992; Zhu, Yan et al. 1981)

As well as confirming previous reports of a well-organised field plot of surface skin resistance on the forearm, the above findings may also add to the discussion on the size of acupuncture meridians. While the 5mm spacing between individual pins of the multichannel probe limits the resolution, the low resistance band observed in the field plot appears to have a width of around 7mm along its long axis. This is in agreement with suggestions that the meridians are around 5mm wide (Yu, Zhang et al. 1981)

The finding of a well-organised distribution of electrical resistance on the skin that corresponds with the traditionally described anatomy of acupuncture provides evidence of the existence of the acupuncture meridian network. Furthermore, this finding supports the suggestion by Becker that acupuncture may involve a biological, direct current control system. (Becker, Bachman et al. 1962a)

# **<u>11.0 Transfer function of an acupuncture meridian</u>**

## **11.1 Introduction**

While it may be evident that electromagnetic events are involved in acupuncture, it is unclear as to how these act to mediate acupuncture effects. If the electrical properties of the body do mediate acupuncture effects then it is possible that these properties have particular frequency characteristics. Certainly, the different physiological responses to different stimulation frequencies suggest that the frequency components of an introduced signal may be important, however the importance of different frequencies with respect to the acupuncture meridian system is not clear.

In a study by Cosic et al., characteristic resonant absorption frequencies for an acupuncture meridian were found in the range from 2-15Hz. (Cosic, Marinkovic et al. 1984) While this work was of a preliminary nature, it suggests that the meridian network may be tuned to specific frequencies. When considering the frequency characteristics of the meridians the extremely low frequency range (ELF) is of particular interest as this is the range of important biological activity such as respiration, heart rate, and cerebral activity. In order to determine whether or not there are specific resonant frequencies within the ELF range along an acupuncture meridian the following study was devised.

### 11.2 Method

Two acupuncture points along the large intestine meridian were located using standard charts and confirmed by detecting low impedance points in the vicinity. As in the previous study of the DC characteristics of a meridian, the points Li 4 and Li 11 on the large intestine meridian were chosen due to accessibility and the fact that these are 'major points' that may be easily identified. Adhesive 1cm<sup>2</sup> Ag/AgCl-gel electrodes (3M) were placed on each point and an additional electrode placed on the palm of the hand as a common reference point (Figure 25).



Figure 25 Experimental set-up for transfer function measurements

A sharp asymmetrical biphasic pulse producing no net DC, with a pulse width of  $200\mu$ sec Imsec/phase and 5 volt peak to peak amplitude was introduced into the distal point (Li 4) at a rate of 1 pulse per second from a standard acupuncture point stimulator (Myer Medical Electronics MME 501 Acupuncture point locator & stimulator, Mentone, Australia). Recordings were taken from this point as well as from a point further along the meridian (Li 11) over a 20 second period using a digital oscilloscope (Nic 3091, Nicolet Instrument Corporation, Madison, Wisconsin) connected to a PC. The data was sampled at a rate of 100/sec to ensure that the Nyquist criteria were met for the ELF range of interest (<50 Hz). (Tompkins 1993) The data from the oscilloscope was then subject to frequency domain analysis using a Fast Fourier Transform (FFT) using custom software to determine the transfer function and hence the spectral characteristics of the meridian. This procedure was adapted from Cosic (Cosic 1995) and was repeated for 10 subjects aged between 20 and 38 years. (Cohen, Behrenbruch et al. 1998b; Cohen, Behrenbruch et al. 1998a)

### **11.3 Results**

When viewed in the time domain, obvious differences were seen between the input and output signal. (Figures 26 & 27) When subject to analysis Fourier analysis for display in the frequency domain, the input signal was seen to have a broad frequency spectrum with no obvious resonance peaks. (Figure 26) This is in contrast to the output signal in which specific resonance peaks in the frequency spectra can be distinguished. (Figure 27)

It is interesting to note that a strong cutput signal was observed only when the adhesive Ag/AgCl electrodes were placed directly over the respective acupuncture points and that in some subjects this coincided with the perception of current flow along the arm. If the electrodes were moved greater than 1cm distant from these points however, the resulting signal was significantly attenuated or indistinguishable and there was no subjective awareness of current.

The transfer function  $H(j\omega)$  was calculated using the formula:

$$H(j\omega) = \frac{\Im \{out(t)\}}{\Im \{in(t)\}}$$

#### **Equation 9**

On observing the resonance spectra obtained, obvious resonance peaks are discernable at around 8, 14, 21, 26, 33, 39 and 45 Hz. (Figure 28). This distinct spectra indicates that the acupuncture meridian is acting as a band pass filter and allowing only certain frequencies to propagate. The similarity between individual responses and the averaged result from 10 subjects further indicates that the transfer function spectra from the large intestine meridian is consistent across different individuals. This experiment has been subsequently repeated many times using the same equipment with similar findings (Cosic 1995)



Figure 26 The input signal applied to the Li 4 point in the time and frequency domain demonstrating a broad frequency spectrum



Figure 27 The output signal obtained from the Li 11 point in the time and frequency domain demonstrating specific resonant peaks



Figure 28 The transfer function of the large intestine meridian demonstrating specific resonant peaks

When the spectral pattern of the large intestine meridian is compared to other spectral patterns, a striking yet unexpected correlation is noted between the spectral component of the large intestine meridian and those of the 'Schumann resonances'. (Figure 29) These are electromagnetic resonances produced from global lightning that propagate between the surface of the Earth and the ionosphere with resonance peaks occurring at 8, 14, 20, 26, 32, 38 and 45 Hz. (Sentman 1995; Polk 1982; Israel 1973) (Figure 31).



Figure 29 Large intestine meridian transfer function and Schumann resonance frequencies

### **11.4 Introduction to Schumann resonances**

Schumann resonances are the most pervasive aspect of the natural electromagnetic environment within the ELF region. However, while they have been present throughout biological evolution, the discovery of these resonances is relatively recent and they are generally considered within the field of atmospheric electrodynamics rather than biology and medicine.

The physical model for the Schumann resonance spectra was first postulated by Tesla and was based on the assumption that the earth and the ionosphere behaved as a spherical capacitor with a specific resonant frequency. (Tesla 1904; Tesla 1905) Half a century later Professor W.O. Schumann from Munich University proposed the existence of standing atmospheric waves and calculated the main frequency to be 10Hz. (Schumann 1952). The first reported measurements were published in 1954 by Schumann and König (Schumann & Konig.H. 1954) and the first publication of the higher harmonics was in 1960 by Balser and Wagner. (Balser & Wagner 1960). Extensive reviews of the atmospheric electrodynamics literature have been provided by Polk and more recently by Sentman. (Polk 1982; Sentman 1995)

Schumann resonances occur in the relatively non-conducting spherical cavity created between the relatively conducting boundaries formed by the ionosphere, which forms the upper atmosphere above around 50 kilometers, and the surface of the earth. The ionosphere is a good electrical conductor due to the high content of ionised gas molecules produced from the effects of by high frequency cosmic radiation, while the earth's surface is a good electrical conductor due to the fact that it is composed primarily of seawater. The relatively non-conducting atmosphere (resistance of around 1014 Ohms) between these two conducting spheres, carries a charge separation of between 200 000 and 1 million Volts.

Within the Earth-ionosphere cavity lightning dischardes produce electromagnetic radiation of many different frequencies, most of which rapidly dissipates as it spreads away from the source. Those frequencies that correspond to wavelengths with similar dimensions to the circumference of the earth however, are able to propagate several times around the planet

within the earth-ionosphere cavity before undergoing significant attenuation. (Akindinov, Potapova et al. 1994) It is these frequencies that contribute to the Schumann resonances and these resonances constitute the principle component of the natural background electromagnetic radiation in the ELF range from 3 to 60 Hz. (Sentman 1995) (Figure 31)

The production of Schumann resonances may be likened to the tone produced when a hammer strikes a bell. When a hammer strikes a piece of metal, the resulting clang contains many different frequency components that dissipate rather quickly. If the metal sheet is fashioned into the shape of a bell however, particular frequencies will naturally resonate with the shape of the structure producing a characteristic sound made up of distinct resonant frequencies that may reverberate for some time. In the case of Schumann resonances, lightning acts as the broadband frequency source and the geometry of the earth-ionospheric cavity acts as the resonating bell. (Figure 30)



Figure 4 Depiction of electromagnetic wave propagation in the earth-ionosphere cavity demonstrating the third harmonic Schumann resonance (dotted yellow line).

The Schumann resonances occur at specific frequencies dictated by the propagation characteristics of the earth-ionosphere cavity, these frequencies however are not fixed, and they exhibit diurnal and seasonal variations. The ionosphere is comprised of distinct layers that consist of bands of ionized particles with electromagnetic propagation characteristics that vary with changes in photonic activity. As a consequence, the extent of the highly conductive ionospheric regions changes with day and night. This diurnal variation of around 0.5 Hz is also subject to day to day variations and seasonal effects possibly due to variation in the total global lightning and height of the ionosphere. (Balser & Wagner 1962)

Y.



Figure 31 Schumann resonances measured in three different locations. Average amplitude spectra from 2 to 100Hz for Arrival Heights, Antarctica (AH), Søndrestrømfjord, Greenland (SS), and Stanford, California (SU) for the interval January to March 1990. The spectrums are dominated by sharp spectral features of the power supply networks at 50 and 60 Hz. At the Stanford site, modulation frequencies at 30 and 90 Hz occur, which result from non-linearities of the power transmission system. Every spectrum exhibits a carrier frequency at 82 Hz produced by a Russian submarine communication system. Superimposed on the natural background, eight Schumann resonances can be distinguished. (From Füllekrug & Fraser-Smith 1996) While the Schumann resonances are produced from the totality of global lightning, it seems that at any one time there are specific geographical regions that are the primary contributors. The Defense Meteorological Satellite Program observations have indicated that the vast majority of global lightning is concentrated over three broad continental tropical regions. These regions are situated around the equator and coincide with the earth's most prominent rainforest areas located in Southeast Asia, sub-Sahara Africa and the Amazon basin and Central America (Orville & Henderson 1986).

Thunderstorm activity tends to be concentrated in rainforest areas in the late afternoon at approximately 1000, 1600 and 2200 UT respectively, leading to corresponding intensification of the Schumann resonances at these times. Thus while lightning over the oceans and other regions may be intense locally, it is relatively insignificant on a global scale and lightning outside of the major rainforest areas contribute very little to global Schumann resonances. The finding that the principle peak of the diurnal modulation of the Schumann resonances is at 2200 UT suggests that in addition to being the major rainforest areas of the planet, the Amazon basin and the Americas are also the globally dominant lightning source. (Sentman 1995)

Since global lightning activity is not strictly periodic, there is no specific localization of propagated electromagnetic waves, yet variation in ionospheric and surface conductivity (i.e. oceans, ferrous deposits) may change the localized value of Schumann resonances. Schumann resonances however, are global phenomena and as they travel around the planet they can in principle be detected anywhere on earth. The global nature of Schumann resonances is evident by the finding of Füllekrug and Fraser-Smith who report good correlations between the frequency spectra of the horizontal magnetic field component in the Schumann range at three sites well separated in latitude and longitude, situated at Arrival Heights in Antarctica, Søndrestrømfjord in Greenland and Stanford in California. (Figure 31) (Füllekrug & Fraser-Smith 1996)

While Schumann resonances are the most pervasive aspect of the natural electromagnetic environment within the ELF region, it is unclear what effect they may have on living

systems and the finding of an apparent correlation between Schumann resonances and the spectrum of the large intestine meridian was striking and unexpected. Initially it was thought that this finding may have been due to aliasing from higher frequencies or other errors introduced during the analysis, or from experimental artifact introduced by the equipment. It was therefore decide to repeat the measurements using an entirely different experimental set-up with different instrumentation and analysis software including different electrodes, input signal and sampling rate.

### 11.5 Revised methodology for transfer function measurements

The experimental procedure for transfer function measurements was repeated using the Biopac<sup>TM</sup> environment, which consists of PC-controlled signal generator and biopotential amplifiers along with the specialised MP100 data acquisition system and AcqKnowledge® data acquisition and analysis software (Biopac Systems Inc, Golenta, CA).

To eliminate the effects of the skin-electrode interface it was decided to replace the Ag -AgCl adhesive electrodes with standard stainless steel acupuncture needles inserted approximately 0.5-1.0cm into the respective acupuncture points. A large brass hand-held electrode was then used to serve as the common reference point. The acupuncture point stimulator was also replaced with a signal produced from the signal generator within the Biopac<sup>™</sup> environment. The input signal was designed as a biphasic pulse 1msec/phase (2msec pulse width) with an output of 1 volt peak to peak. The sampling rate was also altered from 100 to 200/sec. Thus every element from the original recordings was substantially altered and the experimental procedure was then repeated for ten subjects using this new configuration. (Figure 32)

### **11.6 Results using revised methodology**

When the measurements were repeated with the revised experimental setup, the resultant spectrum was similar to the spectra previously obtained thus confirming the apparent correlation between the spectra of the large intestine meridian and Schumann resonances.

(Figure 32) Furthermore, in accordance with the difficulty in obtaining a signal when the Ag-AgCl electrodes were not placed precisely on the acupuncture points, when the needle electrodes were used a strong output signal was obtained only when the needle was placed precisely into the Li 11 point.

The finding of a distinct transfer function using needle electrodes suggests that the properties of the acupuncture meridians are distinct from the properties of the skin at acupuncture points. The use of needle electrodes effectively bypasses the epidermal barrier, therefore the propagation characteristics of the introduced signal appears to be dependent on the properties of the subdermal tissue and the acupuncture meridian and not just on the low resistance properties of the acupuncture points.







# Figure 33 The meridian transfer function using Biopac<sup>™</sup> and needle electrodes demonstrating an apparent correlation with Schumann resonance frequencies

On confirming the similarity between the Schumann resonance spectra and the transfer function of the large intestine meridian, an attempt was made to obtain direct measurements of Schumann resonances so that the correlation coefficient between the two spectra could be calculated. Detection of the Schumann resonance depends on very sensitive magnetometers or antennas that are able to detect very small signals (magnetic field strengths of the order of picoTeslas and electric field strengths of the order of microVolts per meter) superimposed on a background of noise at much higher level (Sentman 1995) and it has been suggested that this may be achieved using a simple ferrite core antenna. (Carlson 1996)

While a ferrite core antenna along with appropriate circuitry was constructed in our lab for this purpose (Farang 1998), it proved extremely difficult to obtain a clean signal from this equipment as the measurements were subject to excessive noise. Noise contamination is a recognised impediment to accurate measurements of Schumann resonance as there are many sources of noise, including man-made and natural radiation. Prominent noise sources include geomagnetic micro-pulsations, which have much greater amplitude (several nanoTeslas) and occur at frequencies immediately below the Schumann band. Immediately above the Schumann band at 50 Hz, power line radiation is a significant source of extraneous noise. Nearby lightning and thunderstorms as well movement of nearby magnetic objects such a vehicles and trains and wind blowing charged dust and aerosols also produce local noise sources. Furthermore, movement of the sensor by acoustic or mechanical vibration has significant components in the ELF range and commonly interfere with Schumann resonance measurements. (Sentman 1995)

After much effort it was decided to abandon the attempt to obtain continuous Schumann resonance data and to use the published data obtained from specialised Schumann resonance observatories. (Israel 1973) This information however, is published as discrete frequencies and not as continuous time or frequency domain data suitable for use in a formal calculation. A visual comparison of the spectral peaks of the meridian transfer function with the reported Schumann resonance regions however, certainly points to the existence of a correlation. (Figures 29 & 33)

### **11.7 Discussion**

### 11.7.1 Schumann resonances and biological ELF

The present finding is the first report of characteristic resonant frequencies in the ELF range of the spectra of the large intestine meridian that correspond to Schumann resonances. While this report certainly needs to be confirmed by further measurements, the consistency of the results with two different experimental set-ups suggests that this finding is not due to experimental artifact or calculation error.

The finding that the spectral characteristics of an acupuncture meridian correspond to the Schumann resonance was unexpected and its significance is not clear. Certainly there may be no significance as the observed correlation may be entirely due to coincidence; just because different phenomena share similar frequency characteristics does not mean that they are necessarily related. This finding however, invites speculation that there maybe a

relationship between environmental electromagnetic radiation and the acupuncture meridian network. Further speculation is invited by the fact that there appears to be a correspondence between the primary Schumann resonance frequencies and the spectral components of the human EEG (Figure 34) and that the dominant mode of the Schumann resonance is similar to the frequency of the alpha waves of the human EEG (Kenny 1991) which maybe enhanced by acupuncture and meditation.

In a highly provocative article, Kenny suggests that the similarity of the frequency spectrum of the EEG and the Schumann resonances is more than coincidence (Kenny 1991) Kenny proposes that cerebral cortex may act as a cavity resonator that is somehow able to detect and store these signals and that EEG signals maybe stored Schumann resonances. Kenny goes on to suggest that the spinal cord may act as an antenna for Schumann resonances, or that the cerebral cortex may act as a Fresnel lens to focus electromagnetic signals onto the pineal.



Figure 34 Comparison of typical Schumann ELF and human EEG spectral response. (Adapted from Kenny 1991)

While Kenny's suggestions are highly speculative, the possibility of the central nervous system being affected by naturally-occurring ELF electromagnetic radiation has been considered in detail by Persinger. (Persinger 1973) Based on values for electrical component intensities ranging from less than 1mV/m to slightly more than 1 V/m and magnetic components less than a milliGauss, with calculated power densities of 10<sup>-8</sup> W/m<sup>2</sup>, Persinger suggests that the energy available from environmental ELF phenomena can contribute to neuro-energetic functioning and protein lipid activity. (Persinger 1973) This suggestion is further supported by experimental evidence of complex magnetic fields in the nanoTesla range evoking changes in human melatonin levels (Weaver & Astumina 1990) This is supported by calculations by Weaver and Astumian showing that detection of electric fields that appear to be below the thermal noise limit can occur when the response is exhibited within a narrow band of frequencies, or if signal averaging occurs through field-induced variation in the catalytic activity of membrane associated enzymes. (Weaver & Astumina 1990) (Jacobson 1994; Sandyk 1992)

### 11.7.2 Information and electromagnetic interactions

The biological effects of EMR may arise from many factors. The factors include: the electric or magnetic field components, the energy content, the degree of resonance or coherence, the frequency or modulation of a fundamental frequency, the waveform, amplitude or modulation of amplitude, the length of, or timing of exposure, the area exposed, interference effects with other fields, presence of existing pathology or genetic sensitivity, as well as the information content of the fields. (Presman 1970; Smith & Best 1989; Becker 1991; Becker & Seldon 1985)

The large number of variables to consider when examining the biological effects of electromagnetic fields makes this an extremely complex area. This complexity is compounded by the fact that biological systems are non-linear and that enzymes systems are capable of an amplification factor of the order of  $10^{10}$  allowing biological systems to respond to so-called 'quantum events'. This is evident when considering that the dark-adapted eye is able to detect a single photon or the ear can detect sound ranging from silence (0dB) to the output of a jet engine (120 dB). {Smith & Best 1989 349 /id}

The suggestion that low level environmental electromagnetic activity may affect physiological changes is based on the idea that the information content of a field may be more important than the field strength. Persinger discusses this idea and suggests that the apparent dependence of organismic responses upon the intensity of applied electromagnetic fields may be *a*n artifact of the absence of 'biorelevant' information within the wave pattern. Thus, he proposes that if biorelevant information exists in a field, a response may elicited by field intensities several orders of magnitude below the intensities that have been previously shown to elicit changes. (Persinger 1995a)

The idea that in certain circumstances the information content of a signal may be more critical to biological systems than its energy content is supported by everyday experience. For example, a 1000 Hz sine wave would evoke a response (avoidance) only when the intensity exceeded 90dB. However, if the sound waves were modified to exhibit biorelevant information such as "help me I am dying", field strengths several orders of magnitude weaker, at around 30dB may be sufficient to elicit a response. (Persinger 1995a)

In the above example the information is being presented to conscious processes, however, similar principles may apply to physiological processes. Persinger supports this proposal with extensive correlational and experimental data that indicate that environmental ELF fields can influence reaction time, timing behaviour, ambulatory behaviour, oxygen uptake, endocrine changes, cardiovascular functions, and precipitation-clotting times of colloids. (O'Connor & Persinger 1997; Persinger 1973; Persinger 1996; Persinger & Richards 1995)

While humans as well as other organisms are able to respond to fields as low as the earth's static magnetic field, (Bergiannaki, Paparrigopoulos et al. 1996; Olcese, Reuss et al. 1988; Semm, Schneider et al. 1980) it is still not clear how, and to what extent, low level magnetic and electric fields effect the human organism. The are many suggestions however, that these fields do affect living systems with either positive or negative effects on health. For example, static magnetic fields have been shown to have profound effects on health and improve chronic pain (Wicks & Cohen 1998) and there are suggestion that low

frequency fields such as produced by power lines may produce adverse health outcomes. (Carstensen 1995)

### 11.7.3 Alpha activity, acupuncture and information processing

While most of the work on environmental electromagnetic fields has focused on the production of abnormal or pathological states, the correlation between Schumann resonances, EEG alpha frequencies and the spectral characteristics of acupuncture meridians suggests that ambient radiation may also act to promote homoeostasis. Homoeostatic responses are consistently correlated with the occurrence of human EEG alpha-wave activity, which is a feature of the normal EEG spectrum between 8 - 12 Hz. When these waves become prominent the conscious state is described as 'quiet alertness' or the 'alpha state', which is subjectively experienced as a calm and pleasant. (Hutchison 1994) The alpha state is also often termed the meditative state as many authors have also noted that alpha wave activity is more prominent during meditation (Benson 1975) and *Qi*-gong, (Zhang, Zhao et al. 1988) and that during meditation, alpha activity exhibits greater coherence and synchrony. (Orme-Johnson 1973)

Not only is the meditative state associated with prominent alpha waves, it is also associated with often profound physiological changes that indicate a quieting of physiological activity and the enhancement of homoeostasis. These changes include the lowering of body temperature, reduction in oxygen consumption, lactate levels, blood pressure, heart rate and skin resistance (Benson 1975) as well as subjective sensations of relaxation and wellbeing along with reduced pain awareness and anxiety. (Hutchison 1994)

The idea that EEG alpha activity may enhance information processing within the central nervous system is discussed by Weiner in his classical text on cybernetics. Weiner notes that any processing device that combines a large number of impulses into fewer impulses generally requires a gating mechanism so that messages can be stored, combined and then released concurrently. He further suggests that the central nervous system is just such a device and that EEG alpha rhythm may serve to regulate the 'combining period' of inhibitory and excitatory signals at shared synapses. (Weiner 1961) Weiner further

suggests that the alpha rhythm may be entrained by external oscillations just as the 23-hour biological diurnal rhythm can be pulled into the 24-hour rhythm of day and night by changes in the external environment.

The desirability of the alpha state has led to attempts to enhance this state using biofeedback devices, as well as 'entrainment devices' designed to induce this state using light, sound and other stimuli. (Hooper & Teresi 1990; Hutchison 1994; Watson, Woolet Heart et al. 1979) While EEG alpha-wave activity may be enhanced by mediation and biofeedback, (Wallace 1970) it may also be induced by acupuncture. (Banquet 1973; Orme-Johnson 1973) (Varrassi, Manna et al. 1986) This has led Freed to suggest there is functional isomorphism between acupuncture and meditation, as both of these states manifest prominent alpha rhythm activity, elicit deep general relaxation, exhibit a high degree of unresponsiveness to ordinarily painful stimuli and involve the entire body in their effects. (Freed 1989)

Freed goes on to suggest that the relative internal 'quietness' of meditation and acupuncture serve to promote homoeostasis by reducing the background 'physiological noise levels'. By providing an increase in quality and quantity of available physiological information, this is suggested to enhance the bodies ability to regulate and process physiological information and thus correct imbalances that may not otherwise be addressed. (Freed 1985; Freed 1987) The recognition that the induction of a 'quiet state' is important for acupuncture is also evident within the practice of traditional Chinese medicine which recommends that acupuncture is inadvisable when a patient is too hot, in the grip of fear, anger, hunger, tiredness, drunkenness or when the pulse is greatly disturbed. (Jayasuriya 1991)

While acupuncture and meditation both seems to promote EEG alpha activity and a 'physiological quiet state', how this is achieved is unclear. The finding of resonances between environmental ELF activity, central nervous system activity and the acupuncture meridian system, leads to the speculation that through evolution the acupuncture meridian system has been tuned to the most prominent ambient ELF frequencies and that the act of

meditating or stimulating acupuncture points serves to enhance this. It is also interesting to speculate that this result may have some application in selecting the stimulation frequencies for electroacupuncutre.

While the suggestion of an interaction between environmental Schumann resonances, the acupuncture meridian system and central nervous system activity is speculative and awaits further confirmation, there is evidence for biological effects arising from other sources of natural environmental electromagnetic activity. (Presman 1970)

Some of the most dramatic changes in natural electromagnetic activity arise due to changes in solar activity. During periods of high solar activity there are greater X-ray, ultraviolet and radio emissions from the sun. In addition, solar flares are more frequent during these times and these may produce great disturbances in the earth's magnetic field. These geomagnetic disturbances give rise to natural terrestrial phenomena such as the aurora borealis and the aurora australis as well as producing disturbances to electronic communication and power systems and other man-made devices, especially at high latitudes. (McIntosh 1991) In addition to producing disturbances to electronic equipment, it is possible that disturbances in the geomagnetic field arising from solar activity may also produce disturbances in biological systems and this seems to be supported by epidemiological evidence.

# 12.0 Sunspots and psychiatric admissions

### **12.1 Introduction**

The epidemiological evidence of an association between geomagnetic disturbances and human illness appears to be extensive. This evidence includes suggestions that solar and subsequent geomagnetic activity may influence epilepsy, (Persinger 1995b; Rajaram & Mitra 1981; Stoupel, Martfel et al. 1991) hip fractures, (Caniggia & Scala 1991) changes to immunological status, (Gushchina 1982) flu epidemics, (1999; Ertel 1994; Hoyle & Wickramasinghe 1990) myocardial infarction, (Rozhdestvenskaia & Novikova 1969; Stoupel, Petrauskiene et al. 1996; Stoupel & Shimshoni 1991; Szczeklik, Mergentaler et al. 1983) suicide, (Stoupel, Petrauskiene et al. 1996; Stoupel & Shimshoni 1991; Szczeklik, Mergentaler et al. 1983; Tunyi & Tesarova 1991) psychiatric admissions (Dull & Dull 1935; Friedman & Becker 1963; Kay 1994; Raps, Stoupel et al. 1991) and the ward behaviour of psychiatric patients. (Friedman, Becker et al. 1965) However, while there are many reports of the link between biological disturbances and solar and geomagnetic events, these findings are often not rigorous and many reports are the results of relatively small studies that have looked at data over short periods of time. Furthermore, there are also reports of studies that have found no such relationships. (Pokorny & Mefferd 1966)

By far the most extensively researched and most consistently reported biological disturbances correlated with solar events, is psychiatric hospital admissions. As early as 1935 Dull and Dull examined 40,000 cases over a period of 60 months and described what appeared to be a relationship between magnetic storms and the incidence of nervous and mental diseases and suicides. (Dull & Dull 1935) This study however did not use any statistical analysis. In 1963 Freidman et al. looked at 28642 admissions over 52 months, (Friedman & Becker 1963) and more recently Raps et al examined more than 5000 admissions for depression over 130 months (Raps, Stoupel et al. 1991) and Kay examined 1829 general psychiatric admissions over a 10 year period. (Kay 1994)

While many studies have reported a relationship between psychiatric admissions and solar activity, (Dull & Dull 1935; Friedman & Becker 1963; Kay 1994; Raps, Stoupel et al. 1991) these studies have used only simple statistics such as the Pearson correlation coefficient to report their findings. Few of these studies have explicitly modeled the ordered nature of the data (e.g. monthly bivariate time series of solar activity and hospital admissions). Failure to consider the serial nature of the data is not only an inefficient use of data, it may lead to mistaken inferences. Specifically, large correlations *between* series (cross-correlations) may be spurious if there are large correlations (autocorrelations) within each series. (Box & Newbold 1971)

Autocorrelations are commonly encountered in serial ordered data such as time series data. (Makridakis, Wheelwright et al. 1983) Consequently, the following study was undertaken to look at the relationship between solar activity and psychiatric admissions using appropriate time series methods.

### 12.2 Method

The correlation between solar activity data on all admissions into psychiatric hospitals in Victoria from 1 July 1984 to 31 December 1993 was examined. (Cohen & Wohlers 1998) Hospital admission data was obtained from the Psychiatric Records Information Systems Manager (PRISM) database maintained by the Department of Health and Community Services in Victoria. This database includes all formal psychiatric admissions into the Victorian public-hospital system (43 hospitals) which covers a catchment area of approximately 4 million people. The time period examined covered a period of 3471 days (114 months) during which there was a total of 96050 admissions. (Figure 35)

This is the first time a study has included such a large number of admissions over an extended period. It is also the first time such data has represented the total admissions from a population rather than admissions gathered from selected psychiatric institutions. Therefore, the results presented here are less subject to selection biases. (Cohen & Wohlers 1998)

Sunspots numbers act as indicators for solar activity and fluctuate in a cycle of approximately 11.1 years the most recent maximum being in 1989 when some of the greatest sunspots on record were recorded. (Figure 35) Daily sunspot numbers were obtained from the National Geophysical Data Centre (NCGD) of the National Oceanographic and Atmospheric Administration (NOAA), which provide access to the weighted average of measurements made from a network of cooperative observatories around the world. (NOAA, 1998)



Figure 35 Time series data of psychiatric admissions and sunspot numbers

In this study the time series technique of *prewhitening* was used to examine the correlation between sunspot numbers between 1984–94 and 96050 psychiatric admissions in Victoria, Australia over the same period. In this context, prewhitening involves 4 stages (Figure 36); (Makridakis, Wheelwright et al. 1983)

- 1) Modelling the sunspot series as an autoregressive integrated moving average (ARIMA) process with a white noise residual,
- 2) Filtering the sunspot series with this model to get a white noise series,
- 3) Filtering the admissions series with the sunspot model,
- 4) Forming the cross-correlation of the filtered series of stage 3 with the white noise series of stage 2. For instance, a peak in the estimated cross-correlation function for the monthly series at lag d may indicate that number of admissions is related to the sunspot number after an interval of d months. (Chatfield 1989) The estimated cross-correlation can be tested for the hypothesis that none of the correlations up to a given lag are significately different from zero.

### Transfer Function (TF) Model



### Figure 36 Transfer function (TF) model

The motivation for the prewhitening approach comes from the area of time series forecasting and the notion of a transfer function (TF). If a time series ( $Y_t$  i.e. admissions) is thought to be influenced by another (input) time series ( $X_t$  i.e. sunspots) then a TF is hypothesised to exist that transforms  $X_t$  into  $Y_t$ . If the TF can be estimated then it is possible to forecast  $Y_t$  from  $X_t$ .

In this study, the aim was not to predict psychiatric admissions from sunspot numbers but use the TF approach to test for a relationship between the two. If a TF exists, then a white noise input should be altered so that cross-correlation of the noise input and resultant TF output is *not* that of two white noise series. As the form of the TF is not known, its existence can be inferred by reducing (filtering) the input series to a white noise series and applying this filter to the output. If the cross-correlation function of the filtered series is that of two noise series (null hypothesis) then no TF exists between them. If, however, the null hypothesis is rejected then a TF (relationship) does exist between the series.

### 12.3 Results

The Pearson correlation coefficient between sunspot numbers and psychiatric admissions was 0.399 with a P-value (i.e. null hypothesis of no correlation) of 0.0001. (Cohen & Wohlers 1998) This value is also the value of the zeroth order cross-correlation when neither series has been prewhitened. However, the calculation of the Pearson correlation assumes that the data are independent, that is, the order in which the data is presented is irrelevant. This is not the case with times series data. Both the sunspot number and psychiatric admission series show serial structure. The sunspot series exhibit a maximum between August 1988 and August 1991, while there is a less well-defined increase in psychiatric admissions after August 1987. Thus, the value of the Pearson correlation coefficient may be an artifact of autocorrelations within the two series rather than a relationship between them as this value does not account for the serial nature of the data.

A more appropriate method of examining the correlation between these series is to use the time series transfer function model (as discussed above). The ARIMA model of the sunspot series was found to be a first order moving average of the first differences (Cohen & Wohlers 1998) (standard error of moving average coefficient is given in brackets):

 $Sunspot_{1} - Sunspot_{1} = error_{1} - 0.4983(\pm 0.0823) * error_{1}$ 

Equation 10

The resulting cross-correlation was significantly different from that of two white noise series (up to lag 11, P-value = 0.006). This implies that there is some relationship between the two series. This is despite the significant autocorrelation exhibited by both series. Note, that the zeroth correlation (equal to the Pearson correlation coefficient) of the prewhitened cross-correlation was found to be 0.041. This is much smaller (and not significant) than the Pearson correlation coefficient of 0.399 calculated before prewhitening. (Cohen & Wohlers 1998) Thus although the TF model suggests a relationship between sunspot numbers and psychiatric admissions such a relationship would expected to be quite complex.

### **12.4 Discussion**

The findings from this study suggest there is strong statistical evidence for a correlation between solar activity as measured by sunspot numbers and psychiatric admissions. This evidence is strong for a number of reasons. Firstly psychiatric admission data (96050 admissions) from almost an entire population of 4 million people (Victoria, Australia) was used so the results are not an artifact of small or biased sampling. Secondly, the time series method of prewhitening that explicitly models the serial structure within and between series was used so the results are not an artifact of spurious correlations caused by the intrinsic autocorrelation within series. Finally, the present study supports the findings of previous research demonstrating similar results, albeit with less rigorous methodology.

The finding that there is a correlation between sunspot numbers and psychiatric hospital admissions suggests that environmental electromagnetic activity is able to influence biological information processing. As the most sophisticated information processing in the body occurs during the production of consciousness by the central nervous system, it seems reasonable that conscious processes may be more sensitive to disturbances in ambient fields. It would be interesting however, to perform further investigations using more specific diagnostic criteria, including specific psychiatric condition as well as conditions of other organ systems.

While there is the possibility for much further work, the present result invites speculation as to possible causes. While Becker has suggested that such a correlation provides evidence of an analogue DC control system, the details of this system have not been well established. Previous studies looking at correlations between solar and geomagnetic activity have asumed a direct effect on biological electrical activity and have focused on conditions such as cardiac events (Stoupel, Petrauskiene et al. 1996) and epilepsy. (Persinger 1995b; Rajaram & Mitra 1981; Stoupel, Martfel et al. 1991) Many questions however are left. What feature of the external fields is most important? Which people are most at risk from these effects? What is the nature of the lag period? How are the external fields coupled to internal processes? These questions certainly require much further research before they can be adequately answered.

While the mechanism by which solar activity may effect psychiatric events is not established, it is interesting to speculate that variations in the Schumann resonances may be involved. If the central nervous system is 'tuned' to the ambient ELF radiation in order to facilitate homoeostasis and information processing, the possibility exists for psychological disturbances to arise in susceptible individuals if these frequencies are significantly altered.

Schumann resonances are certainly responsive to solar activity as evidenced by the 0.5 Hz diurnal variation in Schuman resonance frequencies due to the changes in solar radiation and corresponding change in the height of the ionosphere with night and day. (Sentman 1995) Recently there has been the observation of further variations in Schumann resonances that may be related to the 27-day solar rotation period and the corresponding periodicity in sunspot numbers. (Füllekrug & Fraser-Smith 1996) As current records do not yet include observations of Schumann resonance over an entire 11-year solar-cycle, further data is required to confirm these observations. (Füllekrug & Fraser-Smith 1996) Supporting evidence for this relationship however, is provided over a complete solar cycle by observations of ionospheric height variations in the Australian-Japanese longitudinal sector that revealed a correlation between the median ionospheric height and sunspot activity. (Hajkowicz 1991)

While the relationship between psychiatric admissions and Schumann resonance frequency variations is highly speculative, it is interesting to consider that the ancient Chinese were aware of electromagnetic phenomena and considered health to be an energetic balance between the organism and the environment. Chinese historical writings describing the earth's magnetic field and the development of the compass, along with the use of magnets in healing and correlations between illness and sightings of the aurora borealis (a visible indicator of geomagnetic disturbances). (Li 1987) The ancient Chinese were also aware of sunspots which they believed to forewarn of social and other disturbances and recorded sightings have been documented as early as 165 BC. (Wittmann & Xu 1987)

The current finding confirms previous reports with the strongest correlation between sunspots and psychiatric hospital admissions ever established. This finding also supports Becker's idea of an analogue, biological, DC control system and a link between ambient electromagnetic fields, the acupuncture meridian network and health. Much further work is required however before the details of this system are established and this link is understood. Furthermore, it is necessary to develop appropriate conceptual tools and language in order to discuss results across disciplines and thus build up an understanding that may informed from diverse fields of knowledge.

# **13.0 Acupuncture and information theory**

### **13.1** Parallels between basic concepts

The phenomena of electromagnetism and acupuncture is extremely diverse and no one area of research is able to encompass the subject entirely. Thus, further understanding of acupuncture and its underlying mechanisms will depend on an integrated and multidisciplinary approach where workers in different fields can inform each other and contribute to a single growing body of knowledge. Such an approach however, requires a common 'anguage so that discussions across disciplines can occur.

A central aspect of this thesis is that the language of 'information' is common to all fields and thus the application of information theory may provide the basis for mapping from one conceptual system to another. When exploring the parallels between different conceptual systems, it makes sense to first address the most fundamental concepts in either system for presumably they reflect fundamental principles operating in the cosmos and hence should display some coherence. The most basic concepts within Eastern medicine have been described earlier and include the concept of '*Tao*', '*yin*' and '*yang*', and '*Qi*' which can all be found to have Western counterparts.

The concept of "*Tao*" finds a parallel in Western science with the mathematical concept of Absolute infinity. The concept of infinity has been a subject of debate for centuries culminating in the modern day concept of 'Absolute infinity' ( $\Omega$ ) being developed by Georg Camor who is considered the father of mathematical Set Theory and the theory of transfinite numbers. An important feature of the mathematical concept of "Absolute infinity" is that it is by definition, incomprehensible and thus unable to be grasped by the rational mind.
To ensure the incomprehensibility of Absolute Infinity, Cantor devised the Reflection Principle that states: "Any conceivable property of  $\Omega$  is a property of a subset of  $\Omega$ ". Thus if the rational mind attempts to grasp hold of  $\Omega$  it can be assured that it is grasping merely a property of  $\Omega$  and not  $\Omega$  itself. (Rucker 1984) This principle is closely paralleled by Eastern philosophy with the statement; "The Tao that can be spoken of is not the real Tao". (Lao Tsu 1989)

The inherent incomprehensibility of the "Tao" or " $\Omega$ " places these concepts essentially beyond thought. The act of transcending thought however paradoxically allows theses concepts to provide the conceptual basis for an entire system of thought. The concept of *Tao* is seen to represent "the infinite order of nature" and forms the basis of Taoist philosophy. Similarly, the concept of Absolute infinity in mathematics represents "the class of all sets" and this concept forms the basis of set theory, which provides a conceptual framework for the theory of transfinite numbers and a universal language for mathematics. (Rucker 1984) The concept of  $\Omega$  is also expressed in algorithmic information theory by the idea of a perfectly random program. (Chaitin 1987) When it is realised that  $\Omega$  and the Tao represent similar concepts it is possible to begin to demystify Eastern concepts and to thus build a bridge between Eastern and Western ideas.

While concept of *Tao* can be seen to parallel a fundamental concept within mathematics, the concept of *yin* and *yang* finds a close parallel with the quantum theoretical concept of complementative. *Yin* and *yang* refer to pairs of mutually exclusive yet inter-dependant opposites. This idea is well accepted within quantum theory, where light must be understood to have the properties of both waves and particles for a complete description. In fact Niels Bohr, one of the founders of quantum theory included the *yin/yang* insignia in his family coat of arms along with the statement that "opposites are complementary." (Zukav 1979)

## 13.2 'Qi' and the quality of energy

While the concepts of *Tao* and *ying* and *yang* readily find counterparts within Western science, the concept of *Qi* appears to be more problematic. In Eastern thought, the concept of *Qi* represents a subtle form of energy that refers more to the qualitative than quantitative aspects of energy. Thus as Porkert states; "whatever *Qi* the context and absolutely without exception, [*Qi*] always implies a qualitative determination of energy. In other words *Qi* means energy of definite (or definable) quality." (Porkert 1974)

In contrast to the Eastern concept of "Qi" or "life energy", in Western science the concept of 'energy' has a more precise meaning that does not include a form of energy specific to living systems. Thus, the concept of 'Qi' is therefore often rejected as being 'unscientific'. (NCAHF 1991; Skrabanek 1984) The concept of Qi however, does follow many fundamental scientific principles. In particular, the concept of Qi is in accord with the laws of thermodynamics, which are considered as universal laws that comprise the most fundamental principles in Western science. The fundamental nature and wide applicability of the field of thermodynamics greatly impressed Einstein who is quoted as stating: (Tyler Miller 1971)

"A theory is the more impressive the greater is the simplicity of its premises, the more different are the kinds of things it relates and the more extended is its range of applicability. Therefore the deep impression which classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced, that within the framework of applicability of its basic concepts, will never be overthrown."

The laws of thermodynamic are the fundamental laws that deal with mater and energy. The First Law of Thermodynamics deals with the quantity of matter and energy in the universe and states that; "matter and energy cannot be created or destroyed, only converted from one form to another". The Second Law of Thermodynamics is concerned with the quality of energy and deals with the concept of 'entropy' which describes a universal tendency towards disorder. This law states that; "in an isolated system entropy always increase"

The concept of Qi can be seen to be well in accordance with these laws. Chinese pathophysiology, views disease as resulting from a disruption in the normal flow of Qi and this view is in accordance with the First Law of Thermodynamics in that Qi is always preserved. Thus if the flow of vital energy is obstructed, below the obstructed area is deficiency and above the obstruction excess. Furthermore the concept whereby disease arises from a blockage in the flow of Qi, closely parallel the Second Law of Thermodynamics which predicts an increase in disorder in any isolated system. Thus, it seems that the Chinese developed a theoretical framework for understanding life processes and pathology based on the laws of thermodynamics, thousands of years before these concepts were acknowledged in the West.

#### **13.3 Entropy and communication in living systems**

While the Chinese seem to have recognised that the concept of entropy applies to life processes, it see as somewhat surprising that, despite its universal application, the concept of entropy is not widely utilised within the medical sciences which aim to study biological disorder. The reason for this appears to be mainly historical. The second law was originally formulated an engineering concept and described in terms of the usefulness of energy by Thompson in 1852. Subsequently the concept of entropy was reformulated in terms of heat by Clausius in 1864, and then in terms of probability by Poltzmann in 1872. (Coveney & Highfield 1991) Thus, the concept of entropy was derived as an engineering concept when man was claiming domination over the inanimate world during the industrial revolution. (Prigogine & Stengers 1984)

For many years it seemed that the concept of entropy could not be reconciled with life processes as biological systems seem to defy the Second Law and increase their order as they evolve, grow and learn. The tendency of living systems to contradict the second law of thermodynamics is discussed by Ludwig von Bertalanffy in his text on General Systems Theory in which he states:

"Entropy must increase in all irreversible processes. Therefore the change in entropy in a closed system must always be positive. But in an open system, and especially in a living

organism not only is there energy production owing to irreversible processes, but the organism feeds, to use an expression of Schrodinger's, from negative entropy, importing complex organic molecules, from the environment. Thus, living systems, maintaining themselves  $\dot{m} \approx$  steady state by the importation of materials rich in free energy, can avoid the increase of entropy which cannot be averted in closed systems." (Bertalanffy 1968)

The reason living systems appear to contradict the 2nd law of thermodynamics is that the 2nd law only applies to isolated systems i.e. systems that do not communicate in any way with their environment. Living systems however are necessarily open systems and thus appear not to fall under the jurisdiction of the Second Law. Indeed, living systems tend to build up order as they grow, learn and evolve. As Bertalanffy states;

"The fundamental characteristics of life, metabolism, growth, development, self-regulation, response to stimuli, spontaneous activity, etc., ultimately may be considered as consequences of the fact that the organism is an open system. The theory of such systems, therefore, would be a unifying principle capable of combining diverse and heterogeneous phenomena under the same general concept, and of deriving quantitative laws."

Bertalanffy goes on to say:

"The theory of open systems opens a new field in physics, and this development is even more remarkable because thermodynamics seemed to be a consummate doctrine within classical physics. In biology, the nature of the open system is at the basis of fundamental life phenomena, and this conception seems to point the direction and pave the way for biology to become an exact science". (Bertalanffy 1968)

The task of deriving laws regarding the ability of open systems to become self-organising and increase their order is the subject of the field of non-equilibrium thermodynamics. Prigogine and Stengers provide a detailed account of this subject and conclude that it is communication throughout the system that allows open systems to maintain their stability and to increase in order. Thus they state;

"The faster the communication taker place within a system, the greater the percentage of unsuccessful fluctuations and thus the more stable the system. Indeed the more complex a system is, the more numerous are the types of fluctuations that threaten it's stability. [Hence] . . .there is competition between stabilisation through communication and instability through fluctuations. The outcome of that competition determines the threshold of stability." (Prigogine & Stengers 1984)

This idea suggests that it is information flow (i.e. communication) that enables systems to retain a high degree of order. Thus in ordered systems there is a transport of information from the environment to the most highly ordered structures and therefore a dissipation of entropy from the most highly ordered structures back to the environment. (Prigogine & Stengers 1984)

## 13.4 Entropy, information and Qi

The idea that information flow enables systems to build up and retain a high degree of order suggests that the link between entropy and communication is a profound one. This was clearly demonstrated by Claude Shannon, who derived a mathematical expression for information that was subsequently shown to be identical to thermodynamic entropy. In the introduction to Shannon's work entitled "The Mathematical Theory of Communication", Warren Weaver states;

"When one meets the concept of entropy in communication theory, he has a right to be rather excited- a right to suspect that one has a hold of something that may turn out to be basic and important. . . . The mathematical theory of communication is so general that one does not need to say what kinds of symbols are being considered -whether written letters or words, or musical notes, or spoken words, or symphonic music, or pictures. The relationship it reveals apply to all these and to other forms of communication. The theory is so imaginatively motivated that it deals with the real inner core of the communication problem. . . . One must think a long time, and consider many applications, before he fully realizes how powerful and general this amazingly compact theorem really is." (Shannon & Weaver 1949)

Shannon's equation, which equates entropy with uncertainty, is defined in terms of a welldefined question (Q) representing a question with a finite set of answers, along with knowledge (X), based on knowledge of the question and past experience. This knowledge leads to the assignment of probabilities (p) to the various possible answers. Shannon's measure is expressed symbolically as S(Q/X) to emphasise that the uncertainty or entropy depends on both the question (Q) and knowledge (X). The expression is written as:

$$S(Q/X) = -K \sum p \ln p$$

#### **Equation 11**

Where K refers to an arbitrary scale factor. (When K=1/ln2; S = bits of information. When K = Boltzmann's constant (i.e.,  $1.38 \times 10^{-23}$ ); S= Joules per degree Kelvin).

This mathematical definition has the property that if one (correctly) assigns p=1 to one of the answers and (therefore) p=0 to all the others, then S(Q/X) = 0 (there is no uncertainty / entropy). On the other hand if all probabilities are assigned equally then S(Q/X) is a maximum (there is maximum uncertainty). (Tribus & McIrvine 1971)

Shannon's expression, which forms the mathematical basis for all types of communication, is certainly versatile. The concept of entropy in information theory applies to any coding system, indeed inherent in information theory is a complete theory of cryptography that applies equally to the coding of signals for data-communications as to the coding or translation of one language into another. (Weaver 1949) Shannon's expression also reveals that in addition to being measured in terms of 'bits', information can also be consider to be a form of energy that is measured as 'Joules per degree Kelvin' (one bit is approximately equal to  $1.8 \times 10^{-23}$  Joules per degree Kelvin) (Tribus & McIrvine 1971).

This description of information in terms of energy provides a link between qualitative and quantitative aspects of energy and suggests that the Chinese concept of Qi, which also refers to the 'quality of energy', may be closely related to Shannon's concept of 'information'. Indeed the similarities between the concepts of information and of Qi are many. At the most basic level, 'information' provides science with the ultimate in reductionism, for the 'bit' (which is either zero or 1) is the smallest quantifiable unit.

Similarly, *Qi* is seen to arise from the interplay of the polar opposites *yin* and *yang*, which are also considered fundamental building blocks of reality. Furthermore, the idea that it is communication (information flow) that allows systems to build up and retain order, closely parallels the idea that the flow of *Qi* maintains the functional integrity of living systems.

Both 'information' and Qi can be seen to refer to the 'quality of energy' that sustains living systems and animate awareness. Thus the view of Eastern medicine and other bioenergetic approaches that see pain and disease arising from a disruption in the flow of Qi, can also be seen to relate to a disruption in the flow of information. If such a disruption produces an 'isolated system' an increase in entropy (disorder) would occur in the system that would manifest as disease (biological disorder). Thus in this view it appears that pain is related to the signaling of biological disorder and that while life is dependent on 'negentropy' in order to build up order and thus grow, learn and evolve, (Schrödinger 1944) entropy represents a threat to life which may be consciously perceived as painful.

The idea that Qi is related to information can be seen to provide a firm basis for understanding Chinese medicine in terms of Western science. This idea suggests that rather than attempting to identify energetic substrates that may correspond to Qi, it is more appropriate to explore the information processing pathways within the body and how they may correspond to the meridian network.

### 13.5 Biological communication and information processing

Biological systems certainly possess very sophisticated communication systems in order to maintain their integrity against the background of internal and environmental fluctuations and much work in the biological sciences is currently involved in exploring these systems. The intricacies of biological communication may be appreciated when it is realised that in addition to information being communicated throughout the nervous system via action potentials, information may also be transmitted via many other pathways.

Schmitt gives a glimpse of the complexity of cellular communication when he suggests that there may be thousands of 'informational substances', including neurotransmitters, peptides, hormones, factors, and various proteins that may be active in concentrations ranging from 10<sup>-3</sup> to 10<sup>-10</sup> molar that may be transmitted not only by the conventional synaptic circuitry, but also via diffusion from release points through the extracellular fluid, C.S.F. and plasma i.e. via "a 'parasynaptic system', which would have the same degree of selectivity as synaptic circuitry, but would also possess a domain of versatility and plasticity lacking in the hard-wired system." (Schmitt 1984)

In addition to neural (action potential) and humoral (chemical) communication, there are other less well-defined mechanisms of information transfer in biological systems. These include communication via mechanical forces that are transmitted via the piezoelectric properties of tissues as well as communication via direct electrical currents and field effects. These direct currents may include ionic currents existing within the tissue fluids, currents that may pass between cells via gap junctions, as well as semiconduction currents existing in the solid-state structures of the body such as the bones, connective tissues and supporting tissues such as glial cells and Schwann cells. (Becker 1991, Bachman et al. 1962a) Additional avenues for communication also exist with the possibility of biophoton emission and other direct electromagnetic emissions (Popp, Li et al. 1996) along with communication mediated by the active movement of cells such as macrophages and antigen presenting cells. (Cormack 1984)

The idea that 'information transfer' is related to 'Qi' and is thus the primary substrate for the acupuncture meridian system suggests that the general principles of information theory are applicable to understanding acupuncture. However, despite the importance of information transmission in biological processes and the wide applicability of these principles, they are not widely applied to problems in medicine. It is possible however, to apply Shannon's equation to the consideration of biological systems by considering the inputs into the system as posing the question (Q); 'How can homeostasis be maintained?'. Living systems must continually answer this question by choosing between a range of possible responses (p) to incoming stimuli. These decisions naturally draw on available knowledge (X) provided by genetic programming and acquired learning. Thus living systems are continually attempting to answer this question by responding to a given situation in accordance with minimum uncertainty (minimum entropy production).

This analysis can be applied to conscious processes by considering that at any instant the central nervous system is required to process vast quantities of information from both internal and external sources. In order to make sense of this information and to formulate appropriate responses it is necessary for this information to be condensed and integrated. The information processing capacity of the sensory system has been reviewed by Nørretranders who provides a detailed analysis of the 'bandwidth of consciousness' that reveals that the bandwidth of consciousness is at least a million times less than the bandwidth of sensory perception. (Figure 37) (Nørretranders 1998)



Figure 37 Schematic diagram of the flow of information through a human being; from the senses through the brain (and consciousness) to the motor apparatus. The thick line shows the information flow from the senses to the brain and onto the motor apparatus. The thin line shows that consciousness processes only a very small proportion of this information. (From Nørretranders 1998) Based on the number of receptors of each sense organ, it has been estimated that the sensory mechanisms receive over eleven million bits per second. Consciousness however is not able to perceive this quantity of information. Indeed it appears that consciousness is able to only perceive around 16-40 bits per second. (Nørretranders 1998) Thus as Zimmermann states; "What we perceive at any moment, therefore is limited to an extremely small compartment in the stream of information about our surroundings flowing in from the sense organs." (Zimmermann 1989)

While consciousness may not have a very high bandwidth, conscious perception generally results from the integration of millions of bits of information into a coherent pattern. Similarly, consciousness can direct complex actions without having to direct each individual muscle. Thus it is possible to learn to perform many seemingly complex tasks such as walking or driving a motor vehicle without overwhelming conscious decision making. The ability to recognise patterns and combine vast quantities of information into a coherent whole appears to be the hallmark of intelligence and greatly improves the likelihood of survival, as Nørretranders states; "Intelligence is about seeing which macrostates best combine all the microstates." (Nørretranders 1998)

The integrating function of nervous processes requires that information from different sites is processed and integrated so patterns may be discerned. While information from the sense organs requires specific processing and association areas within the CNS, information from different body sites must also be integrated. Yet not all sites from the body will be treated equally, as the information from specific body sites may be of more importance. Based on traditional descriptions and experimental findings, it appears that those points that have important informational aspects are also likely to correspond with acupuncture points.

#### **13.6 Information and acupuncture points**

The idea that there is a differential processing of information at acupuncture points seems to fit both the Western research on acupuncture and the traditional Chinese conception of acupuncture points as well as their clinical use. An example of a point that is more important functionally and informationally rather than anatomically, is the acupuncture point called 'Hegu' or Large Intestine 4 (Li 4). Li 4 is arguably the most recognised and important acupuncture point on the body and is considered the point with the most analgesic properties. The anatomical location of this point is over the first dorsal interosseus muscle in an area that is supplied by a branch of the radial nerve. However, while this point is not particularly distinct anatomically, it certainly can be seen to be of great importance 'informationally'

The point Li 4 lies precisely between the thumb and the fingers over the motor point of the adductor pollicis and the first dorsal interosseus muscle (Jayasuriya 1988) which are responsible for the opposition of the thumb to the finders. The information from this point is therefore responsible for determining the position of the thumb in relation to the rest of the fingers and thus the functions of the hand in general. The importance of this area is evidenced by the fact that the area of the motor cortex responsible for controlling this point is substantially larger than the cortical areas controlling other regions of the body. This is depicted graphically by the homunculus, or 'little man', (Figure 38) which is a representation of the body with the various body parts having a size proportional to the area of the cortex devoted to their control. (Snell 1980; Williams & Warwick 1980) It can be seen that the homunculus has a disproportional large hand and thumb and that an exceptionally large amount of cortical area is involved in processing information from the point Li 4. A needle inserted into this point would therefore activate a greater proportion of cerebral cortex than a needle inserted at other points on the body. (Ulett 1996)

Another acupuncture point that may be distinguished by its 'informational' properties is the point named 'Bahui' or Governing Vessel 20 (GV 20). This point is situated on the vertex of the scalp which is an area that has virtually no voluntary muscle control and is an area that is not often touched in a precise manner. Thus the area of the cortex devoted to processing information about the scalp is relatively small and the vertex has one of the smallest proportional representations on the homunculus. The placing of a needle into the point GV 20 would therefore produce a state of physiological awareness and psychological sedation as the body attempts to diminish extraneous activity in an effort to determine the

exact type and extent of the stimulation based on limited information. This is in accordance with the use of this point in clinical practice whereby it is often given as a sedative point, or to coordinate the effect of needling points at other sites. (Jayasuriya 1991)





The idea that information from acupuncture points may be processed differently from surrounding tissue and that these points may exist as specific neurological representations within the central nervous system has been confirmed experimentally by Yang et al. who used a superconducting quantum interference device (SQUID) to image the brain while stimulating the point Li 4. The resulting images confirmed the traditional association of this point with the jaw and face area by revealing an overlap between this region and the projection area of the point. (Yang, Ouyang et al. 1995). In another study using functional magnetic resonance imaging (fMRI) scanning, Cho et al confirmed the traditional association of the vision-related acupuncture point of the foot produces activation of the occipital lobes whereas

stimulation of non-acupuncture points 2-5cm away did not produce this affect. (Cho, Chung et al. 1998)

The idea that information from acupuncture points follows distinct pathways and may be processed differently to information from 'nonpoints' has also been explored by Takeshige. (Takeshige, Oka et al. 1993) In a series of experiment that examined neuronal pathways by means of selective lesioning of discrete brain regions as well as the selective stimulation of brain regions and the recording of evoked potentials arising from stimulation of acupuncture and non-acupuncture points, Takeshige found that pathways connected to an acupuncture point are different from pathways connected to 'nonpoints'. (Takeshige 1985)

The evidence from these experiments suggests that acupuncture and non-acupuncture points can be differentiated by their connection to different pathways in the central nervous system. Further evidence for a correlation between information processing and acupuncture points has been suggested by Shang who proposes that acupuncture points may coincide with 'organising centres'. (Shang 1989; Shang 1993)

Organising centres are most commonly described in embryology and are seen to be 'singular points' where discontinuities and nonlinearities occur, thus at these points a large change in an observable parameter may be caused by an arbitrarily small change in another factor. The properties of these points include a higher electrical conductance along with a higher density of gap junctions and response to non-specific stimuli, and these properties have been confirmed experimentally. (Shang 2000) These points also tend to be located at the extreme points of curvature on the body surface (the locally most convex or concave points). (Shang 1989; Shang 1993)

While the properties of organising centers are most commonly discussed with reference to embryology and morphogenesis, Shang has proposed a morphogenic singularity theory that suggests that organising centres may correspond with acupuncture points. (Shang 1989; Shang 1993) Indeed the properties of these centres seems to coincide well with the properties of acupuncture, as acupuncture points are commonly located at surface 「たいのの湯」

concavities and convexities and are able to respond to many different forms of stimulation, including, pressure, needling, electric current, heat, cold, laser, infrared and ultraviolet radiation and microwaves. (Jayasuriya 1991)

Shang further suggests that coupling and oscillation may underlie the acupuncture meridian network as well as the processes of growth and regulation, and that acupuncture meridians may oscillate in resonance with their respective organs. Shang suggests that this may be mediated by the transmission of electrical signals via gap junctions and draws on the fact that gap junctions in different organs have been found to have different gap junction proteins that may mediate the transfer of electrical signals between functionally, related cells. (Shang 1989)

The possibility of gap junctions mediating the transmission of electrical signals along meridians may explain the low resistance properties of acupuncture points and meridians as well as provide the basis for understanding aspects of the DC control theory. If the cells in the region of acupuncture points and meridians posses greater numbers or more active gap junctions they may appear normal on histological examination, yet they would display preferential passage for electric charge and possibly infrared radiation. As gap junctions provide direct passage of ionic current as well as semiconducting current passing along microtubular filaments, they may also provide a link between the cellular communication network and charge carriage along fascial planes.

The consideration of acupuncture points as organising centres appears to explain many features of the acupuncture meridian system. While this work requires further elaboration, the power of this theory lies not only in its ability to describe and predict the morphological characteristics of acupuncture points, but in its ability to discuss the properties of points in terms of information processes, signal transmission and nonlinearities. By adopting the language of information, Shang's morphogenic singularity theory is able to include and integrate work from diverse fields and thus accept input from the neuro-humoral, biochemical, electromagnetic, anatomical, morphological, and histological approaches to biological communication.

# **14.0 Conclusions and recommendations**

The results of the above experiments provide a broad support for the idea that electromagnetic fields play a role in the traditional practice of acupuncture as well as support for the idea of an analogue direct current control system that mediates energetic exchange between organisms and their environment.

The detection of a potential difference of the order of microVolts induced across an acupuncture needle suggests that the traditional manipulations that involve heating, cooling and thrusting of acupuncture needles may add to the energetic exchange induced by this practice. Similarly, the finding of differential absorption of infrared laser at acupuncture points at low frequencies, suggests the traditional practice of 'sparrow pecking', which involves varying the application of moxibustion with a frequency of around 1 Hz, enhances the absorption of energy delivered by this technique.

While the significance of these practices is uncertain, and the energy exchanges involved are extremely small, the suggestion of acupuncture points coinciding with organising centres that display nonlinearities indicates that significant physiological effects are possible. Further work however is required to further characterise the frequency response of acupuncture points to infrared laser as well as to determine other electrical effects of needling such as the short circuiting of the transcutaneous potential difference and electromagnetic induction effects.

As well as an enhancement of energetic exchange with traditional stimulation techniques, it can be concluded that there is also an interaction between environmental electromagnetic fields and biological functioning. This is supported by the finding of a significant correlation between psychiatric hospital admissions and solar activity as well as by the results of previous studies. While this result appears to be rigorous, the use of psychiatric hospital admissions is a crude measure for psychological functioning and further studies are needed to further define this relationship as well as to extend this work to conditions involving other systems. Furthermore, the existence of a large lag period suggests that the relationship between psychiatric events and solar activity is complex and further work is required to determine how external fields may be coupled to internal processes as well as distinguish the important features of the external fields.

Further support for the relationship between environmental electromagnetic activity and biological functioning is provided by the finding that acupuncture meridians display distinct spectral characteristics that are related to the Earth-ionosphere Schumann resonances. However, while the existence of distinct spectral characteristics of meridians has been confirmed using two different experimental setups, the observation of resonance phenomena is based on comparing the meridian data with published values for the Schumann resonance peaks. It would be useful therefore to obtain continuous Schumann data to confirm this result. Attempts to construct a ferrite-core ELF antenna were confounded by excessive noise contamination and thus future work needs to be focus on obtaining a cleaner signal, possibly by making measurements away from extraneous fields and vibrations, or obtaining continuous data from a specialised Schumann resonance observatory. Further work may also focus on the relevance of these resonances for therapy and the selection of electrostimulation parameters.

In addition to evidence of an interaction between environmental fields and the acupuncture meridian system, evidence suggests that acupuncture points and meridians are distinct entities that may mediate these interactions. Acupuncture points are found to have a relatively low electrical resistance with an organised field distribution and increased infrared absorption at low frequency, while the meridians also display a lowered resistance with distinct field distributions and spectral characteristics. Furthermore, during meridian measurements, strong output signals are only obtained when the surface electrodes or needles are located precisely on the acupuncture points, indicating that the properties of these points are independent of the stratum corneum. While these results extend and confirm the results of previous studies, future work is required to extend the range of measurements to include acupuncture points on different regions of the body, as well as to extend the range of measured parameters to include impedance at different frequencies as well as electrical potential. Further work is also required to develop techniques that may be

used to standardise this research and to examine the functional relationships that acupuncture points may have with visceral and autonomic functioning. In addition to further investigating the properties of points and meridians further research is also required to determine the basis for these properties. Such research may involve characterising the microcirculation at these points, as well as examining the micro-architecture to determine the nature and density of gap junctions and other structures existing within and between cells at these sites.

The investigation of electromagnetic phenomena associated with acupuncture seems a fruitful area for research, however, while electromagnetic considerations may be important in understanding acupuncture, the acupuncture phenomena crosses many disciplines and understandings gained in one area needs to be translated and integrated into other disciplines. In order to facilitate this process, a common language is required so that discussions can take place across disciplines.

Such a language may be derived from the language of information theory, which appears to be able to transcend the boundaries separating different areas of research. The ability of information to act as an integrating concept in acupuncture research is evident when viewing the parallels between Eastern and Western concepts and realising that the Chinese concept of 'Qi', which is considered to be the underlying substrate for all biological functions, closely parallels the concept of 'information'. Parallels may also be drawn between the Eastern view which sees disease arising from a blockage in the flow of Qi, and the Second Law of Thermodynamics, which predicts an increase in entropy in any isolated system.

The utility of this approach for acupuncture research finds expression when ideas from different disciplines are integrated by reference to the informational properties of acupuncture points. However, while the analysis of acupuncture using the principles of information theory seems attractive, any language that is not used is a dead language. Thus, it is only by actively applying this approach to scientific and clinical experience and engaging in multidisciplinary discussions that the potential of an integrated approach to acupuncture will be fully realised.

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Appendix 1

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# PATHWAYS to HOLISTIC HEALTH

edited by DR MARC COHEN

Published by Monash Institute of Public Health Clayton, Victoria Dr. Marc Cohen

### The Evolution of Holistic Medicine

"Medicine is subtle and no one knows most of its secrets. The way of medicine is so vast and its scope is as immeasurable as the height of heavens and the depths of the four seas." Nei Ching Su Wen

Out of all human endeavours medicine can be considered to be the most basic. The aim of medicine to relieve human distress through the treatment and prevention of disease can be seen as a conscious extension of the basic animal instinct to avoid pain that has its origins with the dawn of humanity when consciousness first became self-reflective. Self reflective consciousness freed humanity from the here and now existence of animals by allowing the mind to contemplate and communicate knowledge of the past and present, reflect on the difference between pain and pleasure, life and death, self and non-self, and wonder as to the seemingly infinite natural forces that both sustain and threaten its existence.

The beginning of self-reflective consciousness was an important turning point in human evolution for it marks the beginning of two of the distinguishing features that define humanity; language and medicine. By combining vocabulary and syntax, language enables the mind to create an internal picture of the world, or worldview, which provides the basis for predicting future events and directing conscious action. Such a world view lies at the heart of all medical systems and the practice of medicine acts as an empirical test for the mind's ability to accurately represent the world, the success of which can be measured in terms of human survival and the alleviation of human suffering.

The evolution of medical knowledge closely parallels the evolution of both language and mind, for as Curtis Smith states;

"There is a growing tendency to regard all evolution, not just human evolution, as an accumulation of usable information... Thus one way of measuring biological success might be by asking how much information is available to the organism to help it succeed in the struggle to survive and reproduce." (Smith, 1985)

The evolution of mind has followed the trend set by genetic evolution leading to an increase in autonomy, complexity and colonisation of the planet. The evolution of mind however has out-paced genetic evolution, for while genetic evolution relies on the natural selection of use<sup>4</sup>01 information based on the variability of mutations and their transmission down generations through the life cycle, the evolution of mind results from the conscious selection of useful information and its transmission throughout individual life-spans via language. Thus as Russell states;

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"Self-reflective consciousness brought with it the ability to direct our own destiny. We are not bound to a long slow process of evolution through trial and error, and the selection of the correct adaptations; we can anticipate the results of our actions and consciously choose those which are most likely to take us where we want to go – as individuals and as a species." (Russell, 1983).

Medicine involves the exercising of conscious control over survival through the accumulation and distribution of 'survival knowledge'. The evolution of medical knowledge therefore parallels the distribution of this knowledge through human communications which has progressed from a tribal basis, where communication takes place via actions and words, to a social basis where information is made available through the written word, to the present, where global telecommunications promise to create a new form of medicine where global concerns regarding human health and welfare can be shared amongst all peoples.

#### Tribal medicine

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The first human societies were tribal groups in which survival was limited to extended family units and communication limited to actions, words and the performing of rituals. In such circumstances it was possible for a single individual to accumulate and pass on all the knowledge needed to maintain a tribal existence. Such an individual was the tribal doctor or 'shaman' which literally means "he who knows", however as Stenn points out:

"Were we to address him as a physician he would be offended for pure medicine is indeed a small segment of his knowledge. He is usually, as he has been since most ancient days, the most intelligent and best-informed person of the tribe. He may be king, priest, prophet, conjurer, rain-bringer, and educator all in one. His specific duty is preservation of the tribe against drought, starvation, calamity, wild animals, enemies, plagues and disease generally. He establishes law, order, ethics and morals. He communicates to the tribe knowledge of history, music, dance and the arts. He knows the local soils and waters, the useful and edible plants and animals. He is an expert in agriculture and weather prediction. At the same time his opinion is sought on military appointments and on military strategy. He guides the sexual life of man and predicts the life of those newly born. He is busy healing illness and wounds and preventing disease. He must expose himself to days of starvation, thirst, cold, heat, rain and solitude. He must commit to memory elaborate ceremonial songs and dances and know their symbolic significance. He must cultivate the technique of jugglery. And he is forever placating the spirits and divining the future." (Stenn, 1967)

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The tradition of shamanism is a truly holistic form of medicine whereby religion, science, art, agriculture, engineering, law and other disciplines are fully integrated. This tradition, which has existed since the dawn of history, generally consists of polytheistic or polydemonistic nature worship where diseases are seen to result from either an excess or deficiency of spiritual forces. Shamanism is thus primarily concerned with magical healings, involving the expulsion of evil spirits that have possessed the patient, or luring the errant soul back to its proper habitat. Aided by abnormal trancelike states the shaman, who is mediator between the spirits and men, goes into autohypnotic trances during which time he journeys into the spirit world in order to make sense of a person's ailment and determine a cure. In order to communicate his knowledge to the tribe, a shaman would employ tribal dancing as well as ventriloguy, jugglery and tricks, along with charms, amulets and talismans which were used as symbols of past lessons. Perhaps the most powerful tool the shaman possessed however was the use of specific words, for how things came to be and got their names is the first theorem of spiritual science. The power of words was realised by shamans through the use of spells and incantations and this power remains evident today in the use of present day medical terminology and diagnosis.

The role of the shaman was to access and accumulate knowledge that would help the tribe survive. To do this there were two paths that were followed. One way was to meditate on an unknown entity until it could be incorporated into tribal lore, the other was to observe nature and assess the usefulness of different substances and procedures. These two paths have been labeled by medical historians as 'magico-religious' and 'empirico-rational'. In the magico-religious approach diseases are explained as resulting from a disregard or disharmony with some cosmic principle or deity and treatment is aimed at restoring harmony with the supernatural forces. The magico-religious approach can thus be seen as a top-down approach whereby disease is explained by general theoretical principles, which are usually coined in either magical or religious language.

In contrast to magico-religious medicine, the empirico-rational approach does not necessarily seek to explain disease but aims to discover useful remedies by the rational observation of disease and of different therapeutic procedures and substances. The empiricorational approach is thus a bottom-up approach whereby physical, dietetic and pharmacological remedies are sought for conditions which may be considered 'natural' in that the do not require supernatural explanations. This approach would thus be primarily used to treat minor ailments of everyday life such as coughs and colds, upset stomachs and

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minor wounds, and would include treatments such as poulticing, bloodletting, massage, counter-irritation, purgatives and emetics.

Tribal shamans employ both empirico-rational and magico-religious methods, however as many empirical treatments may be considered routine, they may be performed by the patient or by members of their family or neighbours, particularly women. The Shaman however would be called in to consult on any serious illness or when explanations or interpretations are sought after, as well as acting as a repository of empirical remedies.

#### The beginning of recorded history

As human populations grew and tribes began to settle themselves into cities, it became increasingly difficult for a single individual to access and distribute the available knowledge through actions and words alone. To sustain great civilizations knowledge had to be more readily available, and thus with the appearance of the first civilizations came the beginnings of writing, the establishment of the calendar, and thus the beginning of recorded history. With the development of civilization many of the shamanic duties differentiated into distinct disciplines and the empirico-rational and magico-religious paths were elaborated upon and extended to form the beginnings of science and religion.

In early civilizations the written word arose as an extension of shamanism and thus was associated with the gods and the spirit world. The shamans of this era may be considered amongst the greatest that ever lived. This era, which spans from 3000 BC to 500 BC produced such legendary and godlike figures as the Egyptian physician Imhotep, the Hebrew leader Moses, the Greek physician Asklepios, and the Chinese physicians Shen Nung, and Huang Ti (The Yellow Emperor). These figures, who were often responsible for the health of entire civilisations, are accredited with the accumulation of great stores of empirical knowledge including great technological achievements such as the invention of agriculture and writing, as well as important philosophical and religious treatise, many of which remain in widespread use to this day.

It was towards the end of this era that the foundations of both Eastern and Western thought were first committed to writing, with Socrates, Aristotle and Plato laying the foundation for Western thought, and Lao Tzu, Confucius, and Gautama Buddha providing the basis for the development of Eastern thought. It was also around this time that the foundations of Eastern and Western medicine were being forged, with the formation of the Hippocratic writings (Corpus Hippocraticum) in the West, and the canonization of the Nei

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Ching Su Wen in the East. These medical works are significant as they mark the beginnings of modern medicine and are the first treatise to view disease as arising from interactions between the environment and constitutional factors, rather than the actions of gods or supernatural forces. They are also significant in that they represent two different yet complementary approaches to medical knowledge with Eastern medicine being an extension of the magical-religious approach and Western medicine of the empirico-rational approach.

#### Chinese medicine and the art of prevention

Chinese medicine according to legend commenced with Fu Hsi. To him is attributed the invention of the eight Diagrams made up of broken and unbroken lines used to explain the working of all natural phenomena and forming the basis of the I-Ching which acts as a pictorial representation of the Chinese universalistic philosophy. The elaboration of Chinese medicine was continued by the emperor Shen Nung (died 2698 B.C.) who is venerated as the father of agriculture and is reputed to have undertaken systematic empirical observation of all herbs by tasting each one in order to acquaint himself with their value. To him is commonly attributed the writing of the herbal classic. By far the most renown of the legendary rulers of ancient China however, was Huang Ti, also known as the Yellow Emperor.

Huang Ti is said to have been miraculously conceived by his mother Fu Pao, who gave birth to him on the banks of the river Chi and he supposedly reigned from 2696-2598 B.C. Su-ma Ch'ien, the great historian of the second century B.C. began his Historical Records with an account of Huang Ti, whom he defined as the founder of Chinese civilization and the first human ruler of the empire. To him is accredited the invention of wheeled vehicles, armour, ships, pottery, and other useful appliances, as well as the art of writing. Huang Ti is also regarded as the author of the Canon of Internal Medicine called the Nei Ching Su Wen (The Yellow Emperors Classic of Internal Medicine) which is said to be the oldest extant medical book in the world and remains the theoretical foundation for Chinese medicine to this day. As Ilza Veith states in the introduction to her translation of the Nei Ching Su Wen;

"The Nei Ching, the Classic of Internal Medicine, attributed to Huang Ti, the Yellow Emperor, is indeed a very important if not the most important early Chinese medical book, particularly its first part, Su Wen, "Familiar Conversations" between the Emperor and has physician Ch'i Po. It is important because it develops in a lucid and attractive way a theory of man in health and disease and a theory of medicine. It does this in very much the same way as did the

physicians of India who wrote the classic books of Yajutvedic medicine, or the Hippocratic physicians of Greece; that is by using the philosophical concepts of the time and picturing man as a microcosm that reflects the macrocosm of the universe. The theory expounded in the Nei Ching Su Wen has remained the dominating theory of Chinese indigenous medicine to the present day." (Veith, 1966)

The theory behind Chinese medicine is truely holistic. In the Chinese view true health is achieved only when the division between the self and the rest of the universe is dissolved and there is an awareness of the "wholeness" of nature. Thus the Eastern concept of the universe is one of infinite order as described by the 'Tao' (pronounced 'Dow'). As Veith states:

"The essence of the universalistic Chinese philosophy is the concept of Tao. It is difficult to translate the exact meaning of this word. The "Way" is probably the closest equivalent. All the ideas of Chinese philosophy converge in Tao. Tao has been described as "formless, nameless, the motive force of all movements and actions, and the mother of all substances." The important preaching of the ancient Chinese was to "live according to the Tao". Living according to Tao means to integrate one's self with the rules of nature, which regulate both earthly and heavenly changes. It is a code of physical, mental and ethical conduct based on unchanging cosmic truths and not on the rules and regulations codified by man. Thus the Tao means the way of shaping one's earthly conduct in accordance with the operation of the natural laws, in order to reach the goal of perfection." (Veith, 1966)

'Being at one with the Tao', is considered by the Chinese as being the ultimate state of health. This is seen as a dynamic process, for it involves being in harmony with all of the continually changing cycles of nature and thus to be separated from this universal order is seen as a source of pain and disease. This worldview can be considered an extension of the magico-religious, or theoretical approach to disease, whereby diseases are explained by reference to a general cosmological theory. The concept of the Tao for the Chinese however is more than a theoretical concept, it is a way of defining an ultimate state of existence and thus provides an ideal which is used to guide everyday life.

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The concept of Tao originated with the early Taoist philosophers, who persued an ascetic tradition by withdrawing into the forests and mountains in order to meditate upon the Order of Nature. The concept of 'Tao' was popularised in the fourth century BC by Lao Tzu, an older contemporary of Confucius, whose name literally means 'Old Master', and who is considered the author of the Tao Te Ching (Canon of the Virtues of the Tao) which many

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scholars regard as the most profound and beautiful work in the Chinese language. The concept of Tao, which stressed harmony with nature, was later elaborated on to form the basis of the Taoist religion, however this concept was also adopted by Confucianism which stressed harmony through social relations, as well as Buddhism which stressed harmony with personal desires. Thus as Dr Heinrich Hackmann in his volume on Chinese philosophy says;

"The word Tao, which later became the shibboleth of a separate creed, Taoism, is basically a concept common to all Chinese and therefore retains its validity also in Confucianism and even in Buddhism. Tao is the key to the mysterious intermingling of 'Heaven and earth,' Tao means the way and the method of maintaining the harmony between this world and with the demands of the other world." (Hackmann, 1927)

The Nei Ching Su Wen is unusual for a general medical text for over three-quarters of it is devoted to preventative measures. In it we find the following passage where the concept of Tao is elaborated on in a discussion between the Yellow Emperor and his physician/adviser Chi Po:

"Tao was practiced by the sage and admired by the ignorant people. Obedience to the laws of Yin and Yang means life; disobedience and death. The obedient ones will rule while the rebels will be in disorder and confusion. anything contrary to harmony (with nature) is disobedience and means rebellion to nature. Hence the sages did not treat those who were already ill. They did not want to rule those who were already rebellious; they guided those who were not yet rebellious... To administer medicine to diseases which have already developed and to suppress revolts which have already developed is comparable to the behaviour of persons who begin to dig a well after they have become thirsty, and of those who begin to caste weapons after they have already engaged in battle, would these actions not be too late?" (Veith, 1966)

As already stated the Nei Ching Su Wen is devoted to primarily to preventative measures through outlining the ideal state of "living in accordance with the Tao". Following in this tradition Chinese physicians emphasised the healthy state and aimed to maintain it, rather than defining different disease entities and attempting to treat illness. As Crozier states:

"It should be noted that specific disease categories, as such, do not figure very prominently...Certain diseases were recognised and their symptoms described in the earliest medical works, but the major stress had been treating the human condition itself. Since diseases arise out of a disequilibrium in the human organism, the basic cure is in restoring harmony." (Crozier, 1968)

a di seconda di seconda da seconda de seconda da seconda da seconda da seconda da seconda da seconda da second Seconda de seconda da se Having defined a state of health, it was the aim of Chinese physicians to detect any deviation from this state and correct it before disease could develop. Accordingly the ancient Chinese physicians were paid only while their patients remained healthy and, if a patient was to die unexpectedly, the physician responsible was required to hang a lighted lantern outside his practice for a full month so that other patients would be made aware of his shortcomings. This attitude is expressed in the Nei Ching with the following passage;

"The superior physician helps before the early budding of the disease. The inferior physician begins to help when the disease has already developed; he helps when destruction has set in, and since his help come when the disease has already developed, it is said of him that he is ignorant." (Veith, 1966)

#### Hippocratic medicine and the science of cure

The Eastern attitude of preventive medicine lies in stark contrast to that of the Hippocratic tradition. The Hippocratic physicians practiced in a market economy, where physicians were sought only after disease had become established and a physician's worth was judged on his ability to make accurate predictions, even if powerless to alter an adverse outlook. The Hippocratic writings, or 'Corpus Hippocraticum', consist of many astute observations and aphorisms, many of which remain relevant today ; these include the well known aphorism; "Life is short the Art is long, crisis fleeting, experiment risky, decision difficult", and the signs of death or so-called, 'Hippocratic facies' which consists of: "A sharp nose; hollow eyes,; collapsed temples; ears cold, contracted and their lobes turned out; the skin about the forehead rough, stretched and parched; the colour of the face greenish, dusky, livid or leaden."

The Hippocratic tradition concentrated on defining specific disease entities rather than abstract notions of health, for it was considered that "Every disease has its own nature and arises from external causes, from cold, from the sun, or from changing winds". This emphasis on defining different disease entities arose from the practice of forecasting, for it was only by defining the evolution of clinical syndromes that specific prognostic features could be recognised and the likely course of disease, and success of interventions, be determined. Hippocrates placed great emphasis on prognosis, writing that: "I hold that it is an excellent thing for the physician to practice forecasting; he will carry out treatment best if he knows beforehand from the present symptoms what will take place later." (Cohen and Drabkin, 1948)

While the Hippocratic tradition laid the foundation for modern medical practice it also established a model for the practice of holistic medicine. The book "Airs, Waters and

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Places" from the Hippocratic collection outlines how the well being of individuals is influenced by environmental factors such as the quality of air, water, and food, the topography of the land, and general living habits. While an understanding of these factors was considered an essential basis of the physicians art, according to Renes Dubos, "the relevance of environmental forces to the problems of human biology, medicine and sociology has never been formulated with greater breadth and sharper vision than it was at the dawn of scientific history" (Dubos, 1979)

Treatment according to the Hippocratic tradition was mainly carried out empirically, with the caveat of "first do no harm", and only later were diseases considered in terms of a general theoretical framework. The Hippocratic tradition was thus based on the accurate recording of clinical observations, supportive care of the patient in order to assist the patient's natural healing forces (the 'vix medicatrix naturae'), and a code of conduct for physicians befitting an honored role in society. As Stenn states:

"Paramount was the method employed by Hippocrates : the use of mind and senses as diagnostic instruments; the transparent honesty; the elevated conception of the dignity of the physicians calling; and the seriousness of purpose and deep respect for the patient... lacking scientific instruments, he nevertheless initiated a scientific approach through accurate observation and logical reasoning." (Stenn, 1967)

In following the Hippocratic tradition, Western medicine employs an extension of the empirico-rational or practical approach to medicine which aims to define the natural history of disease and thus forecast how symptoms develop, and how different procedures may alter the disease outcome. However while the Hippocratic physicians were to develop a methodology which forms the basis for today's scientific method, perhaps more important for medicine was the laying down of a moral and ethical code by which to practice medicine, as is specified in the Hippocratic oath.

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#### The Hippocratic Oath

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I swear by Apollo Physician and Asclepius and Hygienia and Panaceia and all the gods and goddesses, making them my witnesses, that I will fulfil according to my ability and judgment this oath and this covenant :

I will look upon him who shall have to reckon him who taught me this Art equally dear to me as my parents to share my substance with him, and relieve his necessities if required; to look upon his offspring in the same footing as my own brothers, and to teach them this Art, if they shall wish to learn it, without fee or stipulation; and that by precept, by lecture and by every other mode of instruction, I will impart knowledge of the Art to my own sons, and those of my teachers, and to disciples bound by a stipulation and oath according to the Law of Medicine, but to none others.

The regimen I adopt shall be for the benefit of my patients according to my ability and judgement, and not for their hurt or for any wrong. I will give no deadly drug to any, though it be asked of me, nor will I council such, and especially I will not aid a woman to produce abortion. Whatsoever house I enter, there will I go for the benefit of the sick, refraining from all wrongdoing or corruption, and especially from any act of seduction, of male or female. of bond or free. Whatsoever things I see or hear concerning the life of men, in my attendance of the sick or even apart therefrom, which ought not to be noised abroad, I will keep silence thereon, counting such things to be as sacred secrets. (Wheelwright, 1966)

#### The Complementary nature of Eastern and Western medicine

It is interesting to note when comparing the origins of Eastern and Western medicine that they appear not merely different, but diametrically opposed, as each approach the world from opposite but complementary points of view. Ilza Veith notes the complementary nature of Eastern and Western medicine in the introduction to her translation of the Nei Ching when she writes:

"If the history of the Yellow Emperor's Classic is to be compared with that of the Corpus Hippocraticum, which originated at clout the same time, a curious and somewhat contradictory development may be noted. The works of the Greek tradition were composed to serve as textbooks for the practitioner, yet the practical value of their contents was superseded centuries ago. Apart from their significance for the medical historian, the value of these works has for centuries consisted in creating for the Western physician the moral, and ethical concept of the ideal

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physician. on the other hand, ... China's earliest book concerned with the art of healing was never meant to be a mere textbook of medicine, but rather a treatise on the philosophy of health and discase; and yet it was taken over by the physician, here comply as a guide towards an ideal of life, but as a help for the actual practice of medicine." (Veith, 1966)

It seems that the survival knowledge transmitted through medical theory and practice is actually shaped and formed by the language used to transmit it and it has been suggested that the complementary nature of Eastern and Western medicine has arisen through their respective use of language. Eastern thought, which places much emphasis on the concept of flow and on symbolic representations of natural phenomena, is based on an intuitive language which uses ideograms and symbolic constructs. As Capra states:

"Both the Confucian Analects and the Tao Te Ching are written in the compact suggestive style which is typical of the Chinese way of thinking. The Chinese mind was not given to abstract logical thinking and developed a language that is very different from that which evolved in the West. Many of its words could be used as nouns, adjectives or verbs, and their sequence was determined not so much by grammatical rules as by the emotional content of the sentence. The classical Chinese word was very different from the abstract sign representing a clearly delineated concept. It was rather a sound symbol that had strong suggestive powers, bringing to mind an indeterminate complex of pictorial images and emotions. The intention of the speaker was not so much to express an intellectual idea, but rather to affect and influence the listener. Correspondingly, the written character was not just an abstract sign, but was an organic pattern – a gestalt – which preserved the full complex of images and the suggestive power of the word." (Capra, 1983)

In contrast to Eastern thought, Western thought emphasises the process of systematically observing nature and deriving rational explanations, and is based on rational languages (the epitome of which is mathematics), which utilise a phonetic alphabet and logical construction. Furthermore while Chinese thought has remained fairly consistent throughout the ages, as has the Chinese language (even though pronunciation differs in different regions), Western thought has undergone numerous additions, corrections and modifications as it has been translated into the dominant language of the time. As Jayasuriya states;

"An Englishman of today can hardly go further back than three or four hundred years in his own literature; the earliest periods he can only appreciate after special philological study. To the Chinese, the literature of a millennia is open; and his unrivalled love for and knowledge of

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the ancient culture of his country is largely due to the peculiar genius of his literary heritage." (Jayasuriya, 1991)

Manfred Porkert sheds further light on the relationship between language and the pervading worldview when he writes:

"Philologically striking is the fact that the languages of all civilizations which developed atomic theories had alphabets, but that the Chinese who devised the wave and field theories had written characters, ideographs, which probably influences their thinking along gestalt or organismic lines. Another important fact is the continuity of information by means of the written word. Here India and the Western world were in reality litt' villages, each with its own language making communication difficult and in some instances, almost impossible. Even among the villages (or nations) time and usage often change the meaning and intent of the language. A dead language, like morbid anatomy, gives very little information about the living civilization. The Chinese ideograph is their universal language and has the same meaning for the modern as for the ancient, a great advantage to the scholar and for the continuity of thought. Contrast this aspect with the practice in the West, where the language of the scholar was Greek, Latin, Hebrew, then Arabic, French, German, Russian, and English." (Porkert, 1974)

The different approaches to medical knowledge characterised by Eastern and Western medicine can be considered to be parallels of what are commonly called the holistic and reductionist worldviews. Although these views appear opposite they are in fact complementary with neither being more correct or more useful. The truly holistic practitioner needs to be able to apply both approaches and to determine which approach is the most appropriate for an individual at any particular time in their life. Certainly the ideals of modern medical practice encompass this type of holistic approach and this is becoming more common in practice as evidenced by the current integration of the Eastern philosophical ideas of prevention and health enhancement with Western scientific principles and the hi-tech management of acute medical conditions.

With increasing specialisation and differentiation of the health professions however, it is common for individual practitioners to preferentially adopt a particular approach and thus there is a need for practitioners to work together to meet the varied needs of individual patients. There is also a great need for individuals to be the final arbiters of their own health and healthcare choices. To practice or live holistically implies an attitude and a process rather than a specific methodology and hopefully by continuing to combine complementary approaches it is possible to obtain a deeper understanding of health, illness and life. To quote Capra again:

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"We are heading towards a new synthesis, a new naturalism. Perhaps we will eventually be able to combine the Western tradition, with its emphasis on experimentation and quantitative formulations, with a tradition such as the Chinese one, with its view of a spontaneous, self organising world." (Capra, 1983)

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# MEDICINE of the MIND

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### The Art and Science of Joy

Joy and happiness are difficult subjects to study scientifically. Like pain, joy is totally subjective and therefore it is ultimately whatever people say it is. There is no blood test or imaging technique to detect happiness or joy, and while the funny bone has been identified, as yet a physical substrate for joy or happiness is elusive. The subjective nature of joy effectively places the study of joy outside the realms of science, and scientific attempts to define joy or happiness have met with only limited success.

#### Happiness as a Psychiatric Condition

One recent attempt to classify happiness scientifically was discussed in the Journal of Medical Ethics. In a paper titled 'A proposal to classify happiness as a psychiatric disorder', it is suggested that happiness fits all the requirements for classification as a psychiatric condition and that it should be listed in DSM IV as Major Affective Disorder — Pleasant Type<sup>1</sup>. In this (somewhat tongue in cheek) article, the authors argue for classifying happiness as a psychiatric condition based on the fact that happiness is statistically abnormal, consists of a discrete cluster of symptoms and is associated with particular affective, cognitive and behavioural components.

This paper goes on to examine the diagnostic indicators of happiness and gives evidence for both genetic and environmental factors. Happiness is also identified as being either reactive, manifesting as an acute episode followed by a rapid remission of symptoms, or endogenous happiness which is more chronic and less likely to be associated with spontaneous recovery. Cognitive components of happiness are identified as including general satisfaction with specific areas of life such as relationships and work, as well as the happy person's belief in his or her own competence and self-efficacy. Behavioural components of happiness, while less easily characterised, include particular facial expressions such as smiling, as well as carefree, impulsive and unpredictable behaviour. Certain kinds of social behaviour are also identified including a high frequency of recreational interpersonal contacts and pro-social actions towards others.

Happiness, it seems, is also associated with irrational behaviour including overestimating one's control over environmental events (often to the point of perceiving completely random events as subject to personal will), and giving unrealistically positive evaluations of personal achievements. In summary, the author concludes that happiness fulfills all the criteria for being labelled as a psychiatric condition. The only reason against classifying happiness as a psychiatric disorder is that

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happiness is not undesirable. However, as desirability is a question of ethics or aesthetics and not science, it was decided that this is scientifically irrelevant.

It seems that Western medicine is much more comfortable with analysing disease and pathological conditions than looking at positive states of health. In the psychiatric literature over the past thirty years there has been around 46,000 articles on depression, 36,000 on anxiety, 5,000 on anger and only 2,000 on happiness and 400 on joy. These scientific studies on happiness and joy have relatively little to say about what joy or happiness actually is. They do however, describe the common correlates of these conditions based on epidemiological data.

# The Epidemiology of Happiness

There are numerous scientific studies based on statistical analysis of population data that attempt to answer the question: What makes people happy? A recent review of the literature on happiness reported in *Scientific American* is quite enlightening<sup>2</sup>. This paper suggests that happiness is unrelated to demographics such as age, sex, income, country (unless you live in a war-torn or famine-torn country where people tend to be less happy), occupation, or the ownership of consumer goods such as house, car etc. The evidence collected to date seems to suggest that, rather than being related to external circumstances, happiness is a trait that is related to personality factors such as high self esteem, feelings of personal control, optimism and extroversion.

Many people in today's society endure the present, waiting for the promise of future happiness, thinking: 'I'll be happy when I'm rich', or 'I'll be happy when I get a good job', or 'I'll be happy when I get a nose job', or 'when I get married ... or divorced', this line of thought however, is not supported by available evidence. If you are happy now, you are likely to be happy later, and if you are unhappy now, instead of changing your circumstances, you need to change your attitude to your circumstances. Therefore, it is no use waiting for a winning lottery ticket to make you happy. In fact, one study looked at lottery winners and found that they tended to be much less happy after winning than before.

While happiness in life appears to be unrelated to external factors, there are consistent correlates of happiness that include a sense of control and the sharing of one's life circumstances through close personal relationships, most commonly found in marriage. A further factor that is consistently associated with happiness is participation in religious activity, with self-reported happiness and life satisfaction being twice as likely to occur in highly religious people. It appears that religious affiliation is associated with greater social support and hopefulness, as well as a sense of belonging or feeling of having a place in the wider scheme of things.

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Along with the literature on the factors that are associated with happiness, there is considerable literature on the health benefits of being joyous which been acknowledged since antiquity. However, while the bible proclaims that: 'a merry heart doeth good like a medicine' (Proverbs 17:22), the serious study of the health benefits of happiness had to wait until the 1960s when it was brought to the attention of conventional medicine through the work of Norman Cousins.

Norman Cousins was stricken with the progressive condition, ankylosing spondylitis, and, while receiving only limited benefit from conventional medical treatments, he was able to overcome much of his pain and debility through comedy and laughter. In his book *Anatomy of an Illness*<sup>3</sup>, Cousins chronicles his fight with this debilitating condition and details how he obtained positive changes in his condition as well as biochemical improvement. Thus, Cousins was one of the pioneers of the new discipline of psycho-neuro-immunology which examines the interactions between the emotions, the brain and the immune system.

# The Tao of Joy

While awareness of the benefits of joy on health is relatively recent in the West, in the East these benefits have been acknowledged for thousands of years. Eastern medicine has no difficulty defining happiness or joy. In fact, most Eastern traditions are based on a concept of perfect bliss called 'nirvana', 'satori', 'enlightenment' or 'living according to the Tao'. This state occurs when you are 'at one with the universe' and is said to be our natural state, and is achieved when we give up our day-to-day worries, desires and attachments.

While the enlightened state suggests a state of ideal health occurring where perceptions flow freely, the states of pain and disease occur when there is an obstruction in one of the many forms of information flowing throughout biological systems. The idea of nirvana corresponding to a blissful state of being at one with the universe fits in with Western concepts of thermodynamics, whereby entropy (disorder) is seen to increase in any isolated system. Thus the Eastern view of 'life is pain' can be seen to relate to the fact that our sense of identity necessarily creates a distinction between us and the outside universe. In the enlightened state however, there is no distinction between self and non-self and thus perceptions are no longer isolated and subject to the second law of thermodynamics.

To help achieve the state of enlightenment, most Eastern traditions have developed a sophisticated series of daily practices that can promote this state. These practices generally involve yoga, meditation and an attitude to daily life. Perhaps the most researched area involves the practice of meditation, which attempts to dissolve the barriers between the ego and the outside world. By

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focusing the mind until the object of concentration disappears, a state is reached where there is no longer a separation, and the simple state of *being* remains. While this is the aim of meditation, the process of achieving this state has many benefits, for it involves letting go of attachment to daily concerns and thus shifting perspective on thoughts that may otherwise preoccupy consciousness.

While there are many different systems of meditation and different philosophies that accompany them, any single-minded endeavor may be considered a meditation. Thus, anytime you are involved in an activity that totally absorbs your awareness so that you seem to 'lose yourself in the activity', you can consider that activity to be akin to meditation. During such an activity, it is common to not only lose your sense of self, but to also lose your sense of time. Thus, during such activities, time may seem to fly and many minutes or hours may seem to pass in an instant.

Activities that are likely to give this experience include formal mediation techniques, as well as any other activity that so involves the awareness that all else is excluded. Such activities may include pursuits such as gardening, individual sports, martial arts and yoga, or creative activities such as painting, ceramics etc. These activities are commonly activities that people '*love*' to do. It seems that the act of *loving* an activity, enhances the ability to lose oneself completely, and the inclusion of these activities in the daily routine enhances the overall experience of life.

As well as having psychological benefits, the practice of meditation initiates predictable and reproducible changes in physiological functioning. These include a reduction in heart rate, blood pressure, oxygen consumption and stress hormones. There are also <u>distinctive</u> EEG changes associated with meditation and these include a greater coherence and synchrony across the brain, and a tendency for increased activity in the alpha/theta frequencies (around 8 hertz). This altered EEG activity results in the brain adopting similar frequencies to the electromagnetic frequencies that occur around the planet, called Schumann Resonances.

# Tuning into the Planet

Schumann Resonances are naturally-occurring electromagnetic waves that travel freely around the planet as a result of global lightning. They are named after Professor W.O. Schumann, who proposed the existence of such waves and calculated the main frequency<sup>4</sup> to be 10Hz. These resonances occur in the relatively non-conducting spherical cavity created between the relatively conducting boundaries formed by the ionosphere, which forms the upper atmosphere above around 50 kilometers, and the surface of the earth consisting mainly of sea water.

Lightning discharges within the earth-ionosphere cavity produce electromagnetic radiation of many different frequencies, most of which rapidly dissipate as they spread away from

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the source. Those frequencies that correspond to wavelengths of similar dimensions to the circumference of the earth however, are able to propagate several times around the planet within the earth-ionosphere cavity, before undergoing significant attenuation. As there are approximately 100 lightning strikes per second on the planet there are many such waves which undergo phase addition and cancellation, resulting in an incoherent superposition of waves producing a frequency spectra known as Schumann resonances. These resonances have been found to occur at 8, 14, 20, 26, 32, 38 Hz with the principle component at around 8 Hz<sup>5</sup>.

The production of Schumann resonances may be likened to the tone produced when a hammer strikes a bell. When a hammer strikes a piece of metal, the resulting clang contains many different frequencies that dissipate rather quickly. If the metal sheet is fashioned into the shape of a bell however, particular frequencies will naturally resonate with the shape of the structure, producing a characteristic sound made up of distinct resonant frequencies that may reverberate for some time.

It is interesting to speculate that during meditation the brain appears to harmonise with planetary electromagnetic activity. The correlation between planetary and cerebral electromagnetic activity however, must be noted merely as an association, for it is almost impossible to prove a causal connection between the two. This association can be seen as even more interesting when it is realised that the vast majority of global lightning is concentrated over the three main rainforest areas of the planet. These areas, located in Southeast Asia, sub-Sahara Africa and the Amazon basin tend to have thunderstorm activity in the late afternoon, and, as they are distributed fairly evenly around the globe, they maintain a constant level of lightning activity that maintains the global Schumann Resonance<sup>6</sup>. It is therefore possible that when we meditate, we have a subconscious connection to the greatest life force on the planet — the planetary rainforests.

# Moving from the Still Point

Meditation seems to have a homeostatic effect on the body and on consciousness. By finding a still point in consciousness, other extraneous thoughts are expelled and the mind gets a chance to free itself from mundane concerns. After meditation, the mind gains a renewed sense of focus and perspective. Finding the still point in consciousness thus allows for obtaining the most movement.

The idea that the greatest movement comes from a still point is an ancient one. In physical movement this finds its expression in martial arts and gymnastics or dance where the most powerful movements arises from the 'hara' or 'dantien'. This is a point below the navel that represents our physical centre of gravity. It is from this point that martial artists are best able to initiate defensive

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or attacking moves. This is also the point about which a gymnast rotates when executing a somersault, or a ballet dancer may be held in the air by one hand of a partner.

The principle of acting from a still point can be translated into everyday life by allowing events to unfold naturally and 'going with the flow'. This is also an ancient concept that is expressed by the phrase 'living according to the Tao'. This concept can be extended to include the idea that by remaining truly centered it is possible to 'do less and achieve more', until a point of enlightenment is reached where it is possible to 'do nothing and achieve everything'. In Eastern traditions this state is achieved by reaching the state of enlightenment, whereby remaining totally centered and non-attached, all one's desires are met.

# Pronoia — Letting the World Make you Happy

This state may be likened to the state of 'pronoia' which is the positive counterpart of paranoia (i.e. it is the belief that the universe is plotting to make you happy and that there is nothing you can do about it). This state has been discussed in the psychiatric literature and like happiness, it is considered to be a pathological condition<sup>7</sup>. Symptoms of pronoia include 'delusions of support and exaggerated attractiveness, as well as the delusion that others think well of one and the products of one's efforts are thought to be well received'.

The state of pronoia is a state of enchantment with life that requires a continual, dynamic effortlessness. Pronoia, like happiness, is a subjective state of being that may occur, irrespective of external circumstances. By adopting the attitude that whatever happens is for your benefit, you open yourself up to the possibility of positive outcomes, and thus stop being afraid of change. You simply assume that any change occurring is for your benefit. This frame of mind gives rise to the belief that you are always in the right place at the right time and ends up becoming a self-fulfilling prophesy.

Just as Eastern traditions believe that bliss is our true nature, it may also be true that pronoia is our natural state. Infants and children naturally have pronoia and this seems justified, for in many ways their universe is continually conspiring to make them happy. From an infant's point of view, parents exist simply to feed, bathe, clothe, toilet and play with them. Most people however, grow out of this state and some even claim that they never experienced it due to having a difficult upbringing. While this may be the case, it is possible to renew the sense of childhood pronoia in our adult lives. It is never too late to have a happy childhood! This may be achieved by applying some basic childish principles to daily life. These principles include the following: Express your emotions enthusiastically. Children are naturally quite overt when expressing their emotions and may go from emotional extremes in minutes if not seconds. It seems that one of the most basic laws

of the emotions is that if you share joy it increases, and if you share pain it decreases The act of sharing joy in life may actually produce happiness.

A way to practice this is to simply go around smiling at people. Unless you live in a small country town, you may be considered a little crazy if you go around smiling indiscriminately. You shouldn't let this bother you — it doesn't seem to bother children. If you are a bit hesitant doing this you may like to start in safe situations such as in heavy traffic. Traffic is a great situation to practise smiling at strangers. Letting another driver into the traffic flow provides one of the few situations where it is socially acceptable to smile and wave at a complete stranger who is more than likely to return the gesture. After a while practising this you may progress to smiling at strangers in the street and while some of them may think that you are crazy, it is probably just Major Affective Disorder — Pleasant Type.

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# RESEARCH

# **Complementary therapies: have they become accepted** in general practice?

THE PAST DECADE has seen a dramatic increase in the reported use of nonorthodox or complementary therapies by the public.<sup>1-4</sup> In one year in Australia, almost half of a representative sample had used at least one non-medically prescribed complementary remedy and at least one in five had attended a nonmedically trained complementary therapist.<sup>1</sup> Further, Australians consume as much non-traditional medicine, vitamin and mineral supplements as prescription drugs.<sup>5</sup>

There is evidence that the increasing public use of complementary medicine is paralleled by acceptance among family doctors. In one region of the United Kingdom in one week, 25% of general practitioners (GPs) referred patients for complementary therapies,6 while in Canada half<sup>7</sup> to two-thirds<sup>8</sup> of family doctors had at some time referred patients to alternative practitioners; these studies did not explore reasons for such referral. However, patient pressure is an acknowledged factor in medical referrals,9 so willingness of family doctors to refer their patients for these therapies may not be a good measure of their acceptance of them.

Interest by GPs in training in and practising complementary therapies may give a better indication. In New Zealand, 54% of GPs were interested in further training in non-orthodox therapies,<sup>10</sup> while in Israel 88% wanted training and 16% had trained.<sup>11</sup> Estimates of practice of complementary Marie V Pirotta, Marc M Cohen, Vicki Kotsirilos and Stephen J Farish

# ABSTRACT

*Objectives:* To describe Victorian general practitioners' attitudes towards and use of a range of complementary therapies.

**Design:** A self-administered postal survey sent to a random sample of 800 general practitioners (GPs) in Victoria in July 1997.

Participants: 488 GPs (response rate, 64%).

*Main outcome measures:* GPs' knowledge; opinions about harmfulness and effectiveness; appropriateness for GPs to practise; perceived patient demand; need for undergraduate education; referral rates to complementary practitioners; and training in and practice of each therapy.

**Flesults:** Acupuncture, hypnosis and meditation are well accepted by the surveyed GPs, as over 80% have referred patients to practitioners of these therapies and nearly half have considered using them. General practitioners have trained in various therapies — meditation (34%), acupuncture (23%), vitamin and mineral therapy (23%), hypnosis (20%), herbal medicine (12%), chiropractic (8%), naturopathy (6%), homoeopathy (5%), spiritual healing (5%), osteopathy (4%), aromatherapy (4%), and reflexology (2%). A quarter to a third were interested in training in chiropractic, herbal medicine, naturopathy and vitamin and mineral therapy. General practitioners appear to underestimate their patients' use of complementary therapies.

**Conclusions:** There is evidence in Australia of widespread acceptance of acupuncture, meditation, hypnosis and chiropractic by GPs and lesser acceptance of the other therapies. These findings generate an urgent need for evidence of these therapies' effectiveness.

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therapies by GPs vary from around 16% in Canada<sup>8</sup> and the UK,<sup>6,12</sup> to 30% in New Zealand,<sup>10,13</sup> 47% in Holland (mainly homoeopathy)<sup>14</sup> and up to 85% in Germany (mainly herbal medicine).<sup>15</sup>

Despite this degree of interest in and use of complementary therapies by family doctors, in the United States it has been estimated that 70% of people who attend non-medically train:  $\pm$  complementary therapists do not inform their family doctor.<sup>3</sup>

The corresponding situation in Australia is largely unknown. At least 15% of Australian GPs practise acupuncture,<sup>16</sup> the only non-orthodox therapy that attracts specific funding from Medicare. In this study, we describe Victorian GPs' attitudes towards and use of a range of complementary therapies.

# For editorial comment, see page 102; see also page 110 Department of General Practice and Public Health, University of Melbourne, Carlton, VIC. Marie V Pirotta, MMed, FRACGP, Senior Lecturer. Stephen J Farish, BSc(Hons), MEd, Biostatistician and Senior Lecturer. Complementary Medicine Research Unit, Monash University, Melbourne, VIC. Marc M Cohen, PhD, MB BS(Hons), Senior Lecturer. Clayton, VIC. Vicki Kotsirlios, MB BS, General Practitioner. Reprints will not be available from the authors. Correspondence: Dr M V Pirotta, Department of General Practice and Public Health, University of Melbourne, 200 Berkeley Street, Carlton, VIC 3053. m.pirotta@gpph.unimelb.edu.au

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METHODS

We obtained a random sample of 800 Victorian GPs who had each seen at least 1500 patients in 1996 from the Health Insurance Commission, which administers the national health insurance scheme (Medicare).

#### RESEARCH

We designed an 11-page survey to investigate various aspects of GPs' interactions with the following complementary therapies: acupuncture, aromatherapy, chiropractic, herbal medicine, homoeopathy, hypnosis, meditation, naturopathy, osteopathy, reflexology, spiritual healing (eg, Reiki) and vitamin and mineral therapy. We developed the survey from the existing literature<sup>17</sup> and by using a focus group of local GPs. After pilot testing, the survey was mailed to the 800 GPs with a reply paid envelope in July 1997. Non-responders were sent a reminder postcard and then a follow-up survey if necessary. Doctors who had left their clinic leaving no forwarding address, taken extended leave, were seriously ill, or had moved overseas, retired or died were excluded.

The study received ethical approval from both the University of Melbourne and Monash University.

The statistical analysis was performed using SAS.<sup>18</sup> Responses were analysed to search for groupings of common levels of use/acceptance. (In all instances, for these data the 95% confidence intervals for percentages never exceed  $\pm 4.5\%$ .) Qualitative data from space left for comments were coded and classified by themes.

## RESULTS

Thirty-six GPs were excluded according to the exclusion criteria, leaving 764 GPs. Questionnaires were returned by 488, giving a response rate of 64%. The sample was representative of Australian GPs<sup>19,20</sup> in terms of sex, age distribution, metropolitan or rural practice location and number of patients seen per week up to 199; doctors seeing more than 200 patients per week, however, were underrepresented. There was no significant difference in age or sex between responders and non-responders.

# Knowledge of complementary therapies

At least 80% of GPs reported that they knew something of acupuncture, hypnosis, meditation and chiropractic; about half knew something of herbal medicine, naturopathy and vitamin and mineral therapy; while 60%-70% had only heard of osteopathy, homoeopathy,

# 1: Attitudes among the 488 general practitioners on the harmfulness and effectiveness of complementary therapies\*

	Harmful			Effective			
	Frequently	Occasionally	Seldom	Highly	Moderately	Seldom	
Acupuncture	1 (0)	76 (16%)	395 (82%)	93 (21%)	294 (67%)	41 (9%)	
Chiropractic	32 (7%)	362 (75%)	82 (17%)	48 (11%)	306 (70%)	61 (14%)	
Hypnosis	1 (0)	141 (29%)	305 (63%)	77 (18%)	260 (60%)	61 (14%)	
Meditation	0	10 (2%)	436 (90%)	124 (29%)	230 (53%)	41 (10%)	
Osteopathy	12 (3%)	180 (37%)	141 (29%)	31 (7%)	138 (32%)	114 (26%)	
Herbal medicine	20 (4%)	262 (54%)	144 (30%)	14 (3%)	128 (30%)	199 (46%)	
Naturopathy	16 (3%)	200 (42%)	165 (34%)	19 (4%)	125 (29%)	191 (44%)	
Vitamin and mineral therapy	/ 11 (2%)	214 (45%)	182 (38%)	22 (5%)	94 (22%)	224 (52%)	
Spiritual healing						. ,	
(Reiki)	8 (2%)	57 (12%)	199 (41%)	12 (3%)	83 (19%)	123 (28%)	
Homoeopathy	<b>13 (</b> 3%)	143 (30%)	188 (39%)	10 (2%)	72 (17%)	217 (50%)	
Aromatherapy	3(1%)	22 (5%)	313 (65%)	5 (1%)	67 (16%)	215 (50%)	
Reflexology	12 (3%)	47 (10%)	198 (41%)	4 (1%)	31 (7%)	207 (48%)	

\*Many GPs offered no opinion, resulting in some missing values.

spiritual healing, reflexology and aromatherapy.

## Opinions on the harmfulness and effectiveness of complementary therapies

Most GPs agreed that the well-known therapies (acupuncture, meditation, hypnosis and chiropractic) were moderately to highly effective (see Box 1); three-quarters also agreed that chiropractic was occasionally harmful. When given the opportunity to write comments, many doctors expressed concern that complementary therapies could be harmful if a diagnosis is delayed or missed or if a proven (orthodox) therapy is neglected. Complementary therapies were considered to have a strong placebo effect. Some respondents commented that, while some therapies were effective in certain conditions, one could not generalise and effectiveness may depend upon the training and competence of the therapist. General practitioners frequently differentiated between medical and non-medical practitioners and expressed greater confi-

# 2: Opinions among general practitioners about the appropriateness of GPs to practise and charge Medicare for complementary therapies

	Appropriate for trained GPs to practise	Should be eligible for Medicare rebates*		
Acupuncture	97% (419/434)	91% (384/422)		
Hypnosis	92% (396/430)	91% (364/399)		
Meditation	80% (342/428)	77% (282/367)		
Chiropractic	55% (238/432)	69% (207/301)		
Vitamin and mineral therapy	44% (184/423)	54% (137/254)		
Herbal medicine	43% (183/427)	53% (138/263)		
Naturopathy	28% (117/424)	42% (93/224)		
Osteopathy	27% (113/423)	44% (94/216)		
Homoeopathy	23% (98/424)	36% (77/213)		
Spiritual healing (Reiki)	18% (74/422)	27% (50/189)		
Aromatherapy	17% (73/428)	24% (47/197)		
Reflexology	11% (48/426)	22% (38/174)		

"Follow-on question answered only if the therapy was considered appropriate to practise.

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3:	<b>Referral of patients for</b>	complementary	therapies	among	general
	practitioners				

		т	Those who ever referred patients						
	Encourage		Frequency of referrals						
	suggestion to attend	% (No.)	Rarely	Few times a year	At least monthly	At leas weekly			
Meditation	74% (374/470)	80% (379/476)	31% (118)	40% (153)	20% (76)	9% (32)			
Acupuncture	71% (332/470)	90% (424/473)	24% (100)	47% (199)	19% (82)	10% (43)			
Hypnosis	62% (292/470)	82% (386/473)	44% (168)	46% (179)	10% (37)	< 1% (2)			
Chiropractic	29% (137/470)	69% (326/476)	37% (122)	41% (135)	17% (54)	5% (15)			
Vitamin and mineral therapy Osteopathy	17% (79/469) 16% (75/467)	33% (157/472) 30% (141/476)	57% (90) 55% (78)	30% (47) 30% (42)	8% (12) 11% (15)	5% (8) 4% (6)			
(Reiki)	14% (66/469)	20% (93/476)	74% (69)	20% (19)	4% (4)	1% (1)			
Naturopathy	13% (62/470)	30% (141/474)	55% (79)	26% (37)	13% (18)	5% (7)			
Herbal medicine	12% (56/469)	29% (138/474)	63% (87)	24% (33)	9% (13)	4% (5)			
Homoeopathy	9% (43/470)	20% (91/473)	73% (66)	18% (16)	8% (7)	2% (2)			
Aromatherapy	9% (42/471)	18% (83/475)	70% (58)	23% (19)	6% (5)	1% (1)			
Reflexology	7% (22/470)	10% (48/476)	77% (37)	17% (8)	6% (3)	0			

# 4: Training in and practice of complementary therapies among general practitioners

					. b.a	·······			
	Interact	Цама		ł	% Who pra	Who practise			
	in training	trained*	No.	<5%	6%-24%	25%-50%	% >50%		
Meditation	59% (283/477)	34% (151/441)	75	67% (50)	27% (20)	5% (4)	1% (1)		
Hypnosis	52% (246/478)	20% (89/442)	50	78% (39)	20% (10)	0	2% (1)		
Acupuncture	49% (235/477)	23% (102/441)	99	58% (59)	34% (33)	4% (4)	3% (3)		
Herbal medicine	36% (169/474)	12% (53/438)	33	61% (20)	27% (9)	3% (1)	9% (3)		
Vitamin and mineral therapy	34% (160/470)	23% (98/434)	63	46% (29)	38% (24)	3% (2)	13% (8)		
Naturopathy	25% (117/476)	6% (26/439)	25	56% (14)	24% (6)	8% (2)	12% (3)		
Chiropractic	24% (112/475)	8% (34/437)	29	76% (22)	21% (6)	3% (1)	0		
Aromatherapy	17% (83/477)	4% (19/438)	18	83% (15)	16% (3)	0	0		
Homoeopathy	16% (75/477)	5% (23/440)	21	67% (14)	19% (4)	0	14% (3)		
Osteopathy	13% (61/475)	4% (17/437)†	22†	68% (15)	18% (4)	9% (2)	5% (1)		
Spiritual healing	10% (57/472)	5% (21/420)	17	71% (19)	24% (4)	0	6% (1)		
Reflexology	7% (33/475)	2% (9/438)†	12†	100% (12)	0	0	0 0		

\* Includes self-taught.

†These figures, which show that more doctors use osteopathy and reflexology than have actually trained in it, reflect inconsistencies in individual responses.

dence in medically trained colleagues who practised these therapies.

## Opinions on the appropriateness of GPs to practise complementary therapies and eligibility for Medicare subsidy

Box 2 shows responses to the question of whether it is appropriate for general practitioners to practise these therapies.

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Although chiropractic was considered occasionally harmful by 75% of general practitioners surveyed, 55% considered it appropriate for trained GPs to practise.

Those who practise the therapy

Doctors who agreed that it was appropriate to practise a therapy were asked whether GPs should be eligible for Medicare funding when practising these therapies. Nearly all GPs agreed that acupuncture should be funded. There was also strong support for specific funding for GPs practising hypnosis (91%), meditation (77%) and chiropractic (69%). Even the relatively unknown therapies had support from approximately a quarter of GPs for specific Medicare funding.

#### Teaching in undergraduate curricula

Most respondents (93%) agreed that there should be some education on complementary therapies in core medical undergraduate curricula. However, doctors were evenly divided over a fivepoint scale about the importance of this education for students.

#### Patient demand

Fifty-nine per cent of GPs reported that patient demand for complementary therapies was increasing, 29% reported demand was static, and 10% were unsure. A third of doctors estimated that less than 10% of their patients used complementary therapies and another third thought that 11%-30% did. Nearly half of the GPs reported that less than 5% of their patients had asked them about complementary therapies in the past month.

### **Referrals for complementary** therapies

Box 3 summarises GPs' responses on referrals to complementary therapists, from how they would respond if a patient suggested consulting a complementary therapist to how often they themselves refer patients to these therapists. The question did not specify whether the therapists were medically trained.

Most GPs (93%) had referred at least once and 82% had referred at least a few times a year for a complementary therapy.

Just under half of the sample referred at least a few times per year for the bestknown therapies — acupuncture, meditation, hypnosis and chiropractic. While approximately two-thirds of the general practitioners would encourage a patient who suggested consulting a practitioner of acupuncture, meditation or hypnosis, only 29% would do so for chiropractic. In the remaining therapies, GPs were twice as likely to have actually referred

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a patient for these therapies than to endorse a patient's suggestion to consult a practitioner.

## Training and use of complementary therapies

Box 4 shows that half of the GPs expressed an interest in training in acupuncture, meditation and hypnosis and a quarter to a third in chiropractic, herbal medicine, naturopathy and vitamin and mineral therapy. Nearly 20% of GPs practised one of the therapies, 8% used two therapies, 6% three, and 3% of general practitioners practised between 4 and 11 of these complementary therapies. For most of the complementary therapies, 80% or more of the GPs who trained in them practised them to some degree; exceptions were meditation (50%), hypnosis (56%), herbal medicine (62%) and vitamin and mineral therapy (64%). The practice of some complementary therapies, notably homoeopathy, vitamin and mineral therapy, naturopathy and herbal medicine, represented more than half of the clinical work for a small number of Victorian GPs.

#### DISCUSSION

Our survey provides the first comprehensive description of the use of complementary therapies by GPs in Victoria. As the large sample is, in nearly all characteristics, similar to Australian GPs as a whole, our findings about GP attitudes and use of complementary therapies are likely to reflect the situation across the country. Nearly 20% of GPs had used acupuncture, meditation or hypnosis, and almost half had considered practising these therapies. Over 80% of GPs had referred patients to practitioners of these therapies. A quarter to a third were interested in training in chiropractic, herbal medicine, naturopathy and vitamin and mineral therapy. Further, around 5% of doctors use therapies, such as osteopathy, homoeopathy, aromatherapy and spiritual healing, which are relatively unknown to most of their colleagues.

It is interesting to speculate on the discrepancy between the number of GPs who trained in meditation, hypnosis, herbal medicine and vitamin and mineral therapy and the number who actually practise these therapies (Box 4). Possible reasons may include GP or patient dissatisfaction with outcomes, poor acceptance by patients, lack of financial reward, or difficulty accommodating more time-consuming therapies in a busy clinic.

The GPs we surveyed estimated a lower use of complementary therapies by their patients than indicated by population-based research. This may be because the portion of the population who do not attend GPs for their primary health care may attend complementary therapists, and because those who do attend GPs may be less likely to use complementary therapies.

The interpretation of our findings is limited by several possible sources of bias. We have no information on nonresponders, and the 64% who did respond may have been more likely to participate because they had particularly strong positive or negative views. The effects of self-report and recall bias are also unknown. Further, we did not define the therapies listed in the questionnaire and GPs may have different interpretations of the terms used, particularly vitamin and mineral therapy.

Reviewing studies of various designs shows that Victorian doctors have similar levels of interest in training in, and of referral of patients for, complementary therapies as their colleagues in other Western countries, with the exceptions of Holland and Germany.6-8,10,12-15 However, the popularity of therapies varies. For example, the most popular therapy practised in Victoria was acupuncture, with 23% of respondents having trained, whereas only 8% of GPs in Canada<sup>8</sup> and 4% in the UK<sup>12</sup> had had acupuncture training. By contrast, homoeopathy, which has an established role in Europe,<sup>4</sup> was the most popular complementary therapy practised by British GPs,<sup>6,12</sup> but one of the least popular therapies in Victoria.

Complementary therapies may well have something to offer, but it is of concern that therapies of unproven effectiveness are apparently being accepted in mainstream general practice. Many editorials, while acknowledging that ran-

domised controlled trial evidence is lacking for many aspects of orthodox Western medical practice, have called for quality trials in complementary therapies.<sup>21,22</sup> The Cochrane Library is coordinating a search for randomised controlled trials of complementary therapies and is undertaking systematic reviews of therapies for specific conditions.<sup>23</sup> Meanwhile, other reviews have found some evidence of efficacy, for example St John's wort in treating mild to moderate depression,<sup>24</sup> acupuncture for antiemesis,25 and also an overall greater than placebo effect for homoeopathy in a meta-analysis of trials for various conditions.26

There are diverse reasons for the lack of evidence for complementary therapies. Many therapies have not been challenged before because of their long history, "natural" origins or patients' or doctors' anecdotal reports of success. In this era of evidence-based medicine, there are difficulties applying the gold standard of randomised controlled trials to therapies which are based on different and varied paradigms of health and illness. Funding for trials in "natural" therapies is also lacking. Freely available herbs cannot be patented, so there is little incentive for research, particularly if the public is buying them regardless of evidence. Lewith et al suggest that lack of structure to enhance research in complementary therapies is a barrier in Britain.<sup>27</sup> Our experience would suggest a similar situation in Victoria.

Our findings show that general practitioners are actively using complementary therapies. Therefore, whatever the profession's attitude towards these therapies, well-designed trials, disseminated and accessible results and education are urgently needed to inform GPs' decision-making.

Further research is also required into why GPs decide to practise these therapies and why they are less likely to endorse a patient's suggestion to consult a complementary therapist than to refer themselves. The problems of compliance with and interactions between orthodox and complementary therapies are also areas where much research is needed. As our findings support those of Eisenberg et al<sup>3</sup> that GPs may not communicate

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sufficiently with their patients and are not aware of their widespread use of complementary therapies, the issues of communication between doctors and complementary therapists, as well as between doctors and their patients, also need to be addressed.

#### Conclusions

Acupuncture, meditation, hypnosis and, possibly, chiropractic may be considered to be well-accepted therapies in Victorian general practice, while herbal medicine, naturopathy, vitamin and mineral therapy, osteopathy and homoeopathy are accepted by a sizable minority of doctors. Doctors underestimate their patients' use of these therapies, which may contribute to compliance and medication interaction problems. There is an urgent need for well-designed trials to search for evidence of the effectiveness of these non-orthodox therapies, to inform doctors' and patients' use of them.

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## DISCLOSURE

Those who funded this trial had no input into its design. analysis, conclusions, writing of the manuscript or the decision to submit it for publication.

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# Bio-energetics and Basic Science: Bringing together ancient and modern concepts Dr Marc Cohen MBBS (Hons), PhD, Bmed Sci(Hons), FAMAS, Dip Ac.

## PART 1 Musings on Qi

Many of the concepts of Bio-energetic medicine are based on ideas borrowed from Eastern medicine. The underpinning paradigm suggests that life is dependent on a subtle form of energy, often termed "vital force", "life energy", "prana", "chi", or "Qi" which is deemed to flow throughout the organism maintaining both physical and psychological processes. Pain and disease are said to arise when this energetic flow is disrupted or "blocked".

The concepts underlying bio-energetic medicine have not been accepted by Western Science and are criticized as being unscientific. The inability of science to recognise the basic concepts underlying Eastern medicine prevents the theoretical integration of Eastern and Western medicine, leaving medical knowledge divided by the use of different conceptual languages. Thus while one discipline is talking about "*Q*/', or "*yin*" and "*yang*", another is talking in terms of "*receptor transmitter interactions*" and ""*pharmacokinetics*" or "*psychosocial stressors*" and "*life events*". When such different terms are being used it is difficult to find a common ground, even when discussions are focused on the same issues.

Eastern and Western medicine lie on either side of the Cartesian divide between mind and body, subjective and objective, holism and reductionism. Eastern thinking is holistic and outlines a whole philosophy of life that maintains a cosmolgical perspective based on nonlinear logic and acausal relationships. In contrast, Western thought is based on a reductionist approach that emphasises controlled experimentation and mathematical analysis based on analytical reasoning and linear causality.

These approaches may be seen as complementary and an integration of ideas may be achieved by establishing parallels between their basic concepts. Such a mapping of ideas would create a common language that would allow discussions between different traditions to take place and permit each tradition to inform the other, thus providing new insights and understanding. In order to achieve this integration however, many Eastern concepts must be translated into the language of science, for it is in the light of rational scientific inquiry that modern medical knowledge is ultimately assessed.

#### Parallels between Eastern and Western concepts

Many of the fundamental concepts of Eastern medicine such as "*yin*" and "*yang*" and "*Tad*" have fairly obvious parallels in Western science. The concept of *Yin* and *Yang* can be seen to accurately parallel the quantum theoretical concept of complementarity. *Yin* and *Yang* refer to pairs of mutually exclusive yet interdependent opposites. This idea is well accepted within quantum theory, where light must be understood to have the properties of both waves and particles fro a complete description. In fact, Niels Bohr, one of the founders of quantum theory included the *Yin/Yang* insignia in his family coat of arms along with the statement that "opposites are complementary".<sup>1</sup>

The concept of "*Tad*" also finds parallels in Western science in the mathematical concept of Absolute infinity. An important feature of both "*Tad*" and "*Absolute infinity*" is that they are both considered to be inherently incomprehensible and thus unable to be grasped by the rational mind. The incomprehensibility of these concepts places them essentially beyond thought, yet paradoxically allows them to provide the conceptual basis for an entire system of thought. The concept of *Tao* in Eastern thought is seen to represent "the infinite order of nature" or the "way of the universe" and forms the basis of *Taoist* philosophy which considers Tao as "formless, nameless, the motive force of all movements and actions, the mother of all substances." Similarly, the concept of *Absolute infinity* in mathematics represents "the class of all sets" and this concept forms the basis of set theory, which provides a conceptual framework for all mathematics and may even be described as a form of exact theology.<sup>2</sup>

While the concepts of *Tao* and *Ying* and *Yang* readily find counterparts within Western science, the concept of *Qi* appears more problematic. In eastern thought the concept of *Qi* refers to a subtle form of energy that flows throughout the organism along certain defined pathways or meridians. This continuous flow maintains the functional integrity of the system. The ideograph used to denote the concept of *Qi* is made up of two Chinese characters, one of which means "the flow of something that is difficult to grasp" and another that refers to "rice" or the "source of energy of a human or animal" Thus *Qi* refers to "the flow of something that is the source of vital energy to humans and animals."<sup>3</sup>

The normal flow of *Qi* is seen as a necessary requirement of life and a disruption in the flow of *Qi* is seen to be the prime cause of pathology. Furthermore *Qi* is said to come in various forms which animate life so there is *Qi* from air and food, *Qi* that flows in meridians and perverse *Qi* that causes disease. Thus as Porkett states: "whatever the context and absolutely without exception, *Qi* always implies a qualitative determination of energy. In other words *Qi* means energy of definite (or definable) quality."<sup>4</sup>

### Qi and Thermodynamics

In contrast to the Eastern concept of "*Ql*" or "*life energy*", in Western science the concept of "*energy*" has a more precise meaning that does not include a form of energy specific to living systems and thus the concept of "*Ql*" is often rejected as being "unscientific". The concept of *Qi* however, does follow many fundamental scientific principles. In particular, it is in accord with the laws of thermodynamics, which are universal laws that comprise the most fundamental principles in Western science. As Einstein states:

" A theory is the more impressive the greater is the simplicity of its premises, the more different are the kinds of things it relates and the more extended is its range of applicability. Therefore the deep impression which classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced, that within the framework of applicability of its basic concepts, will never be overthrown."<sup>5</sup>

The First law of thermodynamics states that "*matter and energy cannot be created or destroyed, only converted from one form to another*" while the Second law of thermodynamics concerns the concept of entropy. This describes a universal tendency towards disorder and states: "*in an isolated system entropy always increases.*"

The concept of *Qi* can be seen to be in good accord with the laws of thermodynamics. Chinese pathophysiology views disease as resulting from a disruption in the normal flow of *Qi* and in this view, *Qi* is always preserved. Thus if the flow of vital energy is obstructed, below the obstructed area is deficiency with excess above. Furthermore the concept whereby disease arises from a disturbance in the flow of *Qi*, may be seen to parallel the second law of thermodynamics which predicts an increase in disorder in any isolated system. Thus, the Chinese have developed a theoretical framework for understanding life processes and pathology based on the Second law of thermodynamics, thousands of years before the concept of entropy was acknowledged in the West.

#### **Entropy and biology**

While the Chinese seem to have recognised that the concept of entropy applies to life processes, it seems somewhat surprising that, despite its universal application, the concept of entropy is not widely utilised within Western medical science. The reason for this appears to be mainly historical.

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The 2<sup>nd</sup> law was originally formulated as an engineering concept and described in terms of the usefulness of energy by Thompson in 1852. Subsequently the concept of entropy was reformulated in 1872. Thus the concept of entropy was derived as an engineering concept when man was claiming domination over the inanimate world during the industrial revolution. In fact, at the same time as the Second law of thermodynamics was being acknowledged, the biological sciences were busy integrating the concept of evolution and natural selection which seems to contradict the Second law.

The reason living systems appear to contradict the 2<sup>nd</sup> law of thermodynamics is that the 2<sup>nd</sup> law only applies to isolated systems i.e. systems that do not communicate in any way with their environment. Living systems however are necessarily open systems; and thus appear not to fall under the jurisdiction of the Second law. Indeed, living systems tend to build up order as they grow, learn and evolve. As Bertalanffy states:

"The fundamental characteristics of life, metabolism, growth, development, selfregulation, response to stimuli, spontaneous activity, etc., ultimately may be considered as consequences of the fact that the organism is an open system. The theory of such systems, therefore, would be a unifying principle capable of combining diverse and heterogeneous phenomena under the same general concept, and of deriving quantitative laws."<sup>6</sup>

The task of deriving laws regarding the ability of open systems to become self-organising and increase their order is the subject of the field of non-equilibrium thermodynamics. In his book *Order out of Chaos,* the Nobel Laureate, Ilya Prigogine maintains that it is communication throughout the system that allows open systems to maintain their stability and to increase in order. As he states:

"The faster the communication takes place within a system, the greater the percentage of unsuccessful fluctuations and thus the more stable the system. Indeed the more complex a system is, the more numerous are the types of fluctuations that threaten its stability. [Hence]...there is competition between stabilisation through communication and instability through fluctuations. The outcome of that competition determines the threshold of stability."<sup>7</sup>

# Communication, information and entropy

This idea suggests that it is information flow (i.e. communication), that enables systems to build up and retain a high degree of order. The link between communication and entropy is indeed a profound one. This was demonstrated by Claude E. Shannon who in 1948, while working in Bell laboratory on the engineering problems of communication channels, derived a mathematical expression for information that was subsequently shown to be identical to thermodynamic entropy. In the introduction to Shannon's work entitled "The Mathematical Theory of Communication," Warren Weaver states:

"When one meets the concept of entropy in communication theory, he has a right to be rather excited — a right to suspect that one has a hold of something that may turn out to be basic and important...One must think a long time, and consider many applications, before he fully realises how powerful and general this amazingly compact theorem really is."<sup>8</sup>

Shannon's equation, which equates entropy with uncertainty, is defined in terms of a well-defined question (Q) representing a question with a finite set of answers, along with knowledge (X), based on knowledge of the question and past experience. This knowledge leads to the assignment of probabilities (p) to the various possible answers. Shannon's measure is expressed symbolically as S(Z/X) to emphasise that the uncertainty or entopy depends on both the question (Q) and knowledge (X). The expression is written as:

## $S(Z/X) = -K \Box p \ln p$

Where K refers to an arbitary sacale factor. (When K = 1/In2; S = bits of information. When K = Boltzman's constant (i.e.,  $1.38 \times 10^{-23}$ ); S = Joules per degree Kelvin). This mathematical definition has the property that if one (correctly) assigns p = 1 to one of the answers and (therefore) p = 0 to all the others, then s(Q/X) = 0 (there is no uncertainty / entropy). On the other hand if all probabilities are assigned equally then s(Q/X) is a maximum (there is maximum uncertainty).<sup>9</sup>

# Information and Qi as energy

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Shannon's expression, which forms the mathematical basis for all types of communications, neatly defines entropy in terms of "*uncertainty*" or "*information*" and reveals that information may be considered as a form of energy. Information can thus be measured in terms of "bits" or "Joules per degree Kelvin" (one bit is approximately equal to  $1.8 \times 10^{-23}$  Joules per degree Kelvin). This expression therefore provides a link between qualitative and quantitative aspects of energy and suggests that the Chinese concept of *Qi*, which also refers to quality of energy, may be closely related to the concept of *"information."* 

The similarities between the concepts of information and of *Qi* are many. At the most basic level, "information" provides science with the ultimate in reductionism, for the "bit" (which is either 0 or 1) is the smallest quantifiable unit. Similarly *Qi* is seen to arise from the interplay of the polar opposites of yin and yang which are also considered fundamental building blocks of reality. Futhermore, the idea that it is communication (information flow) that allows systems to build up and retain order, closely parallels the idea that the flow of *Qi* maintains the functional integrity of living systems. Thus both "information" and *Qi* can be considered to be types of energy that sustain living systems and animate awareness. An obstruction in the flow of either information or *Qi* would therefore produce an isolated system and result in an increase in entropy that would manifest as pain and disease (biological disorder). Thus while life is dpendent on "negentropy" in order to build up order and thus grow, learn and evolve, entropy represents a threat to life which may be consciously perceived as painful.

### Pain and entropy

The idea that pain is related to entropy is strengthened when examining the language of pain. Pain is usually described in terms of the mechanism of injury (stabbing, burning, crushing, pinching, etc.) which describe the ways in which biological order may be disturbed. In addition, the symptoms commonly associated with pain (calor, tumour, ubor, and lasor - heat, swelling, redness and loss of function) may all be seen to describe a decrease in biological order. As well as being associated with biological disorder, the physiological correlates of pain can be seen to reflect the cosmological correlates of entropy, which represent a trend towards an expanding universe (swelling), energy dissipated at heat (heat and redness), and an increase of useless energy (loss of function). The idea of pain as entropy suggests therefore, that the same process that lays waste to galaxies, also results in disruption and destruction on a personal level. This is in accordance with the Eastern medicine idea of the microcosm reflecting the macrocosm and enables a cosmological perspective to be applied to pain within a scientific framework, without resorting to the non-rational language of mystical experience.

The entropic view of pain allows otherwise esoteric Eastern concepts to be expressed in the language of science. Thus the Eastern view of "life is pain" can be seen to relate to the fact that homeostasis is never perfect and that life is necessarily an entropic process. The ultimate state therefore is one of "nirvana" or "enlightenment", which state of "being at one with the universe". In the enlightened state there is no distinction between self and nonself and thus perceptions are no longer isolated and subject to the second law of thermodynamics.

### Disease and obstructions in information flow

While the enlightened state suggests a state of ideal health occurring where perception is flowing freely, the states of pain and disease occur when there is an obstruction in one of the many forms of information flowing throughout biological systems. Thus pain and disease may arise as a result of many different types of obstructions, ranging from blocks in enzyme pathways and biochemical processes, to mechanical disruptions in arteries, veins, ureters and intestines to blocks in nerve conduction or the transmission of direct currents. In addition to the many well-defined physical pathways in the body, there are also pathways that appear to be more "informational" than physical. Thus the concept of information flow may be applied to conscious processes and psychological disorders may be seen to arise from emotional blocks occuring when information is too overwhelming to be processed and is blocked from emotional expression. Furthermore the classical acupuncture meridians represent pathways where the informational substrate is less well defined.

The acupuncture meridian system describes a system of pathways for the flow of information where certain points may act as channels for information transfer between the organisms and its

environment. This exchange may take place in many different ways. Information may be exchanged through mechanical means such as pressure or needling, through heat and cold, through the application of direct electrical or electromagnetic energy such as electroacupuncture or laser stimulation, as well as through more subtle means, such as through changes in environmental electromagnetic fields. Thus these points may be responsive to both man-made and natural electromagnetic fields as well as to interactions with the fields produced by other people such as healers.

While the exchange of information at acupuncture points may take on many forms, the substrate for information flow throughout the meridians has not been precisely determined. There is much evidence however to suggest that electromagnetic energy is involved. Acupuncture points have consistently been shown to be points of low electrical resistance<sup>10,11</sup> and acupuncture meridians have been shown to be low resistance pathways.<sup>10,12</sup>

The evidence has not yet included a full explanation of how different meridians may carry different types of information according to their corresponding organ system, however, there are many possibilities, including different waveforms, frequencies, resonance, etc. Modern attempts to measure and influence these pathways have met with considerable success however there is much that still needs to be learned before technology can take full advantage of the insights provided by Eastern medicine.

Acupuncture is based on the view that information and energy flow are the primary substrates for both health and disease. While this view is supported by the laws of thermodynamics, the challenge remains to be able to access this information flow for the purposes of diagnosis and therapy. Much work remains to be done both on a clinical level to demonstrate the efficacy of different diagnostic and therapeutic techniques as well as on a theoretical level to integrate many of the insights provided by Eastern medicine with modern technology. The ability to integrate Eastern and Western ideas has been explored within the framework of theoretical physics by Capra who in his book "The *Tao* of Physics" suggests:

"We are heading towards a new synthesis, a new naturalism. Perhaps we will eventually be able to combine the Western tradition, with its emphasis on experimentation and quantitative formulations, with a tradition such as the Chinese one, with its view of a spontaneous, self organising world."<sup>13</sup>

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# PART 2 Diagnostic and Therapeutic Implications

Bio-energetic medicine covers a wide range of different therapeutic and diagnostic approaches based on the idea that life is dependant on a subtle form of energy. Pain and disease are said to be produced when this energetic flow is disrupted or blocked and bio-energetic therapies are aimed at restoring the natural energetic flow and thus aiding the bodies own homeostatic responses. As science is yet to recognise a form of energy specific to living systems, many of the concepts underlying bio-energetic medicine have often been criticised as being unscientific. Many bio-energetic concepts however, may be translated into more rigorous scientific terms and are supported by the discovery of the electromagnetic spectrum and the development of information theory as well as evidence from clinical trials.

Bio-energetic therapies involve many different approaches including acupuncture, various forms of electrotherapy, homoeopathy, various forms of psychotherapy as well as prayer. These therapies share many common underlying principles in that considerable attention is often paid to the patients emotional and physical state and the therapeutic act usually involves relatively small, yet very specific, energetic or physical stimuli in which the timing is often important. Thus bioenergetic therapies are often also referred to as vibrational or information-based medicine.

While science does not recognise life energy as a distinct entity, 'information' itself can be considered as a type of energy. Information can be measured in bits or joules/degree Kelvin (one bit is approximately equal to 10<sup>-23</sup> joules/Kelvin) and thus information may be considered as a form of subtle energy that animates our awareness. The concept of disease arising from a blockage of 'qi' can thus be seen to parallel the second law of thermodynamics which is one of the most fundamental laws in Western as argued above, A blockage in the flow of information through a biological system would therefore tend to produce disorder (disease) and by restoring information flow, homeostasis would naturally return.

# Electromagnetic radiation as subtle energy

Life has evolved bathed in a constant stream of energy. While much of this energy is obvious to us in kinetic, chemical, gravitational and thermal forms, there are other forms of energy that are more subtle. Electromagnetic energy may be considered as a subtle energy for except for the visible and infra-red regions, most of the electromagnetic spectrum is not obvious unless specific receivers (such as radios, mobile phones, televisions or photographic plates) are used. The 'invisible' parts of the electromagnetic spectrum however can be found to have profound effects on living systems which may result in either gross or subtle changes.

The study of the biological effects of electromagnetic radiation is an extremely complex and controversial one. Although gross effects from electromagnetic radiation (EMR) are usually attributed to its thermal or ionising properties, it is now widely accepted that there may be many non-thermal effects of EMR. The biological effects of EMR may arise from many factors including: the electric or magnetic field components, the energy content, frequency, coherence, resonance, or modulation of a fundamental frequency, the waveform, amplitude or modulation of amplitude, the length of and timing of exposure, the area they are applied to, interference effects with other fields, presence of existing pathology, (tumor promoting rather than initiating effects), and the information content of the fields. <sup>1,2,3</sup>

The large number of variables to consider when examining the biological effects of electromagnetic fields makes this an extremely complex area. This complexity is compounded by the fact that biological systems are non-linear and are capable of responding to so-called 'quantum events' such that a single quantum of energy is able to cause biological effects. Enzyme systems within the body are typically capable of an amplification factor of the order of 10<sup>10</sup> and this is evident when considering that the dark-adapted eye is able to detect a single photon or the ear can detect sound ranging from silence to the output of a jet engine<sup>3</sup>. The sensitivity of biological systems to EMR has led to suggestions that that both natural and man made EMR may be responsible for producing various types of pathology. Over the past 100 years the natural background EMR has been overtaken by man made sources so that we are all currently exposed to artificial EMR of various frequencies from numerous sources ranging from powerlines, radio, television, video display units, microwave ovens and mobile phones. However,

while it is now clear that humans as well as other organisms are able to respond to fields as low as the earth's static magnetic field, and that pineal melatonin production may be influenced by EMR, <sup>4;5</sup> it is still not clear how low level magnetic and electric fields effect the human organism.

Due to the difficulty of performing research in this area, most studies of EMR induced pathology are based on epidemiological evidence. Epidemiological studies exist that demonstrate correlations between magnetic storm activity and psychiatric hospital admissions<sup>6-8</sup>, or between exposure to power line radiation and the development of childhood leukemia<sup>9;10</sup>, however, while these studies are suggestive, they do not help to explain the causal pathways involved. Proponents of the harmful effects of low level EMR suggest that EMR may act as a general stressor which would compromise already susceptible individuals as well as having long term effects on otherwise healthy people <sup>3</sup>. There are certainly many cases of electromagnetically sensitive individuals with so-called electromagnetic allergies, that may present with non specific ailments or chronic fatigue as well as many cases of illness occurring in domiciles that are subject to extreme EMR exposure due to local geography and the siting of radio or microwave towers. <sup>11</sup>

While there is much controversy as the harmful effects of EMR, it may also be possible that natural EMR has a balancing effect on the body. This is suggested by the finding that there are naturally occurring extremely low frequency (ELF) electromagnetic waves produced by lightning (Schumann resonances) that travel in the cavity between the ionosphere and the earth's surface with similar frequency components to the EEG during meditation <sup>12</sup>. Recently these Schumann resonance frequencies have also been found to preferentially propagate along acupuncture meridians <sup>13</sup>. The possibility of positive effects of natural EMR has led to the development of many devices that supposedly enhance these natural frequencies. Very few of these devices however have been subject to rigorous research and supporting evidence for their use remains anecdotal.

#### **Diagnostic applications**

The diagnostic applications of different types of electromagnetic energy is relatively recent, beginning around the start of this century with the discovery of X-rays and the use of the galvanometer to detect the electrical activity of the heart, and progressing towards increasingly more sophisticated and more subtle uses. Current diagnostic techniques involve either subjecting the body to an energy source and detecting the output, such as in conventional X-ray or MRI scanning, or the detection of the bodies own internal electrical activity such as in the electro-cardiogram (ECG), electro-encephalogram (EEG), electro-myogram (EMG), electro-oculogram (EOG), or detecting other electrical properties of the body such as the galvanic skin response (GSR) or impedance such as used in impedance plethysmography, and body composition studies. Cther diagnostic instruments that work on more subtle levels involve detecting the magnetic fields produced by the body to produce the magneto-cardiogram (MCG) or the magneto-encephalogram (MEG).

While there are many conventional applications of energy in diagnosis, the more bio-energetic approaches generally involve perturbing the bodies own electrical homeostasis and monitoring the response. This approach is commonly used in acupuncture-related diagnostic instruments and Kirlian photography. Electrical measurements may also be used to detect acupuncture points which can be defined electrically as points of low electrical resistance <sup>14-18</sup>. The electrical properties of acupuncture points have also been shown to alter during pathological processes <sup>19</sup>.

Acupuncture is perhaps the most well researched bio-energetic therapy and is also one of the oldest. The neurophysiological basis of acupuncture has now been well established on the basis of endorphin and other neurotransmitter involvement, the diffuse noxious inhibitory control system (DNIC) and the gate control theory <sup>20</sup>. The reality of acupuncture points however is often questioned for no consistent structural correlates for them have been identified. Acupuncture points it seems are best considered as functional, rather than structural entities, and this is confirmed by the finding that there is an extremely high correlation between acupuncture points and musculoskeletal trigger points, which are points of focal muscle tenderness that can be identified using a pressure algometer or palpation, and which are found to have a local twitch response to mechanical stimulation <sup>21</sup>.

While functional correlates of acupuncture points have been shown to exist, sceptics often point out that the acupuncture meridians have not been objectively identified. Most acupuncturists

however would maintain that acupuncture meridians are a conceptual tool, such as the lines of latitude and longitude on the earth, and thus while they are useful for navigating a specific territory, to search for anatomical correlates of the meridians would make as much sense as digging in the ground to look for the equator. Recently however there has been the suggestion of objectively defining the meridians using techniques capable of imaging functional, rather than structural relationships. Studies utilising radioactive tracers have shown that certain tracers appear to migrate along the acupuncture meridians <sup>22</sup> and electrical impedance studies have shown significantly lower impedance along the acupuncture meridians compared to surrounding skin <sup>16</sup>.

The electrical properties of acupuncture points and meridians may be utilised for both diagnostic and therapeutic purposes. Many different electro-diagnostic devices have been developed such as the 'Mora', 'Vega', 'Biocom', 'Electro-acupuncture According to Voll (EAV)', 'Electro-dermal Screening Test' (EDST) and 'Listen' systems. These instruments may be used to determine a person's energetic balance as well as modify this balance with small but precise electrical stimulation. Most of these systems have been developed on clinical grounds for the bio-energetic basis for these systems it is still not well understood. Attempts to explain these systems include quantum mechanical phase matching and phase modulation of electron waves within the body <sup>23</sup> however these explanations are by no means complete.

## Therapeutic applications

The use of electromagnetic energy for therapeutic purposes goes back at least as far as ancient Greece where electric eels were used in the treatment of arthritis and ancient China where lodestone was used in healing. Today the therapeutic uses of electromagnetic energy are widespread and used routinely in many applications ranging from the use of large fields such as ECT or defibrillation to lesser fields applied more specifically such as pacemakers or diathermy devices, to even more subtle uses such as in electro-acupuncture or Transcutaneous Electro-Neuro Stimulation (TENS), magnetic stimulation for bone healing, low level laser therapy and the use of static magnetic fields for pain. Other bio-energetic therapies may work on even more subtle levels where the type of energetic interaction has not been precisely classified.

### **Bio-energetics and human consciousness**

Perhaps the most interesting and challenging areas in bio-energetics is the field of human consciousness where studies have begun to show that human consciousness through a simple act of volition may be able to alter otherwise random physical processes and that the act of praying for patients may have substantial therapeutic benefits. Many researchers when hearing of telekinesis or other psychic phenomenon tend to get a bit agitated and frustrated at the inability to reproduce these phenomena or to explain them using conventional wisdom. There are a few serious researchers however, who have applied rigorous scientific principles to the study of these phenomena and have provided evidence that this is an area that deserves further study.

Robert Jahn, Dean Emeritus of the School of Engineering and Applied Science at Princeton University established the Princeton Engineering Anomalies Research (PEAR), in 1979 to investigate anomalous human-machine interactions. Since this time, Jahn's group have established an impressive body of evidence to suggest that human consciousness can indeed affect otherwise random physical processes. In a series of experiments involving over 50 million trials and over 3 billion binary events the PEAR group have demonstrated that human intention is able to alter otherwise random physical processes which include electrical, mechanical, fluid dynamical, optical, acoustic, micro/macroscopic and digital and analog processes, all of which can be calibrated with a predictable and precise statistical output <sup>24,25</sup>

While the Princeton group have performed studies demonstrating that human volition may effect otherwise random physical processes, there have also been many different studies demonstrating potential clinical applications. One of the earliest rigorously designed, double blind, randomised, placebo controlled, trials of prayer was performed by Randolph Byrd involving 393 coronary care patients at San Francisco General Hospital. In this study the patients were randomised and various religious groups were recruited and given the first name of a patient as well as a brief description of the patient's diagnosis and condition and were asked to pray for them. When comparing the patients who were prayed for with the control group there were dramatic differences. None of the prayed for group required intubation while 12 in the control group

required ventilatory support. The prayed for patients were found to be five times less likely to require antibiotics (3 vs16) and three times less likely to develop pulmonary oedema (6 vs 18)<sup>26</sup>. Many of the studies on the ability of human consciousness to affect life processes have been summarised in the book "Healing Words" by Larry Dossey<sup>27</sup> which also discusses some of the barriers to subjecting this area to scientific scrutiny:

Bio-energetic medicine certainly challenges the existing medical paradigm. It is often suggested that research into bio-energetic medicine will provide new understandings of health and disease and that bioenergetic medicine will be the medicine of the 21<sup>st</sup> Century. Certainly a more complete understanding of health and disease must include the electromagnetic nature of the body and the field nature of consciousness. However, even though science cannot fully explain the basis of bio-energetic medicine, the scientific method supports its clinical use. Many of the techniques such as acupuncture <sup>28</sup>, homeopathy <sup>29 30 31</sup> and prayer <sup>26</sup> have been shown to be of value when subjected to randomised, placebo-controlled trials, and thus these techniques can no longer be ignored or pushed aside as being irrelevant. Indeed the evidence suggests that these techniques deserve further serious research as well as consideration when deciding upon a therapeutic intervention.

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#### Needle match

NZJA

Acupuncture works. So say German scientists who have put the therapy to the test using a "placebo" needle.

Rather like a theatrical dagger, the placebo has a blunt needle that retracts into the handle when pressed onto the skin. The patient feels a pin prick and "sees" the needle being inserted, but there is no real acupuncture going on.

Konrad Streitberger, an anaesthetist at the University of Heidelberg who invented the placebo needle, believes it can inject rigour into acupuncture research. "It helps differentiate the physiological effects of the needle from the psychological effects," he says.

Streitberger's team used the needle on patients with rotator cuff tendinitis, a painful shoulder problem. Of 52 patients, 25 were given acupuncture and the rest received the placebo. After eight sessions, the first group showed much bigger improvements. Streitberger hopes to confirm the effect in trials with patients suffering from other diseases.

Ted Kaptchuk of the Centre for Alternative Medicine Research and Education at Harvard Medical School describes the needle as a "creative step forward". But he would like to see a double-blind trial, in which neither the patient nor the doctor knows who is getting the placebo. Doctors need to know the identity of Streitberger's needle to manipulate it properly.

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# Mapping Acupuncture Points Using Multi Channel Device\*

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# Abstract

The practice of acupuncture involves the stimulation of specific points on the skin called 'acupuncture points' which are small regions of local or referred pain that are more sensitive than surrounding tissue. The fact that acupuncture points can be identified subjectively as tender points and are found to have characteristic electrical properties suggest that they are functional entities rather than structural ones. These functional properties are used diagnostically in a clinical setting as pathology in a particular body location has been shown to correlate with increased tenderness and electrical conductivity of the 'corresponding' acupuncture point using electronic 'point locators', which measure the DC resistance of points compared to surrounding skin.

Commercially available point locators generally utilize a metal locator probe and an indifferent electrode and are designed to produce an auditory output (usually a high pitched tone) when a point is located. These devices however, are open to criticism. They are unable to control for local variations in skin thickness, surface secretions, or pressure placed on the electrode, and are only able to measure a single point at a time. These make them time consuming to use and subjective to user bias in point selection. Furthermore these devices do not store data and are therefore unsuitable for producing a map of skin resistance, which can be accessed over time. To overcome some of the limitations of currently available single probe devices, we have designed a multichannel probe capable of measuring and then mapping the skin resistance of multiple points.

#### Keywords:

Bio-electronics Measurement and Instrumentation, Acupuncture, Skin Resistance Map, Object Oriented C Programming, Electronic Design.

## Introduction

Acupuncture has been used as a therapeutic modality since the beginning of recorded history and is currently utilized by over one quarter of the world's population. In clinical practice acupuncture has proven to be a relatively safe and effective therapy, the main use of which is in the treatment of pain and addiction. The current integration of acupuncture into Western medicine however, is based on clinical rather than scientific grounds for as yet there is little understanding of how acupuncture achieves these results.

The practice of acupuncture involves the stimulation of specific points on the skin called 'acupuncture

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points' which are small regions of local or referred pain that are more sensitive than surrounding tissue. Drawings and figurines describing acupuncture points and meridians, which are lines linking these points into functional groups, have been used by traditional Chinese physicians for centuries and are still used by modern acupuncturists as a guide to therapy. The reality of acupuncture points however, is often questioned for no consistent structural correlates for them have been identified. While acupuncture points are not associated with any unique anatomical structures, they can be objectively identified using electrical parameters. In particular, acupuncture points have been found to be points of low electrical resistance compared to surrounding tissue<sup>123</sup>.

The significance of the unique electrical properties of acupuncture points is uncertain at present. The physiological basis for these altered electrical properties has been attributed to regional hyperactivity of the sympathetic nervous system, which may affect both sweat gland activity and blood flow regulation. Alterations in skin resistance have also been shown to relate to temperature, the

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thickness of the stratum corneum, the amplitude and frequency of stimulation and the pressure on the recording electrode<sup>4</sup>. As well as varying with objective parameters, skin conductivity has also been shown to vary with subjective sensations of pain, with painful areas demonstrating a reduced skin resistance. A close correlation has also been shown to exist between acupuncture points and musculoskeletal 'trigger points' which are points of localised tenderness<sup>3</sup>.

The fact that acupuncture points can be identified subjectively as tender points and are found to have characteristic electrical properties suggest that they are functional entities rather than structural ones. These functional properties may be used diagnostically in a clinical setting as pathology in a particular body location has been shown to correlate with increased tenderness and electrical conductivity of the 'corresponding' acupuncture point. The clinical assessment of acupuncture points is generally accomplished using palpation or via an electronic 'point locator', which measure the DC resistance of points compared to surrounding skin<sup>4</sup>.

Commercially available point locators utilise a metal locator probe and an indifferent electrode and produce an auditory output (usually a high pitched tone) when a point is located. These devices however, are open to criticism. They are unable to control for local variations in skin thickness, surface secretions, or pressure placed on the electrode<sup>2</sup>, and are only able to measure a single point at a time. These make them time consuming to use and subjective to user bias in point selection. Furthermore these devices do not store data and are therefore unsuitable for producing a map of skin resistance, which can be accessed over time. To overcome some of the limitations of currently available single probe devices, we have designed a multi-channel probe capable of measuring and then mapping the skin resistance of multiple points.

# Method

We have designed a probe that consists of 256 pins in a precise 16 x 16 square grid pattern. The probe is placed on the skin so that the pins slide freely allowing the weight of each pin to apply a constant pressure at each contact point. The probe is then connected to a 16 x 16 multiplexer configuration. The output of the multiplexer goes to a Wheatstone bridge. A regulated 5 volts DC is applied between the top and bottom of the Wheatstone bridge to power the 2 branches. The voltage different taken from the mid point of the 2 branches result in a ratio between the reference resistance and the skin resistance measured by the probe, and this voltage is then passed to an analog to digital converter (ADC). The digital signal is then sent to the parallel port of a PC. The measurement cycle for all 256 pins is 120 seconds,

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short enough to prevent polarisation effects during measurement<sup>3</sup>.

The whole process is controlled by dedicated software designed for the purpose. The software controls the initialization of the probe, the pin selection sequence, data logging, filtering and compensation of the acquired data, as well as the plotting of the skin resistance map. Selection of the grid size is also done via the software by setting the number of columns to read from the probe. The resulting output is a shaded contour plot with darker shade showing points of low electrical resistance on the skin, which may correspond to classical acupuncture points.

# Hardware Design

The multi-channel probe has been designed with up to 256 channels, with each channel having a stainless steel flat-ended pin acting as an electrode. Each pin is 1mm in diameter. The electrode array used has 256 points spaced 5mm apart which cover an area of the skin measuring 8 cm by 8 cm. Each pin is allowed to slide freely along its length so that the weight of the pins applies constant pressure at each contact point. The pins are connected to 16 multiplexers. These are the MPC506A, which are single-ended 16-to-1 channel CMOS analog multiplexers (Figure 1). This 16 x 16 pins grid configuration connected to the 16 x 16 two-tiered multiplexer expansion, which enables the 256 pins to be selected sequentially during measurement. The channel selection is achieved via a high-performance, CMOS silicon-gate, dual 4-stage binary ripple counter, the 74HC393. The two 4-bit counters are cascaded together to provide an 8-bit counter, thus giving 256 possible selections. The 4 least significant bits of the counter are connected to the 16 first stage multiplexers, while the 4 most significant bits are connected to the stage two multiplexer. The output of the stage two multiplexer then goes to a Wheatstone bridge, which uses two 1 megaOhm  $(1M\Omega)$  resistors on one of its branches. The other branch is made up of the skin resistance between the palm and the back of the hand as reference resistance (Rf), and the resistance between any single pin electrode on the probe and a point on the skin near the area to be measured. Depending on the area to be measured, the resultant measurement could either be transversal or longitudinal. The voltage resulting from the imbalance of resistance between the 2 branches of the Wheatstone bridge provides the ratio between the reference resistance, which is constant, and the resistance being measured. The signal is then fed through a pocket sampler', which act as a data logger.

The functionality of the pocket sampler had been extended through the modification of the control

software to provide a RESET signal from pin 17 of the SK2 DB25 socket incorporated in the design of the sampler. A CLOCK signal is also extracted from the sample to provide synchronisation of the channels selection and data logging. The digital output from the pocket sampler is then sent to the PC through the parallel port. (Figure 1)

# Software Design

During measurement, the pins are placed on a s'kin area and the whole process of the measurement and the data logging sequence is controlled via the computer software developed for the probe. This software is written in C++ using the object-oriented programming  $m\epsilon$  od and controls the initialization of the probe unit and the data logging unit, the pin selection sequence, data logging, etc. Figure 2 shows a flow chart for the software. The software will first check for the existence of the system and then initialize the multiplexer unit and the analog to digital converter unit. When the data logging starts, it controls the selection of the channels, and samples and holds the data in the analog to digital converter, which converts the analog voltage to an 8-bit digital data. The software then selects the higher nibble,

which is the 4 most significant bits of the 8-bit digital data, and reads it via the status register of the parallel port on the PC, followed by selecting the lower nibbles and reads it. Consequently, it combines both high and low nibble together to get back the original 8-bit data. The software saves the data in the memory and plots a graph of the data versus time as it comes into the stream. The data, once collected, can be saved to a file. The measurement cycle for all 256 pins is about 120 seconds so that each point has a voltage applied for less that 0.5 seconds which should be short enough to avoid polarisation of cells'.

In order to produce the final resistance map, points were plotted every 1 mm using an interpolation method similar to a spline function'. This function was used to interpolate the voltage distribution between the four normalized values which were measured from the electrode array which had electrodes spaced 5mm apart. After calculating the normalized value for every millimeter, points were assigned a shading according to their value, with the colour changing in increments of 0.022 normalized units. The resulting map was plotted using the Microsoft Excel standard graph function (fig 4).



Figure 1 Design Schematic – Multi-Channel Resistance Probe.

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Figure 2 Flow Chart for Sampler's Software.

# Results

Figure 3 shows an example of a skin resistance map produced by the multi-channel skin resistance mapping probe. To produce this map, a  $16 \times 8$  array was selected via the software, which produced a grid of 128 points over an area of  $8 \times 4$  cm. This array was applied to the anterior surface of the lower arm and the back of the lower arm directly under the area was used as the second point, as shown in figure 3. Measurements were done sequentially from pin 1 to

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pin 128 as indicated by the numbers in figure 4.5 subjects were measured in the experiment. The example in figure 4 is the resulting map for one subject for which 3 repeats were done. It represents a shaded plot with light areas representing higher resistance and dark areas representing lower resistance. The map produced shows that areas of particularly low resistance can be identified. These points are proposed to correspond to acupuncture points. Furthermore the map showed that these points are distributed longitudinally along the forearm which is consistent with the Chinese theory that points are connected along a low resistance pathway or 'meridian'.

## Discussion

The probe described in this paper has many advantages over conventional acupuncture point locators. The ability to measure the resistance of multiple points with a single application of the electrode overcomes the user bias in point selection that may occur with single point electrodes. Using a PC to log the data also ensures that the same time is spent measuring each point and that the total exposure time of the skin to electrical stimulation is short enough to prevent polarisation of the cells. The use of the weight of each pin to provide consistent pressure to each point also helps to remove potential user bias that may occur with existing devices, which depend on the user to apply pressure on a single handheld electrode.

The most useful features of the device is the fact that it produces a skin resistance map produced by simultaneous measurement of the whole area and thus objective determination of acupuncture points with respect to surrounding tissue. This has many advantages over the auditory output produced from single point devices. The map produced by this device may be printed out and retained for future reference thus enabling comparisons to be made



**Figure 3** Position of the multi-channel probe on the Anterior Surface of the lower arm. Measurement is done longitudinally as indicated by the position of the pin numbers. The second electrode is presented in hidden view, as it is on the back of the arm. Kwok et al "Mapping Acupuncture Points Using Multi Channel Device

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between different subjects or for the same subject at different times. This device therefore allows resistance maps to be followed over the course of an illness, as well as allowing resistance maps with similar conditions to be compared thus enhancing the study of the relationship between illness and the electrical properties of acupuncture points.

In order to correlate the resistance map with the location of traditional acupuncture points, it is necessary to accurately define the outline of the electrode grid on the body surface so that the location of anatomical landmarks used to locate acupuncture points can be accurately determined. One limitation of the current device is that the electrode array only covers an area of 8 cm<sup>2</sup>. However, multiple readings can be taken from the same patient over different 8cm<sup>2</sup> blocks, thus building up a picture of skin resistance over a large area. Furthermore, provisions have been made in the software to vary the number of electrode pins thus allowing the measurement of either a larger total area or the same area with a reduced spacing between the pins so as to produce a map with a finer resolution.

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#### ACUPUNCTURE NEEDLES AND THE SEEBECK EFFECT: DO TEMPERATURE GRADIENTS PRODUCE ELECTROSTIMULATION?

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#### ABSTRACT

Acupuncture may act through modifying bioelectric events and this may occur through different mechanisms including the application of external currents. According to the Seebeck effect which produces a potential difference when a temperature gradient is placed across a conductor, the physical properties of acupuncture needles may produce internal currents due to the temperature gradient across the needle when placed *insitu*. Such currents were detected when needles were differentially heated and these currents were found to be in the range capable of producing biological effects. The traditional design of acupuncture needles and traditional needle manipulations seem to maintain a temperature gradient across the needle and thus enhance the Seebeck effect.

<u>KEYWORDS</u>: Electrostimulation, Seebeck effect, Acupuncture, Needles, Temperature gradients

#### INTRODUCTION

Many theories have been proposed to explain acupuncture effects, yet the mechanism of acupuncture is still not well understood. There is evidence to suggest that bioelectric phenomena may be involved in the action of acupuncture as acupuncture points have been found to have electrical skin resistance up to 100 times less than surrounding skin [2, 6] and acupuncture meridians, which are lines connecting functionally related points, have been shown to be low resistance pathways with characteristic transfer functions [4, 5]. These findings have led to the suggestion that the techniques of acupuncture act on an electrical basis by effecting a biological control system that underlies healing and regeneration [2].

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That acupuncture may be related to bioelectric phenomena is also suggested by the success of electrostimulation techniques. Modern electrostimulation techniques involve the use of specially designed electrostimulators which provide voltages in the range of millivolts and currents in the range of micro to milliamps. These devices permit the application of positive or negative potentials to acupuncture points and for the frequency of stimulation to be modulated from 1 Hz to 10 kHz. Low frequencies in the 2 to 20 hertz range are used to produce an acupuncture like effect [8, 11]. While there is much evidence to suggest that electrical stimulation contributes to acupuncture effects, it is not clear if electrical effects play a role in traditional acupuncture needle insertion.

When an acupuncture needle is inserted into the body, a temperature differential of around 10 to 15 degrees is created between the handle of the needle at room temperature and the needle tip at body temperature. Whenever a temperature gradient is placed across a conductor a potential difference is produced according to the Seeback effect [3, 9] which describes the flow of electrons down a temperature gradient. Thus the temperature gradient across an acupuncture needle when placed *insitu* is capable of inducing a potential difference due to the Seeback effect, with the needle tip being of negative potential compared to the more positive handle. The traditional design of acupuncture needles appears well suited to maintaining such a temperature gradient because the classical coiling of copper around the handle of the needle acts to increase the surface area and thus acts as a thermal radiator. The classical technique of heating the handle of an inserted needle with burning moxa (artemesia vulgaris) [7] acts to reverse the potential gradient causing the handle to be positive.

The above analysis suggests that the acupuncture needle insertion produces electrical effects, however, the order of magnitude of these effects is yet to be determined. The present study aims to determine the order of magnitude of the electrical potentials and currents produced in an acupuncture needle due to the temperature gradient between the environment and the body, as well as to determine the effect caused by heating the handle of the needle as done with moxibustion stimulation.

#### METHODS

Traditional 'Hwato' brand acupuncture needles 0.2 mm in diameter and 40 mm in length, made in China from stainless steel with coiled copper handles were used. Needles were connected to a standard BIOPAC, EEG, biopotential amplifier circuit as presented in figure 2, in order to record potentials down to the microvolt range. The gain of the amplifier was set at 10,000 with the sampling rate set at 50 Hz. The EEG amplifier's built in 'alpha filter' was used which consists of an analog 8-13 Hz band pass filter followed by a full wave rectifier and a 5 Hz two pole low pass filter. A 0.1 Hz low pass digital filter was also added to exclude low frequency noise and drift. This configuration was used to observe slow changes in the DC potential across the needle and was found to eliminate the majority of high frequency noise and to produce the cleanest signal with the available equipment. The needle was connected in series with a  $2M\Omega$  resistor to rnatch the input impedance with the impedance of the amplifier.

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The BIOPAC was interfaced with a PC and the related "ACKNOWLEDGE" software was used to display the output and to perform the digital filtering. All measurements were carried out inside a Faraday cage to shield from the effects of low frequency electromagnetic radiation. The amplifier set-up and PC were kept outside the Faraday cage and shielded leads were used between the experimental set-up and the amplifier (figure 1).



#### Figure 1. Experimental Set-up

An acupuncture needle was connected in series with a  $2M\Omega$  resistor to a BIOPAC EEG amplifier using shielded leads. All measurements were performed inside a Faraday cage and the cage and amplifier were connected to a common ground. The needle tip was heated to body temperature by holding it between thumb and forefinger. The handle was then heated using a naked flame.

Measurements were made on the needle alone to eliminate the effect of the transcutaneous potential difference. The ambient room temperature was maintained at a steady 22°C. A temperature gradient of 13.4°C was maintained across the needle by heating the needle tip to a temperature of 35.4 degrees Celsius as measured by an electronic temperature probe. This was done by grasping the end of the needle between two fingers. This may have contributed to high frequency noise. A temperature gradient of over 800 °C was maintained by heating the needle handle using a naked flame which should not produce any additional high frequency noise. All measurements were repeated five times using the same type of needles to ensure consistency of results.

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(a) Raw data of recording across a needle: 1) at room temperature, 2) with the needle tip heated to body temperature using investigator's fingers, 3) after the fingers were removed, 4) when the needle handle was heated with a naked flame, and 5) after the flame was removed.

(b) The same results after filtering with a 0.1 Hz low pass digital filter.

(c) Averaged results taken over five different recordings

#### RESULTS

Figure 2a. shows a recording needle potentials before, during and after heating the needle. Figure 2b. shows the same data after digital filtering was applied. As can be seen from the figure, heating of either the tip or the handle of the needle produces an initial peak in measured potential which then drops after a period of about one second to a level above that recorded at room temperature. This indicates that there is an initial current flow in the needle after which an equilibrium is maintained. The equilibrium is reached when a potential difference across the needle can balance the temperature gradient. The equilibrium potential for a heated needle occurs at 18  $\mu$ V and is maintained for as long as the temperature gradient exists. When the needle is heated, a higher level of background noise is also seen due mainly to temperature effects.

The experimental procedure was performed five times on different needles to ensure consistency of results and average values were taken (figure 2c). The average value for potentials across a needle at room temperature was 5  $\mu$ V. When the needle tip was heated to body temperature the average potential was 13  $\mu$ V, while after heating the needle handle with a flame the average potential was 18  $\mu$ V. The average peak value was 270  $\mu$ V which from Ohms law (where I = V/R and V = 270  $\mu$ V and R = 2 M $\Omega$ ) gives a value 135 pA for the initial current flow.

#### DISCUSSION

The above results suggest that the temperature gradient across an acupuncture needle is able to produce an electrical current of the order of pA and a potential difference of the order of  $\mu$ V. This effect was consistently observed whenever heating was applied and was independent of any high frequency interference. The initial effect of heating the tip of the handle is to create a current of 135 pA from the cooler to warmer region (electrons flow from hot to cold). This initial current flows for approximately 1 second at which time an equilibrium is reached and a steady potential difference of 18  $\mu$ V is maintained. It has been shown previously that the Seebeck potential for copper-iron thermocouple pair is approximately linear in the range from 0°C to 200°C, after which it plateaus and drops [9]. Our results are consistent with this finding.

The voltages and currents produced by a temperature gradient across a needle are in the range that has been shown to have biological effects including healing and regeneration [1]. The traditional design of acupuncture needles seems to enhance these electrical phenomenon. The coiled copper handle around a steel or iron shaft used in traditional needles acts to enhance the Seebeck effect due to the handle acting as a thermal radiator. The modern trend however, of using different materials for the handles of acupuncture needles such as plastics which have an insulating effect would tend to reduce any temperature gradient and thus reduce this effect. The use of two different metals in the needle construction should also act to produce electrical effects due to a temperature differential at the interface of the two metals according to the Peltier effect [3, 9]. This effect however would be minimal as the temperature gradient at the bimetallic interface would be small and the effect would be limited to the region of the needle's handle and would not extend down the shaft into the patient's body.

There are many traditional manipulations to acupuncture needles that seem to modulate the Seebeck effect. The classical technique of heating the handle of an acupuncture needle placed in situ with burning moxa [7], would act to reverse the normal temperature gradient by making the handle of the needle hotter compared to the tip and hence would reverse any current flow caused by the Seebeck effect. This would provide acupuncture practitioners with a technique for applying either a positive or negative potential and thus creating current flow either to, or from, the body. Another traditional manipulation that may modulate the Seebeck effect and enhance its therapeutic role is the technique of lifting and thrusting an acupuncture needle in and out of the skin [7]. This technique would cause alternate heating and cooling of the needle and produce an alternating current of between 2 to 10 Hz which is the frequency range used by modern electrostimulation devices to maximize endorphin release [11].

The experiment presented here applies only to the electrical effects produced by a temperature gradient across an acupuncture needle. In a clinical situation however there is the possibility for many other electrical effects. The short circuiting of the biological transcutaneous potential difference, the creation of a half cell potential between the needle and body fluids, and electromagnetic induction on the needle, may all contribute to electrical effects of needling and may play a role in the mechanism of action of acupuncture.

### CONCLUSION

The insertion of a metallic needle into the body results in the generation of electrical currents due to the temperature gradient between the body and the environment. These currents are in the range shown to have biological effects including healing and regeneration [1]. The traditional design of acupuncture needles seems to enhance this effect and traditional manipulations may modify this effect by causing changes in polarity and frequency. The modern practice of using different materials in the needle handle such as plastic which act as a thermal insulator may reduce these effects.

It seems significant that the ancient Chinese, presumably without any knowledge of bioelectric events, should develop techniques that can modulate current flow to and from the body. The above results suggest that the technique of acupuncture can modify bioelectric events without external electrostimulation equipment through the Seebeck effect. This adds weight to the suggestion that acupuncture may work through an internal electrical control system.

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# Low Resistance Pathways Along Acupuncture Meridians Have Dynamic Behavior

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# LOW RESISTANCE PATHWAYS ALONG ACUPUNCTURE MERIDIANS HAVE DYNAMIC BEHAVIOR

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# ABSTRACT

It has been recognized for some time that acupuncture points can be identified as points of lower electrical resistance than surrounding skin with resistance measures being used clinically for acupuncture point location. This study aims to provide a preliminary examination of the resistance along acupuncture meridians compared to the resistance between 'acupoints' and points outside the meridian system. Electrical resistance measurements were performed on healthy human subjects (1 female; 3 male) along the Large Intestine meridian both unilaterally and bilaterally using a constant current source of 10 amps, and adhesive, 1 cm diameter, AgCl-gel electrodes. These measurements were compared with measurements taken between a meridian point and a 'nonpoint' and were repeated at different time intervals and under different experimental conditions.

Results showed that resistance between points located along the Large Intestine meridian was less than resistance between a point and 'nonpoint' both unilaterally and bilaterally which suggests that there is a higher conductance pathway along the acupuncture meridian. The dynamic behavior of these resistance measurements however appear to be complex. Resistance values along the meridian were found to vary for the same subject at different times as well as varying between subjects. Resistance was also found to vary over the time course of an experimental session, and dramatic drops in resistance were noted when subjects were made to undertake vigorous exercise or were unexpectedly distracted.

This study supports the traditional idea from Traditional Chinese Medicine (TCM) that there are conductive pathways between acupuncture points and that 'chi energy' as described by TCM maybe of an electrical nature. To further explore the dynamic behavior of these pathways however requires more elaborate studies involving the measurement of multiple meridians under different pathophysiological conditions.

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INTRODUCTION

Acupuncture has been used as a therapeutic modal-

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ity since the beginning of recorded history and is currently used by over one quarter of the worlds' population including nearly one quarter of Australian doctors. In clinical practice acupuncture has proven to be a cheap, safe and effective therapy, the main use of which is in treatment of pain and addictions yet how acupuncture achieves these results is not well understood. The neurophysiological mechanisms underlying acupuncture has been well described based on the neuro-humoral model which explains different aspects of acupuncture related phenomena through the release of endogenous opiates and other neurotransmitters, as well as on the gate control theory and the Diffuse Noxious Inhibitory Control (DNIC) system. The bioelectric basis of acupuncture however remains uncertain, despite the fact that acupuncture points can be objectively identified using electrical parameters.

Although acupuncture points are not associated with unique anatomical structures, they have been consistently found to be points of low electrical resistance compared to surrounding skin [15,17]. Human skin has also been shown to contain a potential difference of 20-90 mV at rest (outside negative and inside positive), setting up a 'skin battery' [1]. Acupuncture points tend to short-circuit this skin battery and thus can be identified as having resting potentials more positive than surrounding skin [5].

While acupuncture points are identifiable electrically the reasons for this remain uncertain. The physiological basis for these altered electrical properties have been attributed to regional hyperactivity of the sympathetic nervous system which may affect both sweat gland activity and blood flow regulation [18]. Alterations in skin resistance however have also been the stratum corneum [9,19] and the amplitude and frequency of stimulation [12]. Besides varying with objective parameters, skin conductivity has also been shown to vary with subjective sensations of pain, with painful areas demonstrating a reduced skin resistance [16]. A close correlation has also been shown to exist between acupuncture points and painful musculoskeletal 'trigger points' [10], and acupuncture points related to painful body areas have been shown to have a particularly low resistance which may be used for diagnosis [11].

In addition to alterations in skin conductivity, acupuncture has been associated with changes in bioelectric potentials due to the production of local 'currents of injury'. Local tissue damage has been shown to short circuit the skin battery producing a current of injury that is generally in the range of 1-10 mA [1]. The insertion of an acupuncture needle has also been shown to produce such currents that may last up to two days after needle insertion [17]. At the time of needling, currents are also produced due to the metal of the needle reacting with the ionic solutions of the body. The traditional twirling of the needle may also produce very low frequency, pulsing currents.

While currents of injury are insufficient to produce nerve impulses, they have been shown to have profound biological effects, including the stimulation of nerve growth [13], wound healing [1], limb regeneration [7], and bone healing [2], as well as being involved in embryogenesis, differentiation, and tumor growth [4]. These findings have lead to the suggestion that acupuncture points act as 'booster amplifiers' in a primitive analog DC signaling system that subserves the detection of injury and the maintenance of growth and wound healing [4] and that the flow of 'chi energy' along the meridians as described by Traditional Chinese Medicine (TCM) may be of an electrical nature. This suggestion is strengthened by the demonstration of the finding that acupuncture meridians have been shown to posses the electrical characteristics of transmission lines [14]. The AC characteristics of meridians have also been shown to display frequency specificity [6].

While electrical resistance and impedance measures are able to identify acupuncture points and have found a clinical use in point location, the system of acupuncture meridians and other theoretical constructs of Traditional Chinese Medicine (TCM) remain without scientific validation. This study aims to provide a preliminary examination of the DC resistance between acupuncture points along the large intestine meridian compared to the resistance between 'acupoints' and points outside the meridian system.

6
# METHODS

Electrical resistance measurements were performed along the Large Intestine meridian in healthy human subjects (1 female, 3 male) using a constant current source of 10 amps and adhesive, i cm diameter, AgClgel electrodes. Electrodes were placed on the Hegu (Li 4) point over the first dorsal interosseous muscle on either hand, as well as on a point along the same channel (Li 11), and a nearby 'nonpoint' on the dorsum of the hand that was located greater than 1.5 cm from the nearest point or meridian (Fig. 1).

Points were identified by an acupuncture point locator (MME Neurometer) and a medically qualified acupuncturist using traditional Chinese acupuncture charts. The Large Intestine meridian was selected for preliminary experiments due to the ease of electrode placement, and the fact that the point Li 4 is known to be a 'major' point in Traditional Chinese Medicine.

Resistance measurements were made between



Figure 1. Points used for resistance measurements (Li 4, Li 11, nonpoint (np)) and location of Large Intestine meridian (dotted line).

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points along the Large Intestine meridian both unilaterally (Li 4 - Li 11) and bilaterally (Li 4 - Li 4; Li 11 - Li 11). Measurements were also performed and bilaterally (Li 4 - np; Li 11 - np). Further measurements were performed over 15 minute periods with readings plotted at 10 second intervals and these measurements were repeated during periods of aerobic exercise as well as mental distraction caused by the asking of unexpected questions.

# RESULTS

Resistance values ranged from around  $50\Omega$  up to over 4 M $\Omega$  and were found to vary for different subjects, as well as for the same subject at different times. Results showed that the electrical resistance between unilaterally located acupuncture points was consistently less than the resistance between an acupoint and a nearby 'nonpoint' even though the distance between the point and nonpoint was significantly shorter than between the two meridian points. (Fig. 2)

The resistance between the two Li 4 points bilaterally was also found to be less than the resistance between Li 4 and a contralateral nonpoint (Fig 3). It is



Fig 2. Unilateral measurements showing that the points along the meridian (4 -11) generally displayed the least resistance.



Fig. 3. Bilateral measurements showing that the greatest distance (4 - 4) displayed the least resistance.

interesting to note that the resistance between the two Li 4 points bilaterally was also found to be less than the resistance between two other points along the same meridian both unilaterally and bilaterally even though the Li 4-Li 4 length was considerably greater. As these relationships were consistent across subjects, these results demonstrate that the resistance along the Large Intestine merid an is indeed less than the resistance between a merid apoint and a 'nonpoint'.

Time dependence of resistance measurements have been plotted in (Figs 4-6). Note that during these measurements subjects were exposed to constant stimulation by a DC current of 10  $\mu$ A produced by the ohmmeter.

From the limited number of measurements performed three general trends were found. When resistance values were found to be initially high (greater than 8 k $\Omega$ they would either remain fairly constant (Fig 4) or experience an exponential decrease with a time constant of around 90 seconds (Fig 5). When resistance was found to be initially low (less than 3 k $\Omega$ , it would tend to increase exponentially (Fig 6). Dramatic drops in the resistance were recorded when subjects were made to undertake aerobic exercise (Figs. 4 & 6) and lesser drops were noted when a subject was unexpectedly distracted (Fig 6).



Fig. 4. Examples of fairly constant resistance measures showing dramatic decreases with exercise.



Fig. 5. Examples of initially high resistance measures showing exponential decrease.



Fig. 6. Example of initially low resistance measures with exponentially increases and dramatic drops during exercise and distraction

# DISCUSSION

This study is consistent with other studies demonstrating that acupuncture points are of a lower electrical resistance compared to surrounding areas. The finding that the resistance between acupuncture points was less than between a point and nonpoint even though the path length was often greater, suggests that there is a high conductance pathway occurring along acupuncture meridians.

The finding that the resistance between Li 4 - Li 4 bilaterally was often less than the resistance between points along the same meridian both unilaterally and bilaterally even though the Li 4 -Li 4 distance was considerably greater may be explained by a particularly low local resistance at both Li 4 points. In Traditional Chinese Medicine (TCM) the point Li 4 is considered as a "major' point. It may be possible therefore to draw a relation between points of very low resistance and their relative 'importance' in terms of TCM.

The reductions of resistance with exercise and altered attention are likely to be related to alterations in sympathetic activity resulting in increased blood flow and greater ionic permeability. The reduction in resistance over time in some subjects may be due to stimulation of the meridian by the measuring current causing polarization of the channel. This is suggested by potential measurements that showed a rising potential difference during the period  $\omega$  esistance measures. It should be noted that while the subjects received 10  $\mu$ A in most cases there was no subjective awareness of current. Some subjects however did experience a sensation of heaviness similar to the feeling of 'deqi' experienced during an acupuncture session.

Although this study is of a preliminary nature, it is interesting to note that resistance values seemed to remain fairly constant at around 1 M $\Omega$ . The trend for high resistance values to decrease and for lower values to increase over time is consistent with the idea that acupuncture point stimulation is homeostatic in nature and that the same points can be used for both excess and deficiency conditions.

This study supports the traditional idea that there are conductive pathways between acupuncture points and suggests that 'chi' may have an electrical nature. The clinical finding that points related to organs with a disturbed functioning are of a lower resistance than other points suggests that it may be possible to define the functional anatomy described by TCM in terms of electrical parameters. Thus by combining bioelectronic engineering with TCM theory it may be possible to develop a non-invasive diagnostic system which could also be used therapeutically utilizing electro-stimulation or laser. Before firm relationships between electrical measurements and defined clinical conditions can be established however, further studies are needed involving all of the different meridians as well as greater numbers of subjects under different pathophysiological conditions.

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# Acupuncture in Australia - a review of its current position

# **Dr Marc Cohen**

## Historical basis of acupuncture

The use of counterirritation techniques is as old as recorded history. The use of sharpened bone and stone implements has been recorded in diverse geographical locations and amongst widely separated cultures, including the Bantus in South Africa the Singhalese in Sri Lanka, the Eskimos in Alaska as well as in China, Northern Europe and South America. In China, stone needles dating back to 1700 BC have been found at an archaeological site in Anyan, in the Honan province.

The modern day practice of acupuncture has evolved from Traditional Chinese Medicine (TCM) which according to legend commenced with Fu Hsi (B.C.2953) who is attributed with the invention of the eight Diagrams made up of broken and unbroken lines used as the basis of the I-Ching which acts as a pictorial representation of the Chinese universalistic philosophy. The elaboration of Chinese redicine was continued by the emperor Shee Nung (died 2698 B.C.) who is venerated as the father of agriculture and is reputed to have undertaken systematic empirical observation of all herbs by tasting each one in order to acquaint himself with their value.

By far the most renowned of the legendary rulers of ancient China however was Huang Ti, also known as the Yellow Emperor. Huang Ti is said to have reigned from 2696 - 2598 BC and Su-ma Ch'ien, the great nisterian of the second century BC, began his Historical Records with an account of Huang Ti, whom he defined as the founder of Chinese civilisation and the first humane ruler of the empire. Huang Ti has been accredited with the invention of wheeled vehicles, amour, ships, pottery, and other useful appliances, as well the invention of the art of writing. He is also regarded as the author of the Canon of Internal Medicine called the Nei Ching Su Wen (The Yellow Emperors Classic of Internal Medicine) which is said to be the oldest extant medical book in the world and remains the theoretical foundation for Chinese medicine to this day. As Ilza Veith states in the introduction to her translation of the Nei Ching Su Wen "The Nei Ching, the Classic of Internal Medicine, attributed to Huang Ti, the Yellow Emperor, is indeed a very important if not the most important early Chinese medical book, particularly its first part, Su Wen, "Familiar Conversations" between the Emperor and his physician Ch'i Po. It is important because it develops in a lucid and attractive way a theory of man in health and disease and a theory of medicine. It does this in very much the same way as did the physicians of India who wrote the classic books of Yajutvedic medicine, or the Hippocratic physicians of Greece; that is by using the

philosophical concepts of the time and picturing man as a microcosm that reflects the macrocosm of the universe. The theory expounded in the *Nei Ching Su Wen* has remained the dominating theory of Chinese indigenous medicine to the present day. " [22]

Despite the authorship of the Nei Ching Su Wen being attributed to the Huang Ti, its antiquity has been questioned and most historians now date its origins to around the fourth century BC. Kwas at this time that the foundations of both Eastern and Western thought were first committed to writing, with Socrates, Aristotle and Plato laying the foundation for Western thought, and Lao Tzu, Conducius, and Gautama Buddha providing the basis for the development of Eastern thought. It was also around this time that the foundations of Eastern and Western medicine were being forged, with the formation of the Hippocratic writings (Corpus Hippocraticum) in the West, and the canonisation of the Nei Ching Su Wen in the East. These medical works are significant as they mark the beginnings of modern medicine and are the first treatises to view disease as arising from interactions between the environment and constitutional factors, rather than the actions of gods or supernatural forces.

The Nei Ching Su Wen, which is still used today as the theoretical basis for Traditional Chinese Medicine, is unusual for a general medical text in that it is devoted primarily to preventative measures. Rather than defining different disease entities and attempting to treat illness, the ancient Chinese physicians emphasised the healthy state which was defined as being "at one with the Tao", and having defined a state of health, it was the aim of Chinese physicians to detect any deviation from this state and correct it before disease could develop.

Placing great emphasis on the pulse, Chinese physicians aimed to detect premorbid conditions before they developed into overt pathology and since disease was seen to arise out of disequilibrium, the basis of cure was in restoring harmony. The duty of the traditional Chinese doctor was thus to instruct the patient how to remain well. Accordingly the ancient physicians were paid only while their patients remained healthy, and if a patient was to die unexpectedly the physician responsible was required to hang a lighted lantern outside his practice for a full month so that other patients would be made aware of his shortcomings.[8] This attitude is expressed in the *Nei Ching* with the following passage;

"The superior physician helps before the early budding of the disease. The inferior physician begins to help when the disease has already developed; he helps when destruction has set in, and since his help comes when the disease has already developed, it is said of him that he is ignorant." [22]

The Eastern attitude of preventive medicine lies in stark contrast to that of the Hippocratic tradition. The Hippocratic physicians practised in a market economy where physicians wore sought only after disease had become established and a physician's worth was judged on his ability to make accurate predictions, even if powerless to alter an adverse outlook. The Hippocratic tradition thus concentrated on defining specific disease entities rather than abstract notions of health, for it was only by defining the evolution of clinical syndromes that specific prognostic features could be recognised and the likely course of disease, and success of specific interventions be determined.

It has been suggested by some scholars that the complementary nature of Eastern and Western medicine has arisen through their respective use of language.[15] Eastern thought, which places much emphasis on the concept of flow and on symbolic representations of natural phenomena, is based on an intuitive language which uses ideograms and symbolic constructs. In contrast, Western thought emphasises the process of systematically observing nature and deriving rational explanations, and is based on rational languages (the epitome of which is mathematics), which utilise a phonetic alphabet and logical construction. Furthermore Chinese thought has remained fairly consistent throughout the ages, as has the Chinese language (even though pronunciation differs in different regions), whereas Western thought has undergone numerous additions, corrections and modifications as it has been translated into the dominant language of the time.

The development of Eastern medicine has taken an opposite but complementary approach to that of Western medicine. The Eastern way of thinking is holistic, and involves nonlinear logic and causal relationships rather than the reductionist theories and linear causality of Western science. These different approaches to medical knowledge can be considered to be parallels of what are commonly called the holistic and reductionist world views and although these views appear opposite, neither view can be considered more correct or more useful than the other. Reductionism and holism are merely different (or complementary) approaches, and both views are necessary when considering the many complexities of health and disease. [3]

## The Practice of Acupuncture

The practice of acupuncture usually involves needles, but may also involve low level laser, moxibustion, cupping, transcutaneous electrical neural stimulation (TENS), trigger point therapy, point injection therapy and dorsal column stimulation. [2] In Australia at present, acupuncture is offered by a variety of providers including doctors, dentists, veterinary surgeons, physiotherapists, chiropractors, and various lay practitioners. Of these groups however, medical practitioners are the only ones trained to assess patients in a primary health care setting. Registered medical practitioners have extensive training in the basic sciences including anatomy, physiology, pharmacology, microbiology, pathology and immunology as well as in clinical diagnosis, methods and procedures and, when skilled in the use of acupuncture, medical practitioners are able to offer acupuncture as a treatment modality in the full context of diagnosis, treatment and management. [21]

Acupuncture is a procedure involving both diagnosis and treatment and like any other procedure, there are associated risks if used without appropriate skills and knowledge, Risks associated with acupuncture include transmission of infections such as HIV and Hepatitis B and C, etc. from contaminated needles, injury to vital structures by misguided needle placement, and the masking of symptoms preventing early detection and diagnosis. While the risk of infection can be easily prevented through the use of disposable needles or low level laser, the risk of injury can only be prevented through adequate training in anatomy and pathology. Without such training potentially serious complications may arise and death due to acupuncture has occurred in Australia at the hands of a non-medically qualified acupuncturist.

The health system in Australia is such that is not appropriate for acupuncture to be used as a complete form of medicine and thus the practice of acupuncture should be considered a 'complementary', rather than an 'alternative' form of medicine. However, while medical practitioners are the only professional group trained to act as primary health care providers and coordinate and manage all aspects of patient care, there are other registered health professionals (eg. physiotherapists) who may possess sufficient training to use acupuncture as an available modality and identify circumstances when other professional medical services are required. In this position non-medical acupuncturists should be encouraged to work in conjunction with the medical profession rather than in opposition to it, and should thus adopt the role of 'therapists' rather than 'doctors', as they are not subject to the theoretical, ethical, or legal strictures required of medical practitioners, nor are they bound by the medical board's advertising guidelines. Furthermore in adopting the role of primary health care providers non-medical acupuncturists may put patients at risk if they withdraw medications indiscriminately, mask symptoms without performing investigations to determine a medical diagnosis, or discourage patients attending registered medical practitioners and receiving preventative screening measures and immunisations.

# Education of acupuncturists

In Australia there are no agreed standards for the practice of acupuncture or the training of acupuncturists.

At present the extent to which general practitioners practice acupuncture appears to be extremely varied ranging from only a few consultations a month to full time practice. However, as there are no educational or legal requirements necessary for medical graduates to practice acupuncture, it is left up to each individual doctor to determine, and seek out, the level of education and expertise he/she deems adequate. In the absence of accepted standards the use of acupuncture should be on the basis of 'buyer beware' and acupuncturists should be encouraged to display their qualifications

The Australian Medical Acupuncture Society (AMAS) which is affiliated with the Australian Medical Association (AMA), was formed in 1973 as a professional society for doctors with an interest in medical acupuncture. The AMAS aims to set a basic standard for medical acupuncturists by establishing a code of ethics and by setting a common curriculum for the education of acupuncturists . The society is also actively involved with other pacific Nations, namely USA, Canada and New Zealand as well as the UK to standardise the teaching of acupuncture in the Pan-Pacific region and world-wide. In order to maintain a high standard of acupuncture skill and knowledge amongst its members, the AMAS through its state branches organises frequent clinical meetings, seminars and lectures. Often these seminars are conducted by eminent overseas medical acupuncturists and these meetings are generally approved for 2 points per hour Category-A by the RACGP quality assurance (QA) and continuing education (CE) committee.

In addition to educational events, the AMAS conducts an independent fellowship exam (FAMAS), similar in format to other fellowship exams conducted by the Royal Colleges. The FAMAS exam consists of two parts; a written (part 1) and a combined oral/written (part 2). To sit for the part 1 of the FAMAS exam requires candidates to have accrued at least 100 hours of accredited time, while to be eligible to sit for part 2, candidates must have completed their part 1 exam and have accumulated a total of 250 hours of accredited time. Accredited time may be accrued through clinical experience arranged either through acupuncture clinics at large teaching hospitals, such as at the Alfred Hospital and PANCH in Victoria, or through the AMAS preceptor system whereby students can sit in on sessions with experienced practitioners. Time may also be credited for attending Australian or international teaching programs or conferences, and for providing written case commentaries and case documentation. [21]

In 1989 the NH&MRC conducted a working party to review the current state of acupuncture practice and education in Australia.[12] In its report, after praising the members of the AMAS and the Societies fellowship exam the working party went on to express concerns that; "submissions from lay acupuncture training organisations do not indicate a content of training of standard equivalent to that of medical practitioners in the relevant subjects (anatomy, microbiology, diagnosis etc), nor has there been any independent evaluation by suitably qualified authorities in any of these disciplines of the course content and quality or the standards achieved by students."

The NH&MRC working party also suggested that;

"when acupuncture courses have been accredited it has been by administrative bodies and not by authorities able to evaluate curriculum content. Furthermore when acupuncture courses have been adopted by tertiary education institutions it has been by institutions with expertise in certain disciplines (eg. nursing, social sciences) but not in those disciplines considered by the Working party as critical to the safe and informed practice of acupuncture such as anatomy, microbiology, clinical diagnosis, therapeutics and clinical trial research. Moreover, there is no evidence that teachers of acupuncture have had adequate training in these disciplines and most significantly, there is no evidence that they have a capacity to critically evaluate existing or new knowledge in their discipline in order to determine its validity."

The AMAS fellowship is acknowledged world-wide for setting a high standard of professional knowledge and competency and fellows of the society are held in high regard by other medical colleagues both in Australia and internationally. At present however, there are no legal requirements for doctors to obtain their fellowship or other postgraduate qualifications and less than 200 doctors have attained their fellowship of the society. The AMAS however maintains that doctors need formal training to practise acupuncture effectively. To this end the AMAS suggests that medical acupuncture needs to be formally integrated into university medical undergraduate curricula, as well as becoming an acknowledged area of special interest with established minimum qualifications for postgraduates. The AMAS also agrees with the NH&MRC in advising patients to seek acupuncture treatments from suitably trained medical acupuncturists.

#### Uses of acupuncture

In general practice acupuncture has proven to be a cheap, safe and effective therapy, the main use of which is in treatment of pain and addictions as well as being helpful in systemic conditions. Acupuncture can be used either alone, in conjunction with conventional therapy, or as an alternative to pharmacotherapy when patients cannot tolerate certain medications. As many of the conditions treated by acupuncture are painful musculoskeletal conditions, acupuncture is often able to prevent the long term use of NSAIDS and steroids and thus minimise the side effects and cost of treating

these conditions. The relative safety and efficacy of acupuncture compared to other treatment modalities suggests that in many conditions acupuncture should be used as a 'first line therapy', thus keeping with the Hippocratic ethic of 'first do no harm''.

In addition to treating pain, acupuncture has been shown to be effective in systemic conditions as well as in treating addictions including addictions to narcotics, alcohol, tobacco and minor tranquillisers. Acupuncture has also been shown to be effective for surgical analgesia, [20] however its efficacy is such that there would appear no justification for the introduction of acupuncture anaesthesia in competition with orthodox anaesthetic techniques. Acupuncture analgesia however, may have a role when conventional anaesthesia is either contraindicated or unavailable and thus when discussing acupuncture anaesthesia the NH&MRC [12] advises that;

"it may be appropriate to allow such a modality, at the request of a registered medical practitioner skilled in its use, for consumers who request it."

# World Health Organisation List of Indications for Acupuncture

#### Neurological disorders

Headache and migraine Trigeminal neuralgia Facial paralysis Peripheral neuropathy Post poliomyelitis paralysis Meniere's syndrome Neurogenic bladder Nocturnal enuresis Intercostal neuralgia

## **Musculoskeletal disorders**

Acute/chronic muscle strains. Frozen shoulder, Tennis elbow, Lumbar pain and sciatica, Degenerative arthritis, Inflammatory polyarthritis.

#### Mouth disorders

Toothache Post extraction pain Gingivitis Acute or chronic pharyngitis

#### Eye disorders

Acute conjunctivitis Central retinitis Myopia in children Uncomplicated cataract

#### **Gastrointestinal disorders**

Oesophageal and cardia spasm Hiccough Acute and chronic gastritis Gastric hyperacidity Uncomplicated duodenal ulcer Acute and chronic colitis Acute bacterial dysentery Constipation and Diarrhoea Paralytic ileus

## Respiratory system

Acute bronchitis Bronchial asthma

#### Upper respiratory tract

Acute sinusitis Acute rhinitis Common cold Acute tonsillitis

# **Cost of Acupuncture**

At present the acupuncture is covered by a Medicare rebate under item 173 which includes:

"Attendance at which acupuncture is performed by a medical practitioner by application of stimuli on or through the surface of the skin by any means, including any consultation on the same occasion and any other attendance on the same day related to the condition for which the acupuncture was performed." [9]

The current Medicare rebate for item 173 (\$18.30) is less than that offered for a standard consultation for a vocationally registered practitioner under item 23 (\$20.40). The existing rebate system thus acts as a disincentive for doctors to practise acupuncture. However, despite this inequity, in 1992 a Health Insurance Commission study revealed that over 3000 GPs (nearly 25%) claimed rebates for acupuncture. Furthermore this study showed that the costs to medicare were much lower for doctors who had at least 50% of their income derived from acupuncture. Compared to other GPs, these doctors had one fifth as many referrals and utilised one quarter of the expenditure in radiology and pathology, as well as presumably having less prescribing.

Acupuncture is a procedure and, like other procedural items, it should be eligible for accompanying consultation items. This is especially important with regards to initial visits which usually require a long or prolonged consultation. Under the current system it would be better for doctors to give free acupuncture and only charge for a medical consultation, however under item 173 this is not legal. Many doctors who bulkbill are thus forced to bring their patient back to commence acupuncture treatment on a subsequent date in order to receive fair recompense.

The practice of acupuncture represents an area of special interest requiring similar training and expertise as minor surgery or psychotherapy. Furthermore as well as additional training the practice of acupuncture requires more surgery space and more time per patient than conventional consultations. Medicare rebates should reflect these increased demands and thus the AMAS suggest that rebates for acupuncture be at least equal to that of a standard consultation and that for initial consultations it should be permitted to attach a consultation item with acupuncture in accordance with the AMA schedule of fees. The AMAS also suggest that Fellows of the AMAS should be recognised as Vocationally Registered and thus attract a higher rebate for their services in accordance with Fellows of the RACGP. Such moves would encourage more doctors to consider using acupuncture in their practice and would act as a financial incentive for doctors to undertake advanced training in acupuncture and thus achieve a high level of clinical competency and efficacy.

## Modern Theories of Acupuncture

Many theories have been proposed to explain the mechanism of action of acupuncture. These range from the theory of Traditional Chinese Medicine (TCM) couched in the terms of Chinese cosmology, to modern neuro-humoral theories invoking complex nerve pathways and neurotransmitter release, as well as theories invoking bioelectric, biomagnetic and embryological phenomena. [3, 5] So far however, all Western theories on acupuncture are incomplete and while TCM theory claims to be a complete one, its concepts have not yet been integrated into the Western scientific framework thus rendering it incomplete from a scientific viewpoint. In 1989 after investigating the scientific basis of acupuncture the executive committee of the National Health and Medical Research Council concluded that; "the relief of pain by acupuncture can be explained in terms of neurophysiological mechanisms. These mechanisms depend on an intact and functioning peripheral and central nervous system, can be induced without using the full range of traditional acupuncture points and are similar in mechanisms associated with narcotic analgesia. In addition to a neurophysiological effect on pain, acupuncture has a powerful placebo effect."[12]

While the neurophysiological basis of acupuncture is now well established on the basis of endorphin and other neurotransmitter involvement, the diffuse noxious inhibitory control system (DNIC) and the gate control theory [3], the existence of acupuncture points is often questioned, for no consistent structural correlates for them have been identified. It appears however that acupuncture points may be functional, rather than structural entities, and this is confirmed by the finding that acupuncture points can be defined electrically as points of low electrical resistance.[1,10,18] The functional nature of acupuncture points is also evident from the fact that there is an extremely high correlation between acupuncture points and musculoskeletal trigger points which are points of focal muscle tenderness that can be identified using a pressure algometer or palpation, and which are found to have a local twitch response to mechanical stimulation. [11,16] While functional correlates of acupuncture points have been shown to exist, sceptics often point out that the acupuncture meridians have not been objectively identified. Most acupuncturists however would maintain that acupuncture meridians are a conceptual tool, such as the lines of latitude and longitude on the earth, and thus while they are useful for navigating a specific territory, to search for anatomical correlates of the meridians would make as much sense as digging in the ground to look for the equator. Recently however there has been the suggestion of objectively defining the meridians using techniques capable of imaging functional, rather than structural relationships. Studies utilising radioactive tracers have shown that certain tracers appear to migrate along the acupuncture meridians [6] and electrical impedance studies have shown significantly lower impedance along the acupuncture meridians compared to surrounding skin. [17]

There are many different clinical trials on acupuncture in the medical literature, however while the gold standard for clinical trial research is the double-blinded. randomised, placebo-controlled, cross-over trial with defined outcome criteria and sufficient numbers of patients to minimise type 1 and type 2 errors, none of the trials on acupuncture are able to meet this standard. [23] Clinical trials on acupuncture have many inherent methodological problems and published trials generally fall into four different groups; 1) Anecdotal or uncontrolled studies; 2) trials using a no-treatment control group; 3) trials using an alternative treatment control group; 4) placebo controlled trials which may either use a nonacupuncture placebo group such as bogus TENS, or a 'sham acupuncture' placebo group where needles are placed in points considered to be 'non-acupuncture points'. [14, 19]

The methodological problems associated with clinical trials of acupuncture are numerous. These include the fact that in order to have reproducible results a standardised treatment approach is needed. Acupuncture however is considered a 'holistic' therapy, and most acupuncturists tailor their treatments to the needs of individual patients and may even use different points as treatment progresses. Furthermore due to the nature of the treatment, double blind conditions are virtually impossible to achieve, as to perform true acupuncture requires that the therapist know the nature of the treatment. Other methodological problems include the choice of control groups, agreement as to the location of 'true' acupuncture points, the need for large numbers of patients in order to detect a statistical differences between groups, and the requirement of having objective yet multi dimensional measures of outcome.[7,14, 19]

A review of randomised trials on acupuncture [7] has shown that successful response rates vary from 30% for placebo groups, 50% for sham acupuncture groups, and 70% for true acupuncture groups. This review suggests that sham acupuncture cannot be considered an adequate placebo, but rather a 'poor form of acupuncture' and that the use of a sham acupuncture group requires large numbers of subjects to be able to detect a significant difference between the groups (130 patients are needed in each arm of a trial for a p value of 0.05). As most trials do not employ such large numbers of subjects the authors were forced to conclude that

"the majority of published reports have a very low power for distinguishing statistical differences between treatment groups" [and hence] "one cannot necessarily conclude from trials which produce statistically nonsignificant results that acupuncture (when compared with placebo for example) is ineffective."

It is generally acknowledged amongst practitioners that the main mode of action of acupuncture is through stimulating homeostasis. This no doubt involves neurally and chemically mediated phenomena. However while the neurophysiological basis for acupuncture is well established, acupuncture has also been shown to decrease red blood cell viscosity, white cell count, carotid arterial pressure and peripheral vascular resistance, increase free fatty acids, gamma and beta globulin levels, the phagocytic index of white blood cells and the blood glucose level as well as enhancing the release of serotonin, histamine and kinin components. Acupuncture also affects the autonomic nervous system and skin temperature as well as electroencephalograph, electrocardiograph and electromyograph readings. Acupuncture has also been shown to produces multiple effects on defence and immune mechanisms including raising the titre of a variety of specific and nonspecific immune substances such as bacteriolysins, agglutins, opsonins, antibodies and complement components.[21] The above findings are indeed significant however while these findings can be seen to provide evidence suggesting how acupuncture works they do not explain why acupuncture works.

## Traditional theories of acupuncture

Traditional Chinese Medical theory provides a comprehensive explanation of why acupuncture works. This theory however is couched in the conceptual language of Chinese cosmology and philosophy [4] which employs such concepts as; "Tao" (infinite order), "Chi" (life energy), "Wusieng" (five evolutive phases), "ko" and "sheng" cycles (constructive and destructive cycles) and "Yin" and "Yang" (complementary opposites). When expressed in Chinese terminology it is difficult for Western minds to appreciate their significance, yet these concepts can all be found to have parallels in Western science.

The concept of "Tao" can be compared to the mathematical concept of absolute infinity which, like

the Tao, is seen as inherently incomprehensible. The concept of "Chi" which the Chinese consider as a form of 'vital energy' can be compared to the concept of 'information' in thermodynamics which is also considered as a form of energy, and which is measures in terms of 'bits', or jou'es per degree kelvin. The Chinese view of disease aetiology whereby diseases are seen to arise from a blockage in the flow of Chi can thus be seen to parallel the second law of thermodynamics which describes a tendency towards disorder in an isolated system.

Further parallels between Eastern and Western concepts can be found as the 'ko' and 'sheng' cycles (constructive and destructive cycles) can be seen to parallel the concepts of evolution and entropy, and the concept of "Wusieng" or '5 evolutive phases' can be compared to the five phases information passes through during computation, which consists of a program, language, interface, processing and long term memory. Finally the concept of Yin and Yang can be seen to parallel the quantum theoretical concept of complementarity. In fact Niels Bohr, one of the founders of quantum theory included the Yin/Yang insignia in his family coat of arms along with the statement that "opposites are complementary".

While the Chinese were not greatly interested in gross anatomy or precise structural relationships, they did place much emphasis on functional ones and this is evident from the emphasis placed on taking the pulse. The reading of the pulse plays a prominent role in both the Eastern and Western traditions, however whereas in the West information from the pulse is now analysed scientifically using specialised equipment such as the ECG, in the East pulse diagnosis (sphygmology) was developed into a great art which was used by the Chinese to place a persons state of being into a theoretical and cosmological context.[15].

It is claimed that the art of pulse diagnosis can detect a vast range of pathological and premorbid conditions, however to become competent in this art requires many years of intensive practical training and the subtleties involved have been compared to a orchestra conductor listening to a symphony and detecting when a particular string on a particular instrument is out of tune. Thus while few present day practitioners would claim to be expert in pulse diagnosis, the art of sphygmology remains an important aspect of both Chinese medical theory and practice.

Much uncertainty remains as to the mechanism of action of acupuncture. However it is important to acknowledge that it is not necessary to know the mechanism of action of a therapy in order to use it effectively. This is in fact the case with most modern pharmacotherapeutic agents, anaesthetics and even some surgical procedures. Although it may not be necessary to have a precise knowledge of the therapeutic action of a particular therapy, it is necessary to establish that a proposed intervention is without harmful side effects, and is at least as safe, or safer than, other modes of therapy for any given condition. It is also necessary to determine whether there are any potential long term side effects or adverse reactions on subsequent generations. Any therapeutic modality should also be relatively consistent in that treatment responses can be predicted within prescribed limits thus permitting the rational selection of therapies for clinical use.

Acupuncture fulfils all of these criteria and thus deserves a respected place in modern day clinical decision making and practice. Furthermore in elucidating the mechanisms of action of acupuncture new insights into human pathophysiology may be expected as this involves the integration of many diverse areas of knowledge. It should be remembered that five years before endorphins were discovered in the West, the Chinese had performed experiments that had shown the existence of these neurochemicals as a result of performing research into acupuncture.

When investigating the theoretical basis of acupuncture much remains to be learned from scientific enquiries. However there is also much valuable knowledge contained in the ancient Chinese texts and traditional practices. When attempting to translate traditional Chinese practices into a modern day scientific setting however there are many pitfalls, and as the renowned historian Joseph Needham states;

"In evaluating acupuncture through the works of representatives of the present day practitioners in the western World some reserve should be exercised for the following reasons; (a) very few of them have had reliable linguistic access to the voluminous Chinese sources of many different periods, (b) it is often not quite clear how far their training has given them direct continuity with the living Chinese clinical traditions, (c) the history in their works is liable to be minimal or unscholarly, (d) their familiarity of theory are generally very inadequate, (e) they tend to adopt a too simplistic assimilation of classical Chinese disease entities to those of modern western medicine, (f) the cardinal importance of sphygmology [pulse diagnosis] in Chinese differential diagnosis is almost ignored, and (g) their works are naturally so much influenced by modern western concepts of disease aetiology and pathology that they seem not to practice the classical Chinese methods of holistic classification and diagnosis. Not everyone with a modern Western medical training can immediately perform all the traditional-Chinese therapeutic feats. Pulse diagnosis, for example, as well as a very organistic psychosomatic approach, is a fundamental feature of this traditional art, which after all depends on much subtle theorising, not of course in the modern style, but not nonsense either." [13]

#### The future of Acupuncture

Acupuncture has over the past 5000 years proven to be a safe and effective therapy which is currently used by nearly 25% of Australian GPs. Much research however remains to be done at both a basic science and clinical level to come to an understanding of its mechanisms of action yet this is only possible if people are trained in both acupuncture and research methodology. Important steps toward this end have recently been made with the recognition of the academic basis of general practice, involving the training of GPs in research methods, and the introduction of formal training in acupuncture to medical undergraduates. These measures insure that in future there will be a growing number of well trained people able to perform high quality research into the scientific basis of acupuncture.

It is generally recognised that just as there are two sides to the brain, there are two approaches to knowledge; rational and intuitive, subjective and objective, holism and reductionism. Neither of these views however has a more privileged position than the other and a balanced world view requires input from both. The approaches of Eastern and Western medicine represent two such views and thus by combining these views a more balanced and coherent medicine results. Thus, just as Western-trained medical acupuncturists are able to combine the best elements of both Eastern and Western medicine in their practice, modern research has been able to blend ancient wisdom with modern technology to produce new effective therapies. Already there are hundreds of thousands of patients worldwide who have benefited from the new techniques of acupuncture anaesthesia, TENS, laser acupuncture, auricular therapy, and electro acupuncture, and as research continues these techniques will no doubt be refined and perhaps others developed. The ability to integrate Eastern and Western ideas has been commented upon by Capra who suggests;

"We are heading towards a new synthesis, a new naturalism. Perhaps we will eventually be able to combine the Western tradition, with its emphasis on experimentation and quantitative formulations, with a tradition such as the Chinese one, with its view of a spontaneous, self organise g world." [3]

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# Obituary

# Dr Tan Kwang Hoh MBBS, MRCP, FRCP, FRACP, FAMAS.

15.5.1527 to 9.2.1994

Graduate of the University of Hong Kong. Head of Paediatric Department, General Hospital of Singapore.

Past Federal President of AMAS. Past NSW State President of AMAS. Examiner for FAMAS.

AMAS sadly regrets the loss of an outstanding member whose valuable contribution cannot be described by words alone.

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# <u>Bio-Energetics and Basic Science: Bringing together</u> <u>ancient and modern concepts.</u>

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Paper presented at the Third Annual International Congress of BioEnergetic Medicine

Orlando, Florida, February 5<sup>th</sup>-7<sup>th</sup>, 1999

Bio-energetic medicine covers a wide range of different therapeutic and diagnostic approaches, many of which are based on ideas borrowed from Eastern medicine which suggest that life is dependent on a subtle form of energy. This subtle energy, often termed 'vital force', 'life energy', 'life force', 'prana', 'chi', or 'Qi', is deemed to flow throughout the organism maintaining both physical and psychological processes. Pain and disease are said to arise when this energetic flow is disrupted or 'blocked' and bio-energetic therapies tend to focus on restoring the natural energetic flow and thus supporting the bodies homeostatic responses.

While clinical studies support the use of bio-energetic therapies, many of the concepts underlying bioenergetic medicine have not been accepted by Western science and are criticized as being unscientific. The inability of science to recognise the basic concepts underlying Eastern medicine, prevents the theoretical integration of Eastern and Western medicine, leaving medical knowledge divided by the use of different conceptual languages. Thus while one discipline is talking about 'Qi', or 'yin' and 'yang', another is talking in terms of 'receptor transmitter interactions', and 'pharmacokinetics', or 'psychosocial stressors' and 'life events'. When such different terms are being used it is difficult to find a common ground, even when discussions are focused on the same issues.

Eastern and Western medicine lie on either side of the Cartesian division between mind and body, subjective and objective, holism and reductionism. Eastern thinking is holistic and outlines a whole philosophy of life that maintains a cosmological perspective based on non-linear logic and acausal relationships. In contrast, Western thought is based on a reductionist approach that emphasizes controlled experimentation, and mathematical analysis based on analytical reasoning and linear causality.

These approaches may be seen as complementary and an integration of ideas may be achieved by establishing parallels between their basic concepts. Such a mapping of ideas would create a common language that would allow discussions between different traditions to take place, and permit each tradition to inform the other, thus providing new insights and understanding. In order to achieve this integration however, many Eastern concepts must be translated into the language of science, for it is in the light of rational scientific inquiry that modern medical knowledge is ultimately assessed.

# Parallels between Eastern and Western concepts

Many of the fundamental concepts of Eastern medicine such as "Yin" and "Yang" and "Tao" have fairly obvious parallels in Western science. The concept of Yin and Yang can be seen to accurately parallel the quantum theoretical concept of complementarity. Yin and Yang refer to pairs of mutually exclusive yet inter-dependant opposites. This idea is well accepted within quantum theory, where light must be understood to have the properties of both waves and particles for a complete description. In fact Niels Bohr, one of the founders of quantum theory included the Yin/Yang insignia in his family coat of arms along with the statement that "opposites are complementary"<sup>1</sup>.

The concept of "*Tao*" finds parallels in Western science in the mathematical concept of Absolute infinity. An important feature of both "*Tao*" and "*Absolute infinity*" is that they are both considered to be inherently incomprehensible and thus unable to be grasped by the rational mind. The incomprehensibility of these concepts places them essentially beyond thought, yet paradoxically allows them to provide the conceptual basis for an entire system of thought. The concept of *Tao* in Eastern thought is seen to represent "the infinite order of nature" or the "way of the universe" and forms the basis of *Tao* ist philosophy which considers Tao as "formless, nameless, the motive force of all movements and actions, the mother of all substances". Similarly, the concept of *Absolute infinity* in mathematics represents "the class of all sets" and this concept forms the basis of set theory, which provides a conceptual framework for all mathematics and may even be described as a form of exact theology<sup>2</sup>.

While the concepts of *Tao* and *Ying* and *Yang* readily find counterparts within Western science, the concept of Qi appears to be more problematic. In Eastern thought the concept of Qi refers to a subtle form of energy that flows throughout the organism along certain defined pathways or meridians. This continuous flow maintains the functional integrity of the system. The ideograph used to denote the concept of Qi is made up of two Chinese characters, one of which means "the flow of something that is difficult to grasp" and another that refers to "rice" or "source of energy of a human or animal". Thus Qi refers to "the flow of something that is the source of vital energy to humans and animals"<sup>3</sup>.

The normal flow of Qi is seen as a necessary requirement of life and a disruption in the flow of Qi is seen to be the prime cause of pathology. Furthermore Qi is said to come in various forms which animate life so that there is Qi from air and food, Qi that flows in the meridians and perverse Qi that causes disease. Thus as Porkett states; "whatever Qi the context and absolutely without exception, [Qi] always implies a qualitative determination of energy. In other words Qi means energy of definite (or definable) quality."<sup>4</sup>

# Qi and Thermodynamics

In contrast to the Eastern concept of "Qi" or "*life energy*", in Western science the concept of "*energy*" has a more precise meaning that does not include a form of energy specific to living systems and thus the concept of 'Qi' is therefore often rejected as being 'unscientific'. The concept of Qi however, does follow many fundamental scientific principles. In particular, the concept of is in accord with the laws of thermodynamics, which are universal laws that comprise the most fundamental principles in Western science. As Einstein states:

" A theory is the more impressive the greater is the simplicity of its premises, the more different are the kinds of things it relates and the more extended is its range of applicability. Therefore the deep impression which classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced, that within the framework of applicability of its basic concepts, will never be overthrown." <sup>5</sup>

The First law of thermodynamics states that "matter and energy cannot be created or destroyed, only converted from one form to another" while the Second law of thermodynamics concerns the concept of entropy which describes a universal tendency towards disorder and states; "in an isolated system entropy always increase"

The concept of Qi can be seen to be well in accordance with the laws of thermodynamics. Chinese pathophysiology, views disease as resulting from a disruption in the normal flow of Qi and in this view, Qi is always preserved. Thus if the flow of vital energy is obstructed, below the obstructed area is deficiency and above the obstruction excess. Furthermore the concept whereby disease arises from a blockage in the flow of Qi, may be seen to parallel the second law of thermodynamics which predicts an increase in disorder in any isolated system. Thus, the Chinese have developed a theoretical framework for understanding life processes and pathology based on the Second law of thermodynamics, thousands of years before the concept of encropy was acknowledged in the West.

# Entropy and biology

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While the Chinese seem to have recognised that the concept of entropy applies to life processes, it seems somewhat surprising that, despite its universal application, the concept of entropy is not widely utilised within Western medical science. The reason for this appears to be mainly historical. The 2nd law was originally formulated an engineering concept and described in terms of the usefulness of energy by Thompson in 1852. Subsequently the concept of entropy was reformulated in terms of heat by Clausius in 1864, and then in terms of probability by Boltzmann in 1872. Thus the concept of entropy was derived as an engineering concept when man was claiming domination over the inanimate world during the industrial revolution.[prigogine] In fact at the same time the Second law of thermodynamics was been acknowledged, the biological sciences were busy integrating the concept of evolution and natural selection which seems to contradict the Second law.

The reason living systems appear to contradict the 2nd law of thermodynamics is that the 2nd law only applies to isolated systems i.e. systems that do not communicate in any way with their environment. Living systems however are necessarily open systems; and thus appear not to fall under the jurisdiction of the second law. Indeed, living systems tend to build up order as they grow, learn and evolve. As Bertalanffy states;

"The fundamental characteristics of life, metabolism, growth, development, self-regulation, response to stimuli, spontaneous activity, etc., ultimately may be considered as consequences of the fact that the organism is an open system. The theory of such systems, therefore, would be a unifying principle capable of combining diverse and heterogeneous phenomena under the same general concept, and of deriving quantitative laws."<sup>6</sup>

Bertalanffy goes on to say:

The theory of open systems opens a new field in physics, and this development is even more remarkable because thermodynamics seemed to be a consummate doctrine within classical physics. In biology, the nature of the open system is at the basis of fundamental life phenomena, and this conception seems to point the direction and pave the way for biology to become an exact science.<sup>6</sup>

The task of deriving laws regarding the ability of open systems to become self-organising and increase their order is the subject of the field of non-equilibrium thermodynamics. In his book *Order out of Chaos*, The Nobel Laureate, Ilya Prigogine maintains that it is communication throughout the system that allows open systems to maintain their stability and to increase in order. As he states;

"The faster the communication taker place within a system, the greater the percentage of unsuccessful fluctuations and thus the more stable the system. Indeed the more complex a system is, the more numerous are the types of fluctuations that threaten it's stability. [Hence]. . . there is competition between stabilisation through communication and instability through fluctuations. The outcome of that competition determines the threshold of stability."

# Communication, information and entropy

This idea suggests that it is information flow (ie. communication), that enables systems to build up and retain a high degree of order. The link between communication and entropy is indeed a profound one. This was demonstrated by Claude E. Shannon who in 1948, while working in Bell laboratory on the engineering problems of communication channels, derived a mathematical expression for information that was subsequently shown to be identical to thermodynamic entropy. In the introduction to Shannon's work entitled "The Mathematical Theory of Communication", Warren Weaver states;

"When one meets the concept of entropy in communication theory, he has a right to be rather excited- a right to suspect that one has a hold of something that may turn out to be basic and important. . . One must think a long time, and consider many applications, before he fully realises how powerful and general this amazingly compact theorem really is." <sup>8</sup>

Shannon's equation, which equates entropy with uncertainty, is defined in terms of a well-defined question (Q) representing a question with a finite set of answers, along with knowledge (X), based on knowledge of the question and past experience. This knowledge leads to the assignment of probabilities (p) to the various possible answers. Shannon's measure is expressed symbolically as S(Q/X) to emphasise that the uncertainty or entropy depends on both the question (Q) and knowledge (X). The expression is written as:

## $S(Q/X) = -K \Sigma p \ln p$

where K refers to an arbitrary scale factor. (When K=1/ln2; S = bits of information. When K = Boltzman's constant (i.e.,  $1.38 \times 10^{-23}$ ); S= Joules per degree Kelvin). This mathematical definition has the property that if one (correctly) assigns p=1 to one of the answers and (therefore) p=0 to all the others, then S(Q/X) = 0 (there is no uncertainty / entropy). On the other hand if all probabilities are assigned equally then S(Q/X) is a maximum (there is maximum uncertainty). <sup>9</sup>

# Information and *Qi* as energy

Shannon's expression, which forms the mathematical basis for all types of communication. neatly defines entropy in terms of '*uncertainty*' or '*information*' and reveals that information may be considered as a form of energy. Information can thus be measured in terms of 'bits' or 'Joules per degree Kelvin' (one bit is approximately equal to  $1.8 \times 10^{-23}$  Joules per degree Kelvin). <sup>10</sup> This expression therefore provides a link between qualitative and quantitative aspects of energy and suggests that the Chinese concept of *Qi*, which also refers to quality of energy, may be closely related to the concept of '*information*'.

The similarities between the concepts of information and of Qi are many. At the most basic level, 'information' provides science with the ultimate in reductionism, for the 'bit' (which is either 0 or 1) is the smallest quantifiable unit. Similarly Qi is seen to arise from the interplay of the polar opposites yin and yang which are also considered fundamental building blocks of reality. Furthermore, the idea that it is communication (information flow) that allows systems to build up and retain order, closely parallels the idea that the flow of Qi maintains the functional integrity of living systems. Thus both 'information' and Qi can be considered to be types of energy that sustain living systems and animate awareness. An obstruction in the flow of either information or Qi, would therefore produce an isolated system and result in an increase in entropy that would manifest as pain and disease (biological disorder). Thus while life is dependent on 'negentropy' in order to build up order and thus grow, learn and evolve, entropy represents a threat to life which may be consciously perceived as painful.

# Pain and entropy

The idea that pain is related to entropy is strengthened when examining the language of pain. Pain is usually described in terms of the mechanism of injury (stabbing, burning, crushing, pinching etc) which describe the ways in which biological order may be disturbed. In addition, the symptoms commonly associated with pain (*calor, tumor, rubor, and functio-lasor* - heat, swelling, redness, and loss of function) may all be seen to describe a decrease in biological order. As well as being associated with biological correlates of pain can be seen to reflect the cosmological correlates of entropy, which represent a trend towards an expanding universe (swelling), energy dissipated at heat (heat and redness), and an increase of useless energy (loss of function). The idea of pain as entropy suggests therefore, that the same process that lays waste to galaxies, also results in disruption and destruction on a personal level. This is in accordance with the Eastern medicine idea of the microcosm reflecting the macrocosm and enables a cosmological perspective to be applied to pain within a scientific framework, without resorting to the non-rational language of mystical experience.

The entropic view of pain allows otherwise esoteric Eastern concepts to be expressed in the language of science. Thus the Eastern view of "life is pain" can be seen to relate to the fact that homeostasis is never perfect and that life is necessarily an entropic process. The ultimate state therefore is one of 'nirvana' or 'enlightenment', which is the state of "being at one with the universe". In the enlightened state there is no distinction between self and non-self and thus perceptions are no longer isolated and subject to the second law of thermodynamics.

# Disease and obstructions in information flow

While the enlightened state suggests a state of ideal health occurring where perceptions flowing freely, the states of pain and disease occur when there is an obstruction in one of the many forms of information flowing throughout biological systems. Thus pain and disease may arise as a result of many different types of obstructions, ranging from blocks in enzyme pathways and biochemical processes, to mechanical disruptions in arteries, veins, ureters, and intestines, to blocks in nerve conduction or the transmission of direct currents. In addition to the many well-defined physical pathways in the body, there are also pathways that appear to be more 'informational' than physical. Thus the concept of information flow may be applied to conscious processes, and psychological disorders may be seen to arise from emotional blocks occurring when information is too overwhelming to be processed and is blocked from emotional expression. Furthermore the classical acupuncture meridians represents pathways where the informational substrate is less well defined.

The acupuncture meridian system describes a system of pathways for the flow of information where certain points may act as channels for information transfer between the organism and its environment. This exchange may take place in many different ways. Information may be exchanged through mechanical means such as pressure or needling, through heat and cold, through the application of direct electrical or electromagnetic energy such as electro-acupuncture or laser stimulation, as well as through more subtle means, such as through changes in environmental electromagnetic fields. Thus these points may be responsive to both man made and natural electromagnetic fields as well as to interactions with the fields produced by other people such as healers.

While the exchange of information at acupuncture points may take on many forms, the substrate for information flow throughout the meridians has not been precisely determined. There is much evidence however to suggest that electromagnetic energy is involved. Acupuncture points have consistently been shown to be points of low electrical resistance<sup>11, 12</sup>, and acupuncture meridians have been shown to be low resistance pathways<sup>11, 13</sup>. While this evidence has not yet included a full explanation of how different meridians may carry different types of information according to their corresponding organ system, there are many possibilities including different waveforms, frequencies, resonance etc. Modern attempts to measure and influence these pathways have met with considerable success however, there is

much that still needs to be learned before technology can take full advantage the insights provided by Eastern medicine.

Acupuncture is based on the view that information and energy flow are the primary substrates for both health and disease. While this view is supported by the laws of thermodynamics, the challenge remains to be able to access this information flow for the purposes of diagnosis and therapy. Much work remains to be done both on a clinical level to demonstrate the efficacy of different diagnostic and therapeutic techniques as well as on a theoretical level to integrate many of the insights provided by Eastern medicine with modern technology. The ability to integrate Eastern and Western ideas has been explored within the framework of theoretical physics by Capra who in his book "The *Tao* of Physics" suggests;

"We are heading towards a new synthesis, a new naturalism. Perhaps we will eventually be able to combine the Western tradition, with its emphasis on experimentation and quantitative formulations, with a tradition such as the Chinese one, with its view of a spontaneous, self organizing world."<sup>14</sup>

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# IS THERE A RELATIONSHIP BETWEEN SUNSPOT NUMBERS AND PSYCHIATRIC ADMISSIONS?

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ABSTRACT: We examined the correlation between solar activity (sunspot numbers) and 96050 psychiatric admissions between July 1984 and December 1993, in Victoria, Australia. Calculation of the Pearson correlation coefficient gave a value of 0.399 (P value; 0.0001). This value however, may be an artefact of autocorrelations within the two series rather than a relationship between them as the Pearson correlation does not account for the serial nature of the data. To overcome this problem we calculated the prewhitened cross-correlation between the series and tested whether they were uncorrelated. The test was significant (P value; 0.006), which gives strong evidence for a relationship between sunspot number and psychiatric admissions.

# 1. INTRODUCTION

During periods of high solar activity there are greater Xray, ultraviolet and radio emissions from the sun. In addition, solar flares are more frequent producing disturbances in the earth's magnetic field, disruptions to communications and power outages in high latitudes [1]. As well as producing disturbances to electronic communications there have been suggestions that high solar activity may also coincide with disturbances in biological systems.

As early as 1935 studies have reported correlations between various measures of solar and/or geomagnetic activity and psychiatric admissions. In 1935 Dull and Dull [2] examined 40,000 cases over a period of 60 months and described what appeared to be a relationship between magnetic storms and the incidence of nervous and mental diseases and suicides. This study however did not use any statistical analysis. In 1963 Freidman et. al. [3] looked at 28642 admissions over 52 months, more recently Raps *et al* [4] and Kay [5] performed similar studies.

While these studies ([3], [4] and [5]) have reported a correlation between psychiatric admissions and solar activity, they have used only simple statistics such as the Pearson correlation coefficient to report their findings. Few of these studies have explicitly modelled the ordered nature of the data (e.g. monthly bivariate time series of solar activity and hospital admissions).

Failure to take the serial nature of the data into account is not only an inefficient use of data but may lead to mistaken inferences. Specifically, larg correlations between series (cross-correlations) may be spurious if there are large correlations (autocorrelations) within each series [6]..Autocorrelations are commonly encountered in serial ordered data such as time series data. Consequently we have undertaken the following study to look at the relationship between solar activity and psychiatric admissions using appropriate time series methods.

## 2. DATA

Data on all admissions into psychiatric hospitals in Victoria from 1 July 1984 to 31 December 1993 covering a period of 3471 days (114 months) were included. This data was obtained from the Psychiatric Records Information Systems Manager (PRISM) database maintained by the Department of Health and Community Services in Victoria. This database includes all formal psychiatric admissions into the Victorian public hospital system (43 hospitals) which covers a catchment area of approximately 4 million people. During the time period examined, there were 96050 admissions.

This is the first time a study has included such a large number of admissions over an extended period. It is also the first time such admissions represented the total admissions from a population rather than admissions gathered from selected psychiatric institutions. Therefore, the results presented here are less subject to selection biases.

Daily sunspot numbers were obtained from the National Oceanographic and Atmospheric Administration (NOAA), which provide a weighted average of measurements made from a network of cooperative observatories around the world.

Sunspots numbers act as indicators for solar activity and fluctuate in a cycle of approximately 11.1 years. The most recent maximum being in 1989 when some of the greatest sunspots on record were recorded.

# 3. METHOD

In this study the time series technique of *prewhitening* was used to examine the correlation between sunspot numbers between 1984–94 and 96050 psychiatric admissions in Victoria, Australia over the same period. In this context, prewhitening involves [7] 4 stages; 1) modelling the sunspot series as an autoregressive integrated moving average (ARIMA) process with a

white noise residual, 2) filtering the sunspot series with this model to get a white noise series, 3) filtering the admissions series with the sunspot model, 4) forming the cross-correlation of the filtered series of stage 3 with the white noise series of stage 2. For instance, a peak in the estimated cross-correlation function for the monthly series at lag d may indicate that number of admissions is related to the sunspot number after an interval of dmonths [8]. The estimated cross-correlation can be tested for the hypothesis that none of the correlations up to a given lag are significantly different from zero.

The motivation for the prewhitening approach comes from the area of time series forecasting and the notion of a transfer function (TF). If a time series ( $Y_t$  i.e. admissions) is thought to be influenced by another (input) time series ( $X_t$  i.e. sunspots) then a TF is hypothesised to exist that transforms  $X_t$  into  $Y_t$ . If the TF can be estimated then it is possible to forecast  $Y_t$  from  $X_t$ .

In this study our aim was not to predict psychiatric admissions from sunspot numbers but use the TF approach to test for a relationship between the two. If a TF exists then a white noise input should be altered so that cross-correlation of the noise input and resultant TF output is *not* that of two white noise series. As we do not know the form of the TF we infer its existence by reducing (filtering) the input series to a white noise series and applying this filter to the output. If the crosscorrelation function of the filtered series is that of two noise series (null hypothesis) then no TF exists between them. If, however, the null hypothesis is rejected then a TF (relationship) does exist between the series.

#### 4. **RESULTS**

The Pearson correlation coefficient between sunspot numbers and psychiatric admissions was 0.399 with a Pvalue (i.e. null hypothesis of no correlation) of 0.0001. This value is also the value of the zeroth order crosscorrelation when neither series has been prewhitened. However, the calculation of the Pearson correlation assumes that the data are independent, that is, the order in which the data is presented is irrelevant. This is not the case with times series data. Both the sunspot number and psychiatric admission series show serial structure. The sunspot series exhibit a maximum between August 1988 and August 1991, while there is a less well defined increase in psychiatric admissions after August 1987.

A more appropriate method of examining the correlation between these series is to use the time series transfer function model (as discussed above). The ARIMA model of the sunspot series was found to be a first order moving average of the first differences (standard error of moving average coefficient is given in brackets):

 $Sunspot_t - Sunspot_{t-1} = error_t - 0.4983(\pm 0.0823)^* error_{t-1}$ 

The resulting cross-correlation was significantly different (up to lag 11, P-value = 0.006) from that of two white noise series implying some relationship between the two. This is despite the significant autocorrelation exhibited by

both series. Note, that the zeroth correlation (equal to the Pearson correlation coefficient) of the prewhitened crosscorrelation is 0.041. This is much smaller (and not significant) than the Pearson correlation coefficient of 0.399 calculated before prewhitening. Thus although the TF model suggests a relationship between sunspot numbers and psychiatric admissions such a relationship would be quite complex.

#### 5. CONCLUSIONS

We conclude that there is strong statistical evidence for a correlation *between* solar activity as measured by sunspot numbers and psychiatric admissions. This evidence is strong for two reasons. First, we have been able to use psychiatric admission data (96050 admissions) from almost an entire population of 4 million (Victoria, Australia) so that our results are not an artefact of small or biased sampling. Second, we have used the time series method of prewhitening that explicitly models the serial structure within and between series. So our results are not an artefact of spurious correlations caused by the intrinsic autocorrelation within series.

It would be interesting to apply this method to admission data for other conditions such as cardiac events or epilepsy. However, more importantly these results should stimulate discussion as to their cause. If the methodology we employed is inadequate, how can it be improved? However, if the methodology is appropriate, then what is the mechanism of a relationship between sunspot numbers and psychiatric admissions?

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# IS THERE A LINK BETWEEN ACUPUNCTURE MERIDIANS, EARTH-**IONOSPHERE RESONANCES AND CEREBRAL ACTIVITY?**

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#### ABSTRACT

Acupuncture points and meridians have been shown to have distinct electrical characteristics. Acupuncture points have been found to have lower electrical impedance and acupuncture meridians represent low resistance pathways. We examined the spectral characteristics of a section of the large intestine acupuncture meridian in 10 healthy volunteers by inserting a broad-spectrum pulse at one point and detecting the output response further along the meridian. Analysis of the meridian transfer function revealed characteristic resonant frequencies that strongly coincide with the spectral components of Schumann resonances and the human EEG.

## INTRODUCTION

While the mechanism of acupuncture is still not well understood there is evidence to suggest that bioelectric phenomena may be involved. The ancient Chinese were aware of electromagnetic phenomena and considered health to be an energetic balance between the organism and the environment. Chinese historical writings describe the use of magnets in healing as well as the correlation between illness and sightings of the aurora borealis (a visible indicator of geomagnetic disturbances).

More recent investigations have established that electromagnetic phenomena are involved in the practice of acupuncture by demonstrating the lower electrical resistance of acupuncture points and meridians [1,2]. The low impedance properties of acupuncture points gives weight to the traditional idea that acupuncture points are sites of energy transfer. Furthermore, impedance characteristics suggests that certain frequencies may preferentially propagate along acupuncture meridians [3]. The extremely low frequency (ELF) range is of particular interest as homeostatic responses have been linked to the occurrence of electroencephalogram (EEG) alpha activity which may be induced by acupuncture [4].

#### **METHOD**

In order to determine the resonant frequencies of an acupuncture meridian, two acupuncture points along the large intestine meridian were located using standard charts. Conventional 32 gauge stainless steel acupuncture needles were inserted into these points and a broad frequency, biphasic pulse 1 msec/phase (2 msec pulse width) and 1 volt p-p amplitude was introduced into the distal point (Li 4) at a rate of 1 pulse per second. Recordings were taken from this point as well as from a point further along the meridian (Li 11) over a 30 second period (meridian shown in Figure 1). An additional large stainless steel electrode was held in the palm of the subject and was used as common reference point. The recorded signals were subject to frequency domain analysis to determine the transfer function and hence the spectral characteristics of the meridian. This procedure was repeated for 10 healthy subjects aged between 20 and 38 years old.



Figure 1. Li 4-11 Meridian



Figure 2. Meridian Transfer Function

#### RESULTS

Preliminary results indicate the presence of strong resonant peaks in the transfer function spectra of the large intestine meridian (Figure 2). These resonances occur in the ELF range up to 45Hz. Of particular interest are the peaks occurring in the 8, 14, 20, 26, 33 and 39 Hz regions, which closely correspond to the "Schumann resonances". Schumann resonances are the result of lightning-induced electromagnetic propagation between the surface of the earth and the ionosphere [5]. These natural earth-ionosphere resonances have been previously shown to overlap with the principal spectral regions of the EEG [6]. In addition, the dominant Schumann component around 8 Hz corresponds to the alpha region of the EEG, which is known to have beneficial effects on health.

This result confirms our previous studies [7,8] on the resonant frequencies of acupuncture meridians using Ag/AgCl electrodes.

#### CONCLUSION

The results of this study indicate that there are characteristic resonant frequencies in the spectra of the large intestine meridian. These ELF frequencies closely correspond to Schumann resonances and the principal spectral components of EEG. This result suggests there may be a resonant relationship between environmental ELF radiation, acupuncture meridians and central nervous system activity.

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# The Thermodynamics of Subtle Energy

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Bio-energetic medicine covers a wide range of different therapeutic and diagnostic approaches, many of which are based on ideas borrowed from Eastern medicine which suggest that life is dependent on a subtle form of energy. This subtle energy, often termed 'vital force', 'life energy', 'life force', 'prana', 'chi', or 'Qi', is deemed to flow throughout the organism maintaining both physical and psychological processes. Pain and disease are said to arise when this energetic flow is disrupted or 'blocked' and bio-energetic therapies tend to focus on restoring the natural energetic flow and thus supporting the bodies homeostatic responses.

While clinical studies support the use of bio-energetic therapies, many of the concepts underlying bioenergetic medicine have not been accepted by Western science and are criticized as being unscientific. The inability of science to recognise the basic concepts underlying Eastern medicine, prevents the theoretical integration of Eastern and Western medicine, leaving medical knowledge divided by the use of different conceptual languages. Thus while one discipline is talking about 'Qi', or 'yin' and 'yang', another is talking in terms of 'receptor transmitter interactions', and 'pharmacokinetics', or 'psychosocial stressors' and 'life events'. When such different terms are being used it is difficult to find a common ground, even when discussions are focused on the same issues.

Eastern and Western medicine lie on either side of the Cartesian division between mind and body, subjective and objective, holism and reductionism. Eastern thinking is holistic and outlines a whole philosophy of life that maintains a cosmological perspective based on non-linear logic and acausal relationships. In contrast, Western thought is based on a reductionist approach that emphasizes controlled experimentation, and mathematical analysis based on analytical reasoning and linear causality.

These approaches may be seen as complementary and an integration of ideas may be achieved by establishing parallels between their basic concepts. Such a mapping of ideas would create a common language that would allow discussions between different traditions to take place, and permit each tradition to inform the other, thus providing new insights and understanding. In order to achieve this integration however, many Eastern concepts must be translated into the language of science, for it is in the light of rational scientific inquiry that modern medical knowledge is ultimately assessed.

# Parallels between Eastern and Western concepts

Many of the fundamental concepts of Eastern medicine such as "Yin" and "Yang" and "Tao" have fairly obvious parallels in Western science. The concept of Yin and Yang can be seen to accurately parallel the quantum theoretical concept of complementarity. Yin and Yang refer to pairs of mutually exclusive yet inter-dependant opposites. This idea is well accepted within quantum theory, where light must be understood to have the properties of both waves and particles for a complete description. In fact Niels Bohr, one of the founders of quantum theory included the Yin/Yang insignia in his family coat of arms along with the statement that "opposites are complementary".

The concept of "Tao" finds parallels in Western science in the mathematical concept of Absolute infinity. An important feature of both "Tao" and ". Absolute infinity" is that they are both considered to be inherently incomprehensible and thus unable to be grasped by the rational mind. The incomprehensibility of these concepts places them essentially beyond thought, yet paradoxically allows them to provide the conceptual basis for an entire system of thought. The concept of Tao in Eastern thought is seen to represent "the infinite order of nature" or the "way of the universe" and forms the basis of Taoist philosophy which considers Tao as "formless, nameless, the motive force of all movements and actions, the mother of all substances". Similarly, the concept of . Absolute infinity in mathematics represents "the class of all sets" and this concept forms the basis of set theory, which provides a conceptual framework for all mathematics and may even be described as a form of exact theology<sup>2</sup>.

While the concepts of *Tao* and *Ying* and *Yang* readily find counterparts within Western science, the concept of *Qi* appears to be more problematic. In Eastern thought the concept of *Qi* refers to a subtle form of energy that flows throughout the organism along certain defined pathways or meridians. This continuous flow maintains the functional integrity of the system. The ideograph used to denote the concept of *Qi* is made up of two Chinese characters, one of which means "the flow of something that is difficult to grasp" and another that refers to "rice" or "source of energy of a human or animal". Thus *Qi* refers to "the flow of something that is the source of vital energy to humans and animals".

The normal flow of Qi is seen as a necessary requirement of life and a disruption in the flow of Qi is seen to be the prime cause of pathology. Furthermore Qi is said to come in various forms which animate life so that there is Qi from air and food, Qi that flows in the meridians and perverse Qi that causes disease. Thus as Porkett states; "whatever Qi the context and absolutely without exception, [Qi] always implies a qualitative determination of energy. In other words Qi means energy of definite (or definable) quality."<sup>4</sup>

# Qi and Thermodynamics

In contrast to the Eastern concept of "Qi" or "*life energy*", in Western science the concept of "*energy*" has a more precise meaning that does not include a form of energy specific to living systems and thus the concept of 'Qi' is therefore often rejected as being 'unscientific'. The concept of Qi however, does follow many fundamental scientific principles. In particular, the concept of is in accord with the laws of thermodynamics, which are universal laws that comprise the most fundamental principles in Western science. As Einstein states:

" A theory is the more impressive the greater is the simplicity of its premises, the more different are the kinds of things it relates and the more extended is its range of applicability. Therefore the deep impression which classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced, that within the framework of applicability of its basic concepts, will never be overthrown." <sup>5</sup>

The First law of thermodynamics states that "matter and energy cannot be created or destroyed, only converted from one jorm to another" while the Second law of thermodynamics concerns the concept of entropy which describes a universal tendency towards disorder and states; "in an isolated system entropy always increase"

The concept of Qi can be seen to be well in accordance with the laws of thermodynamics. Chinese pathophysiology, views disease as resulting from a disruption in the normal flow of Qi and in this view, Qi is always preserved. Thus if the flow of vital energy is obstructed, below the obstructed area is deficiency and above the obstruction excess. Furthermore the concept whereby disease arises from a blockage in the flow of Qi, may be seen to parallel the second law of thermodynamics which predicts an increase in disorder in any isolated system. Thus, the Chinese have developed a theoretical framework for understanding life processes and pathology based on the Second law of thermodynamics, thousands of years before the concept of entropy was acknowledged in the West.

# Entropy and biology

While the Chinese seem to have recognised that the concept of entropy applies to life processes, it seems somewhat surprising that, despite its universal application, the concept of entropy is not widely utilised within Western medical science. The reason for this appears to be mainly historical. The 2nd law was originally formulated an engineering concept and described in terms of the usefulness of energy by Thompson in 1852. Subsequently the concept of entropy was reformulated in terms of heat by Clausius in 1864, and then in terms of probability by Boltzmann in 1872. Thus the concept of entropy was derived as an engineering concept when man was claiming domination over the inanimate world during the industrial revolution.[prigogine] In fact at the same time the Second law of thermodynamics was been acknowledged, the biological sciences were busy integrating the concept of evolution and natural selection which seems to contradict the Second law.

The reason living systems appear to contradict the 2nd law of thermodynamics is that the 2nd law only applies to isolated systems i.e. systems that do not communicate in any way with their environment. Living systems however are necessarily open systems; and thus appear not to fall under the jurisdiction of the second law. Indeed, living systems tend to build up order as they grow, learn and evolve. As Bertalanffy states;

"The fundamental characteristics of life, metabolism, growth, development, self-regulation, response to stimuli, spontaneous activity, etc., ultimately may be considered as consequences of the fact that the organism is an open system. The theory of such systems, therefore, would be a unifying principle capable of combining diverse and heterogeneous phenomena under the same general concept, and of deriving quantitative laws." <sup>6</sup>

Bertalanffy goes on to say:

The theory of open systems opens a new field in physics, and this development is even more remarkable because thermodynamics seemed to be a consummate doctrine within classical physics. In biology, the nature of the open system is at the basis of fundamental life phenomena, and this conception seems to point the direction and pave the way for biology to become an exact science.<sup>6</sup>

The task of deriving laws regarding the ability of open systems to become self-organising and increase their order is the subject of the field of non-equilibrium thermodynamics. In his book Order out of Chaos, The Nobel Laureate, Ilya Prigogine maintains that it is communication throughout the system that allows open systems to maintain their stability and to increase in order. As he states;

"The faster the communication taker place within a system, the greater the percentage of unsuccessful fluctuations and thus the more stable the system. Indeed the more complex a system is, the more numerous are the types of fluctuations that threaten it's stability. [Hence]...there is competition between stabilisation through communication and instability through fluctuations. The outcome of that competition determines the threshold of stability." <sup>7</sup>

# Communication, information and entropy

This idea suggests that it is information flow (ie. communication), that enables systems to build up and retain a high degree of order. The link between communication and entropy is indeed a profound one. This was demonstrated by Claude E. Shannon who in 1948, while working in Bell laboratory on the engineering problems of communication channels, derived a mathematical expression for information that was subsequently shown to be identical to thermodynamic entropy. In the introduction to Shannon's work entitled "The Mathematical Theory of Communication", Warren Weaver states;

"When one meets the concept of entropy in communication theory, he has a right to be rather excited- a right to suspect that one has a hold of something that may turn out to be basic and important. . One must think a long time, and consider many applications, before he fully realises how powerful and general this amazingly compact theorem really is." <sup>8</sup>

Shannon's equation, which equates entropy with uncertainty, is defined in terms of a well-defined question (Q) representing a question with a finite set of answers, along with knowledge (X), based on knowledge of the question and past experience. This knowledge leads to the assignment of probabilities (p) to the various possible answers. Shannon's measure is expressed symbolically as S(Q/X) to emphasise that the uncertainty or entropy depends on both the question (Q) and knowledge (X). The expression is written as:

$$S(Q/X) = -K \sum pln p$$

where K refers to an arbitrary scale factor. (When K=1/ln2; S = bits of information. When K = Boltzman's constant (i.e., 1.38 x10<sup>-23</sup>); S= Joules per degree Kelvin). This mathematical definition has the property that if one (correctly) assigns p=1 to one of the answers and (therefore) p=0 to all the others, then S(Q/X) = 0 (there is no uncertainty / entropy). On the other hand if all probabilities are assigned equally then S(Q/X) is a maximum (there is maximum uncertainty).<sup>9</sup>

# Information and Qi as energy

Shannon's expression, which forms the mathematical basis for all types of communication, neatly defines entropy in terms of *'uncertainty'* or *'information'* and reveals that information may be considered as a form of energy. Information can thus be measured in terms of 'bits' or 'Joules per degree Kelvin' (one bit is approximately equal to  $1.8 \times 10^{-23}$  Joules per degree Kelvin). <sup>10</sup> This expression therefore provides a link between qualitative and quantitative aspects of energy and suggests that the Chinese concept of *Qi*, which also refers to quality of energy, may be closely related to the concept of *'information'*.

The similarities between the concepts of information and of Qi are many. At the most basic level, 'information' provides science with the ultimate in reductionism, for the 'bit' (which is either 0 or 1) is the smallest quantifiable unit. Similarly Qi is seen to arise from the interplay of the polar opposites yin and yang which are also considered fundamental building blocks of reality. Furthermore, the idea that it is communication (information flow) that allows systems to build up and retain order, closely parallels the idea that the flow of Qi maintains the functional integrity of living systems. Thus both 'information' and Qi can be considered to be types of energy that sustain living systems and animate awareness. An obstruction in the flow of either information or Qi, would therefore produce an isolated system and result in an increase in entropy that would manifest as pain and disease (biological disorder). Thus while life is dependent on 'negentropy' in order to build up order and thus grow, learn and evolve, entropy represents a threat to life which may be consciously perceived as painful.

## Pain and entropy

The idea that pain is related to entropy is strengthened when examining the language of pain. Pain is usually described in terms of the mechanism of injury (stabbing, burning, crushing, pinching etc) which describe the ways in which biological order may be disturbed. In addition, the symptoms commonly associated with pain (*calor, tumor, rubor, and functio-lasor* - heat, swelling, redness, and loss of function) may all be seen to describe a decrease in biological order. As well as being associated with biological discrder, the physiological correlates of pain can be seen to reflect the cosmological correlates of entropy, which represent a trend towards an expanding universe (swelling), energy dissipated at heat (heat and redness), and an increase of useless energy (loss of function). The idea of pain as entropy suggests therefore, that the same process that lays waste to galaxies, also results in disruption and destruction on a personal level. This is in accordance with the Eastern medicine idea of the microcosm reflecting the macrocosm and enables a cosmological perspective to be applied to pain within a scientific framework, without resorting to the non-rational language of mystical experience.

The entropic view of pain allows otherwise esoteric Eastern concepts to be expressed in the language of science. Thus the Eastern view of "life is pain" can be seen to relate to the fact that homeostasis is never perfect and that life is necessarily an entropic process. The ultimate state therefore is one of 'nirvana' or 'enlightenment', which is the state of "being at one with the universe". In the enlightened state there is no distinction between self and non-self and thus perceptions are no longer isolated and subject to the second law of thermodynamics.

# Disease and obstructions in information flow

While the enlightened state suggests a state of ideal health occurring where perceptions flowing freely, the states of pain and disease occur when there is an obstruction in one of the many forms of information flowing throughout biological systems. Thus pain and disease may arise as a result of many different types of obstructions, ranging from blocks in enzyme pathways and biochemical processes, to mechanical disruptions in arteries, veins, ureters, and intestines, to blocks in nerve conduction or the transmission of direct currents. In addition to the many well-defined physical pathways in the body, there are also pathways that appear to be more 'informational' than physical. Thus the concept of information flow may be applied to conscious processes, and psychological disorders may be seen to arise from emotional blocks occurring when information is too overwhelming to be processed and is blocked from emotional substrate is less well defined.

The acupuncture meridian system describes a system of pathways for the flow of information where certain points may act as channels for information transfer between the organism and its environment. This exchange may take place in many different ways. Information may be exchanged through mechanical means such as pressure or needling, through heat and cold, through the application of direct electrical or electromagnetic energy such as electro-acupuncture or laser stimulation, as well as through more subtle means, such as through changes in environmental electromagnetic fields. Thus these points may be responsive to both man made and natural electromagnetic fields as well as to interactions with the fields produced by other people such as healers.

While the exchange of information at acupuncture points may take on many forms, the substrate for information flow throughout the meridians has not been precisely determined. There is much evidence however to suggest that electromagnetic energy is involved. Acupuncture points have consistently been shown to be points of low electrical resistance<sup>11, 12</sup>, and acupuncture meridians have been shown to be low resistance pathways<sup>11, 13</sup>. While this evidence has not yet included a full explanation of how different meridians may carry different types of information according to their corresponding organ system, there are many possibilities including different waveforms, frequencies, resonance etc. Modern attempts to measure and influence these pathways have met with considerable success however, there is much that still needs to be learned before technology can take full advantage the insights provided by Eastern medicine.

Acupuncture is based on the view that information and energy flow are the primary substrates for both health and disease. While this view is supported by the laws of thermodynamics, the challenge remains to be able to access this information flow for the purposes of diagnosis and therapy. Much work remains to be done both on a clinical level to demonstrate the efficacy of different diagnostic and therapeutic techniques as well as on a theoretical level to integrate many of the insights provided by Eastern medicine with modern technology. The ability to integrate Eastern and Western ideas has been explored within the framework of theoretical physics by Capra who in his book "The *Tao* of Physics" suggests;

"We are heading towards a new synthesis, a new naturalism. Perhaps we will eventually be able to combine the Western tradition, with its emphasis on experimentation and quantitative formulations, with a tradition such as the Ch/nese one, with its view of a spontaneous, self organizing world." <sup>14</sup>

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# **Bio-energetic Medicine**

Bio-energetic medicine covers a wide range of different therapeutic and diagnostic approaches based on the idea that life is dependant on a subtle form of energy. This subtle energy, often termed 'vital force', 'life energy', 'life force', 'prana, 'chi', or 'Qi', is deemed to flow throughout the organism maintaining both physical and psychological processes. Pain and disease are said to be produced when this energetic flow is disrupted or blocked and bio-energetic therapies are aimed at restoring the natural energetic flow and thus aiding the bodies own homeostatic responses. As science is yet to recognise a form of energy specific to living systems, many of the concepts underlying bio-energetic medicine have often been criticised as being unscientific. Many bio-energetic concepts however, may be translated into more rigorous scientific terms and are supported by the discovery of the electromagnetic spectrum and the development of information theory as well as evidence from clinical trials.

Bio-energetic therapies involve many different approaches including acupuncture, various forms of electrotherapy, homoeopathy, various forms of psychotherapy as well as prayer. These therapies share many common underlying principles in that considerable attention is often paid to the patients emotional and physical state and the therapeutic act usually involves relatively small, yet very specific, energetic or physical stimuli in which the timing is often important. Thus bio-energetic therapies are often also referred to as vibrational or information-based medicine.

While science does not recognise life energy as a distinct entity, 'information' itself can be considered as a type of energy. Information can be measured in bits or joules/degree Kelvin (one bit is approximately equal to 10 -23 joules/Kelvin) and thus information may be considered as a form of subtle energy that animates our awareness. The concept of disease arising from a blockage of 'chi' can thus be seen to parallel the second law of thermodynamics which is one of the most fundamental laws in Western science stating that; 'in an isolated system there is a universal tendency towards disorder'. A blockage in the flow of information through a biological system would therefore tend to produce disorder (disease) and by restoring information flow, homeostasis would naturally return. Electromagnetic radiation as subtle energy.Life has evolved bathed in a constant stream of energy. While much of this energy is obvious to us in kinetic, chemical, gravitational and thermal forms, there are other forms of energy that are more subtle. Electromagnetic energy may be considered as a subtle energy for except for the visible and infra-red regions, most of the electromagnetic spectrum is not obvious unless specific receivers (such as radios, mobile phones, televisions or photographic plates) are used. The 'invisible' parts of the electromagnetic spectrum however can be found to have profound effects on living systems which may result in either gross or subtle changes.

The study of the biological effects of electromagnetic radiation is an extremely complex and controversial one. Gross effects from electromagnetic radiation (EMR) are usually attributed to its thermal or ionising properties however, it is now widely accepted that there may be many non-thermal effects of EMR. The biological effects of EMR may arise from many factors including: the electric or magnetic field components, the energy content, frequency, coherence, resonance, or modulation of a fundamental frequency, the waveform, amplitude or modulation of amplitude, the length of and timing of exposure, the area they are applied to, interference effects with other fields, presence of existing pathology, (tumor promoting rather than initiating effects), and the information content of the fields.

The large number of variables to consider when examining the biological effects of electromagnetic fields makes this an extremely complex area. This complexity is compounded by the fact that biological systems are non-linear and are capable of responding to so-called 'quantum events' such that a single quantum of energy is able to cause biological effects. Enzymes systems within the body are typically capable of an amplification factor of the order of 1010 and this is evident when considering that the dark-adapted eye is able to detect a single photon or the ear can detect sound ranging from silence to the output of a jet engine.

The sensitivity of biological systems to EMR has led to suggestions that that both natural and man made EMR may be responsible for producing various types of pathology. Over the past 100 years the natural background EMR has been overtaken by man made sources so that we are all currently exposed to artificial EMR of various frequencies from numerous sources ranging from powerlines, radio, television, video display units, microwave ovens and mobile phones. However, while it is now clear that humans as well as other organisms are able to respond to fields as low as the earth's static magnetic field, and that pineal melatonin production may be influences by EMR. It is still not clear how low level magnetic and electric fields effect the human organism.

Due to the difficulty of performing research in this area, most studies of EMR induced pathology are based on epidemiological evidence. Epidemiological studies exist that demonstrate correlations between magnetic storm activity and psychiatric hospital admissions or between exposure to power line radiation and the development of childhood leukemia,however, while these studies are suggestive, they do not help to explain the causal pathways involved. Proponents of the harmful effects of low level EMR suggest that EMR may act as a general stressor which would compromise already susceptible individuals as well as having long term effects on otherwise healthy people. There are certainly many cases of electromagnetically sensitive individuals with so-called electromagnetic allergies, that may present with non specific ailments or chronic fatigue as well as many cases of illness occurring in domiciles that are subject to extreme EMR exposure due to local geography and the siting of radio or microwave towers. While there is much controversy as the harmful effects of EMR, it may also be possible that natural EMR has a balancing effect on the body. This is suggested by the finding that there are naturally occurring extremely low frequency (ELF) electromagnetic waves produced by lightning (Schumann resonances) that travel in the cavity between the ionosphere and the earth's surface with similar frequency components to the EEG during meditation Recently these Schumann resonance frequencies have also been found to preferentially propagate along acupuncture meridians. The possibility of positive effects of natural EMR has led to the development of many devices that supposedly enhance these natura frequencies. Very few of these devices however have been subject to rigorous research and supposed in their use remains anecdotal.

# **Diagnostic applications**

The diagnostic applications of different types of electromagnetic energy is relatively recent, beginning around the start of this century with the discovery of X-rays and the use of the galvanometer to detect the electrical activity of the heart, and progressing towards increasingly more sophisticated and more subtle uses. Current diagnostic techniques involve either subjecting the body to an energy source and detecting the output, such as in conventional X-ray or MRI scanning, or the detection of the bodies own internal electrical activity such as in the electro-cardiogram (ECG), electro-encephalogram (EEG), electro-myogram(EMG), electro-oculogram (EOG), or detecting other electrical properties of the body such as the galvanic skin response (GSR) or impedance such as used in impedance plethysmography, and body composition studies. Other diagnostic instruments that work on more subtle levels involve detecting the magnetic fields produced by the body to produce the magneto-cardiogram (MCG) or the magneto-encephalogram (MEG).

While there are many conventional applications of energy in diagnosis, the more bio-energetic approaches generally involve perturbing the bodies own electrical homeostasis and monitoring the response. This approach is commonly used in acupuncture-related diagnostic instruments and Kirlian photography. Electrical measurements may also be used to detect acupuncture points which can be defined electrically as points of low electrical resistance The electrical properties of acupuncture points have also been shown to alter during pathological processes Acupuncture is perhaps the most well researched bio-energetic therapy and is also one of the oldest. The neurophysiological basis of acupuncture has now been well established on the basis of endorphin and other neurotransmitter involvement, the diffuse noxious inhibitory control system (DNIC) and the gate control theory. The reality of acupuncture points however is often questioned for no consistent structural correlates for them have been identified. Acupuncture points it seems are best considered as functional, rather than structural entities, and this is confirmed by the finding that there is an extremely high correlation between acupuncture points and musculoskeletal trigger points, which are points of focal muscle tenderness that can be identified using a pressure algometer or palpation, and which are found to have a local twitch response to mechanical stimulation. While functional correlates of acupuncture points have been shown to exist, sceptics often point out that the acupuncture meridians have not been objectively identified. Most acupuncturists however would maintain that acupuncture meridians are a conceptual tool, such as the lines of latitude and longitude on the earth, and thus while they are useful for navigating a specific territory, to search for anatomical correlates of the meridians would make as much sense as digging in the ground to look for the equator. Recently however there has been the suggestion of objectively defining the meridians using techniques capable of imaging functional, rather than structural relationships.

Studies utilising radioactive tracers have shown that certain tracers appear to migrate along the acupuncture meridiansand electrical impedance studies have shown significantly lower impedance along the acupuncture meridians compared to surrounding skin.

The electrical properties of acupuncture points and meridians may be utilised for both diagnostic and therapeutic purposes. Many different electro-diagnostic devices have been developed such as the 'Mora', 'Vega', 'Biocom', 'Electro-acupuncture According to Voll (EAV)', 'Electro-dermal Screening Test' (EDST) and 'Listen' systems. These instruments may be used to determine a person's energetic balance as well as modify this balance with small but precise electrical stimulation. Most of these systems have been developed on clinical grounds for the bio-energetic basis for these systems it is still not well understood. Attempts to explain these systems include quantum mechanical phase matching and phase modulation of electron waves within the body however these explanations are by no means complete.

# Therapeutic applications

The use of electromagnetic energy for therapeutic purposes goes back at least as far as ancient Greece where electric eels were used in the treatment of arthritis and ancient China where loadstone was used in healing. Today the therapeutic uses of electromagnetic energy are in widespead and used routinely in many applications ranging from the use of large fields such as employed in ECT or defibrillation to lesser fields which may be applied more specifically such as used in pacemakers or diathermy devices, to even more subtle uses such as in electro-acupuncture or Transcutaneous Electro-Neuro Stimulation (TENS), magnetic stimulation for bone healing, low level laser therapy, as well as the use of static magnetic fields for pain. Other bio-energetic therapies may work on even more subtle levels where the type of energetic interaction has not been precisely classified. Thus therapies such as homeopathy. Reiki, and healing prayer may all be considered as involving bio-energy, however, while they have proven effective in clinical trials, their underlying mechanisms are still to be elucidated.

# **Bio-energetics and human consciousness**

Perhaps the most interesting and challenging areas in bio-energetics is the field of human consciousness where studies have begun to show that human consciousness through a simple act of volition may be able to alter otherwise random physical processes and that the act of praying for patients may have substantial therapeutic benefits. Many researchers when hearing of telekinesis or other psychic phenomenon tend to get a bit agitated and frustrated at the inability to reproduce these phenomena or to explain them using conventional wisdom. There are a few serious researchers however, who have applied rigorous scientific principles to the study of these phenomenon and have provided evidence that this is an area that deserves further study. Robert Jahn Dean Emeritus of the School of Engineering and Applied Science at Princeton University in 1979 established the Princeton Engineering Anomalies Research (PEAR) to investigate anomalous human machine interactions. Since this time Jahn's group have established an impressive body of evidence to suggest that human consciousness can indeed affect otherwise random physical processes. In a series of experiments involving over 50 million trials and over 3 billion binary events the PEAR group have demonstrated that human intention is able to alter otherwise random physical processes which include electrical, mechanical, fluid dynamical, optical, acoustic, micro/macroscopic and digital and analog processes, all of which can be calibrated with a predictable and precise statistical output.

While the Princeton group have performed studies demonstrating that human volition may effect otherwise random physical processes, there have also been many different studies demonstrating potential clinical applications. These have been summarised in the book Healing Words by Larry Dossey in which the benefits of prayer. One of the earliest rigorously designed, double blind, randomised, placebo controlled, trials of prayer was performed by Randolph Byrd involving 393 coronary care patients at San Francisco General Hospital. In this study the patients were randomised and various religious groups were recruited and given the first name of a patient as well as a brief description of the patients diagnosis and condition, and were asked to pray for the patients. When comparing the patients who were prayed for with the there were dramatic differences. None of the prayed for group required intubation while 12 in the control group required ventilatory support. The prayed for patients were found to be five times less likely to require antibiotics (3 vs16) three times less likely to develop pulmonary oedema (6 vs 18). While science has not yet advanced to the stage of being able to explain the basis of most forms of bio-energetic medicine, the scientific method has often supported the clinical use of energy medicine for many of the techniques involved have been shown to be of value when subjected double blind, randomised, placebo-controlled, clinical trials. It is often difficult to accept therapies without an explanation

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# Do Acupuncture Points Have Different Absorption Properties to Laser Light than Surrounding Skin?

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#### ABSTRACT:

Traditional Chinese Medicine suggests that acupuncture points are sites of energy exchange between the body and the environment. We examined the relative absorption of near infra-red laser light (3mw, 780nm) using different pulse repetition frequencies at acupuncture points compared to non-acupuncture points. Results revealed that at 1 Hz absorption was greater at acupuncture points compared to nearby nonacupuncture points. At higher pulse repetition rates this difference was reduced. This suggests that acupuncture points do in fact have different absorption properties to non-acupuncture points and that there is a correlation between the skins' electrical conductivity and absorption of laser light.

#### INTRODUCTION:

Traditional Chinese Medicine proposes that health is an energetic balance between the organism and the environment and that acupuncture points are sites of energetic exchange that may be used to alter biological function. This energy may be in many forms including mechanical, thermal, electrical or electromagnetic including visible and infra-red light [1]. The idea that acupuncture points mediate energy exchange is supported by the fact that these points have been shown to have a lower electrical resistance compared to surrounding skin [2]. The emergence of low level laser therapy as an effective therapeutic modality also supports this notion.

Low level laser therapy involves the stimulation of

acupuncture points with laser irradiation so as to produce photo-biostimulation with effects that include analgesia, accelerated wound healing and the treatment of soft tissue injury and arthritic conditions [3]. While different frequencies of laser radiation have different absorption into tissue producing different biological effects [4], there is evidence to suggest that some biomolecules preferentially absorb only certain size packets or pulses of radiation and that the pulse repetition frequency may be an important factor in enhancing photo-biomodulative effects.[5]

This study aims to determine the absorption of laser irradiation at acupuncture points compared to nonacupuncture points and to determine if there is differing absorption of laser light pulsed at different frequencies.

#### **METHODS:**

Near infrared laser light at a constant 3mW was produced from a 780nm laser diode, using specially designed feedback circuitry to maintain a constant output. This circuitry used a monitoring photo-diode, incorporated within the laser diode to provide a current proportional to output power. This current allowed the circuitry to eliminate any fluctuations in output power due to thermal effects and bias current changes. Focusing optics were used to collimate the laser light. The pulse repetition frequencies were controlled using additionally designed circuitry. This circuitry was interfaced via the parallel port of a computer and controlled using software written in Borland C++, specially for this purpose

Laser light was applied to the acupuncture points



Experimental set-up
large intestine 3 and 4 (LI3 and LI4) as well as to nearby non-acupuncture points. Pulse repetition frequencies of 1, 2, 5, 10 15 and 20 Hz with a 50/50duty cycle were used. The acupuncture points were defined both anatomically by traditional acupuncture charts, as well as electrically by locating points with a reduced skin resistance using a multimeter. Points were chosen based on convenience of experimental set up and reliability of detecting low resistance points. It was found that the acupuncture points generally had an electrical resistance one order of magnitude lower than the non-acupuncture points. Care was taken to avoid obvious skin blemishes or moles at these points that may have altered the reflective properties of the skin.

Reflected radiation was collected and focused onto an infra-red sensitive receiver via a protected gold plated concave mirror (see Figure 1). The receiver had a peak response at 940nm and converted light into current. Daylight filters were used to minimise fluctuations due to ambient lighting. The current output of the receiver was converted into voltage, which was sampled and converted to digital information using the Biopac bio-potential amplifiers and data acquisition system. Signal analysis was carried out using the accompanying Acknowledge software [6].

#### **RESULTS:**

Preliminary results revealed that at 1 Hertz there was a lower output signal and therefore a greater absorption of laser at acupuncture points than at nearby nonacupuncture points (Figure 2). Results also showed that at higher pulse repetition rates there was less difference between the acupuncture points and nonacupuncture points (see Table 1). However, pulse repetition frequencies above 10 Hz showed no significant changes.

<b>Fable 1</b> Mean positive $(\mu^*)$ and negative $(\mu^-)$ difference in
implitude between acupuncture and non-acupuncture points
in Volts).

Frequency (Hz)	μ <sup>+</sup>	μ.
1	0.749	0.772
2	0.146	0.813
5	0.471	0.918
10	NA	NA
20	NA	NA

NA (not applicable) as no measurable difference was observed.

#### **CONCLUSION:**

These results suggest that acupuncture points do in fact have different absorption properties to non-acupuncture points and that there is a correlation between the skins' electrical conductivity and absorption of laser light. The fact that there was less difference between the absorption of infra-red light at acupuncture points and non acupuncture points at higher pulse repetition rates suggests that the points may become 'saturated' preventing further absorption.



#### Figure 2

Voltage (V) versus time (sec) of reflected infra red radiation from the laser, at acupuncture and non-acupuncture points, at a pulse repetition of 1 Hz. The mean positive and negative difference in amplitude between acupuncture and non-acupuncture points is 0.749 V and 0.772 V respectively.

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# The Therapeutic Applications of Static Magnetic Fields - A Case Study

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ABSTRACT: The use of magnetic fields as a therapeutic intervention dates back to antiquity and appears to be undergoing a resurgence. The use of magnets promises to provide a relatively cheap, safe and effective form of therapy, particularly in the treatment of pain and other chronic conditions. The scientific basis for this type of treatment is now well understood and it appears that very little basic or clinical research has been performed in this area. This paper describes how the personal experience of one individual led to the establishment of a company selling magnetic products and the documentation of a large number of anecdotal reports of success of this type of treatment.

### CASE REPORT

Mr. Dick Wicks is a former professional athlete who suffered an injury to his left knee in 1976, following a simple accident, colliding with a concrete pillar. This resulted in chronic knee pain leading to multiple surgical interventions, including removal of his patella as well as hydrotherapy and physiotherapy without relief.

After consulting with doctors in Australia, the United States, the United Kingdom, Canada and Stockholm, it was established that he was suffering from a chronic pain condition called Reflex Sympathetic Dystrophy Syndrome (R.S.D.S.) requiring him to undergo a series of chemical sympathectomy's to destroy the sympathetic ganglia in 1985. Still with no permanent pain relief and facing the possibility of amputation of his leg, Mr. Wicks went to Johns Hopkins University in Baltimore to consult with a world leader in R.S.D.S.

Whilst in Baltimore, the diagnosis of R.S.D.S. was confirmed, yet no effective treatment was offered. It was during this time, however, that a chance meeting with an Australian athlete introduced Mr. Wicks to Magnetic Therapy. By bandaging a pillow containing permanent magnets to his injured knee, he found that he could achieve considerable pain relief. Furthermore, he also found that his leg which was permanently cold after the chemical sympathectomy began to feel warm.

Although the application of magnets has not provided a permanent cure for his pain. Mr. Wicks has found magnets to be the single most effective therapy for pain relief and now during waking hours, constantly wears a knee support containing thirty two, 600 Gauss static magnets in an alternating North-South configuration in addition to arch supports containing similar magnets and magnetic jewelry. He has found that this regimen allows him to function very well during the day, although he must still keep his left leg elevated while sitting. At night, he continues to use a magnetic pillow strapped to his knee as well as using a mattress overlay and pillows containing multiple magnets. Dick Wicks' biography "Dick Wicks a Magnetic Man", is to be released in February 1997 [1].

After having such personal success with the treatment of his chronic pain condition, Mr. Wicks began sourcing suppliers of high quality magnets and began developing and distributing magnetic pain relief products. Through his Australia-wide network he began to receive almost daily testimonials from people who had benefited from these products.

More recently, he has been using a specially designed Magnetic Machine which produces a continuous 71mG oscillating field superimposed on a 600G static magnetic field, via flexible pads wrapped around the injured areas. The instrumentation power consumption is limited to 25W and the exposure time to half an hour. Using this machine, overseas researchers have found greater benefit than with static magnets alone [2].

#### **METHODS**

The therapeutic application of magnets generally involves the placing of permanent magnets over or around the area to be treated. The magnets used are generally either barium ferrite permanent magnets ranging from 400 to 2500 Gauss in field strength, incorporated into bandages, jewelry, or clothing, or 24 Carat gold plated rare-earth magnets placed directly onto the body using adhesive plaster. The placement of magnets is generally over the affected area. However, there is a preference to place individual magnets over traditional acupuncture points.

The magnets are generally small discs, 6mm diameter by 2mm thickness and are placed approximately 1-2cm apart with alternating poles facing the body. The number of magnets that may be used simultaneously ranges from 5 to 200 (underlays, back supports, etc) and the magnets may be left in contact with the body for hours or even days on end.

Magnetic therapy may also be achieved with the use of pulsed magnetic fields and trials suggest that Transcranial Magnetic Stimulation (TMS) is able to selectively stimulate different parts of the brain and to produce anti-depressant and anti-Parkinsonian effects [3]. While TMS is still very much a research tool, further clinical trials are currently underway to test its efficacy.

#### RESULTS

To date, magnetic products have been used by very many people in Australia and overseas. Their main use tends to be in the treatment of arthritis and other painful conditions. However, there is much anecdotal evidence to suggest that they are useful in many other conditions such as asthma, migraine and tinnitus. There is also a great deal of reported evidence regarding the benefits of magnets in treating sporting injuries and many world famous athletes have endorsed the use of these products and attest to their effectiveness [4]. In addition to treating many types of conditions in humans, this type of treatment has been found to be effective in treating painful conditions in animals in general veterinary practice, as well as specific use in treating injuries in race horses, greyhounds and household pets.

The use of magnets in therapy has proven to be very safe. To date, no serious side effects have been identified with the use of magnets, and magnets do not seem to conflict with other forms of therapy that may be used concomitantly. Some people do describe the effects of magnets as a tingling or altered sensation or awareness. However, these sensations are generally described as a positive experience and are not usually distressing. In most cases, they may actually enhance the therapeutic response as they serve as evidence that magnets do produce a real effect.

#### DISCUSSION

Currently magnetic pain relief products represent a world wide industry. Companies claim that the use of their products provide a relatively cheap, efficacious and safe form of therapy, that may be used along side more conventional therapy. However, while each company claims to have many testimonials and case reports of success and puts forward possible explanations for it, such as improved circulation and balancing the body's energy [5], there is very little documented scientific evidence and few controlled clinical trials to support this [6].

Despite the lack of scientific support for the therapeutic use of magnets, the widespread use of this type of treatment and the plethora of testimonials and case reports suggest that there is a real therapeutic interaction taking place and that there is a great need for controlled research on the basic mechanisms as well as the clinical applications for this type of treatment.

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# Prediction of Carotid Pressure Waveforms by Mathematical Transformation of Pressure Waves Recorded From the Radial Artery

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Abstract: Radial pressure waves (RPWs) and carotid pressure waves (CPWs) were recorded using applanation tonometry in 6 healthy subjects (5M, 1F, all aged 21 yrs) at rest as well as after a vasodilator agent (sublingual glyceryl trinitrate [GTN] spray). For each subject, transfer functions between radial and carotid pressure waves were calculated by a nonparametric Fourier method. Using the transfer functions, CPWs were reconstructed from RPWs and compared to tonometrically recorded CPWs. The transfer functions accurately predicted CPWs at rest, however, post-GTN, there were significant differences between reconstructed and recorded CPWs. The timing of peak systolic pressure, as predicted by the reconstructed CPWs, was underestimated by 0.3% at rest and was overestimated by 2.3% post-GTN spray.

#### Introduction

Central aortic pressure waves convey important information about cardiovascular status and function, but direct measurements are invasive and expensive. Previous studies have shown that reasonable estimates of central aortic pressure waveforms can be obtained by applanation tonometry of the carotid artery [1,2] which involves the flattening of the curved surface of the artery and indirect measure of the pressure within using a pressure sensor. Recording the carotid artery using tonometry however is often a tedious and difficult technique because the artery is surrounded by loose tissue, making it very difficult to applanate.

The radial artery, on the other hand, is more accessible and easier to compress, but peripheral pressure waves differ substantially from central pressure waves due to changes in compliance of the vascular tree and reflection of pressure waves. There are suggestions however that peripheral pressure waves may be mathematically transformed to approximate central pressure waves [3].

This study attempts to determine whether it is possible to accurately predict central pressure waveform from peripherally recorded pressure waves both at rest and after a hemodynamic challenge.

#### Method

CPWs and RPWs were recorded simultaneously using two hand-held tonometry devices at rest as well as 2 minutes post-GTN sublingual spray. Subjects were lying supine and recordings were taken for 20 seconds and digitised at 200Hz and stored for off line analysis.

 $O_{i}$  dimal recording was occasionally difficult post-GTN spray due to the strong vasodilatory effect of the drug on the circulation causing a weak pressure wave. In one subject, an insufficient radial pressure wave was obtained and therefore this subject was excluded from the study.

From each 20 second recording at rest, two typical looking RPWs as well as their corresponding CPWs were chosen. One typical looking CPW and its corresponding RPW were also selected from the post-GTN spray recordings for each subject. المانية المالية المالية المالية من المالية المالية. منتشبية الملك من معالمة منالية من من من المالية الم

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Transfer functions between the first selected CPW and corresponding RPW at rest were derived for each subject by the nonparametric Fourier transform method [4].

For each subject, a reconstructed CPW (rCPW) was derived by applying the calculated transfer function to the selected resting RPW. The rCPW was then compared to the corresponding tonometry recording of the CPW (tCPW). The reconstruction procedure was repeated on the post-GTN data which placed a physiological stress on the circulation by inducing marked vasodilation. This was to see if the transfer function still applied when the circulatory system was altered.

Comparisons between rCPWs and tCPWs were performed. Overall agreement was quantified by the sum of square differences between the two waveforms. Area differences between rCPWs and tCPW's were also calculated as the absolute difference between the area under the two curves. Finally, the timing of peak systolic pressure was predicted from the rCPW and compared to the timing of the peak in the tCPW.

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#### Results

Fig 1 displays an example of tCPW compared to rCPW at rest and post-GTN spray by the application of transfer functions. The transfer functions were able to accurately predict CPW contour during resting state, but did not perform as well post-GTN. The reconstruction process was more accurate in the systolic portion of the wave than the diastolic portion.

Figure 1. Examples of measured CPW (solid lines) versus CPW reconstructed by application of the transfer function (dotted lines) at rest (A) and post-GTN spray (B).



The SSD of rCPWs compared to tCPWs showed that the transfer functions predicted CPWs better at rest than post-GTN. The SSDs between rCPWs and tCPWs at rest were not significantly different to beat-to-beat differences (p=0.09), but the differences observed for recordings made post-GTN were significantly different to beat-tobeat differences (p=0.04).

At rest, there was less than a 12% difference in the area under the curve of the rCPWs compared to the tCPWs. Post-GTN, this difference became larger than 35%.

Table 1 displays the prediction of the timing of peak systolic pressure from rCPWs compared to tCPWs. The mean timing for peak systolic pressure calculated from the tCPWs at rest occurred at 14.6% of the cycle length. Mean predicted timing calculated from rCPWs at rest occurred at 14.3% of cycle length. Post-GTN, these values were 14.3% and 16.6% respectively. The rCPWs at rest underestimated the timing of peak systolic pressure by an average of only 0.3%, whereas the rCPWs post-GTN overestimated the timing by 2.3%.

Interestingly, the reconstruction of pressure wave contour seemed to be more accurate for the systolic portion of the wave, both at rest and post-GTN. Accuracy of reconstruction of the diastolic portion of the waves varied from subject to subject suggesting that there is more variability in the diastolic portion of the wave. This variability is probably due to variations in pulse wave velocity and in the reflection of pressure waves.

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Table 1. Prediction of timing of peak systolic pressure from rCPWs and tCPWs as a percentage of total cycle length.

	At Rest		Post -GTN			
	tCPWs	rCPWs	tCPWs	rCPWs	%	% diff.
	%	%	%	%	diff.	post-
					at rest	GTN
sub l	12.4	12.3	16.2	15.6	-0.1	-0.6
sub 2	14.7	12.1	14.2	13.0	-2.6	-1.2
sub 3	13.6	14.0	13.2	17.7	0.4	4.5
sub 4	16.1	20.4	13.2	19.9	4.3	6.7
sub 5	16.2	12.7	14.8	16.8	-3.5	2
	Mean	Mean	Mean	Mean	Mean	Mean
	14.6	14.3	14.3	16.6	-0.3	2.3
					stdev	stdev
					3.1	3.4

### Conclusion

This study demonstrates that at rest, acceptable predictions of CPWs can be obtained by mathematical matipulation of RPWs using transfer functions. This result confirms similar results published in a paper by Chen et al. [3]. However, the study by Chen et al. also found that the predictions were still accurate despite marked changes in pressure induced by hemodynamic transients [3]. This was not observed in the present study whereby the prediction of CPWs from RPWs was only accurate for pressure wave recordings made at rest and not for recordings made after vasodilation induced by GTN spray.

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# Analysis of the Diurnal Variation of Arterial Pressure Waves

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Abstract: Pulse pressure waves (PPWs) were recorded from the radial artery using photoplethysmography in 7 healthy subjects (6M, 1F, mean age 23 yrs) at rest every 3 hours between 9am and 6pm. Analysis of variations of PPWs included sum of square differences between waves, ANOVA and spectral analysis of the components of waves. PPWs recorded at 9am were not significantly different to PPWs recorded at 6pm, however, PPWs between each other time period were significantly different, with the largest difference occurring between 9am and 3pm. There was also some variation in the frequency components of the PPWs with an increase in higher frequency components as the day progresses. The finding of this study supports the suggestion within TCM that there are changes in PPW throughout the day.

#### Introduction

It is commonly accepted that arterial blood pressure exhibits a diurnal variation whereby it is highest during the day and lowest during the sleeping hours and many studies have documented this physiological variation [1,2,3]. Practitioners of Traditional Chinese Medicine suggest that during the course of the day, there are changes not only in the arterial blood pressure but also in PPW [4]. While alterations in PPWs are taken into account clinically when performing traditional Chinese pulse diagnosis, to date no published studies have documented these changes.

#### Method

PPWs from the radial artery were recorded for 7 subjects at rest over 4 time periods in the day from 9:00am till 6:00pm at three hourly intervals. Recordings were taken for 30 seconds using a photoplethysmogram transducer (TSD100) consisting of a matched infrared emitter and photo resistor connected to a BIOPAC data acquisition system. These recordings were digitised at 100Hz and stored in AcqKnowledge for off-line analysis. The ECG was also recorded simultaneously and blood pressure was measured before each recording using an automated oscillometric blood pressure monitor (MS-700) on the brachial artery.

Recordings were performed with the subjects lying on their left sides in a reclining armchair with their left arm extended and relaxed. The PPW was recorded noninvasively from the left radial artery by taping the transducer just proximal to the styloid process overlying the radial artery.

Three typical looking PPWs were chosen for each subject at each time period. One of these PPWs was randomly chosen for each subject at each time in order to calculate variations in PPW contour. In order to account for differences in amplitude of recorded pressure waves, the amplitude of the waves were normalised. The variation in PPW contour was assessed by calculating the averaged sum of square differences (aSSDs) at each time period for each subject relative to the beat-to-beat differences (b-bDs). The aSSD between two waves describes the average difference at any point in time between the two waves. This was performed using the Solver function on Microsoft Excel.

ANOVA was used to determine whether there was a significant change in cycle length or mean arterial pressure (MAP) that may account for any variations in PPWs. Significance was accepted at a value of P < 0.05.

The cycle length was determined by calculating the R-R interval on the ECG that corresponded to each of the selected waveforms. This was performed for each subject on all three of the selected waveforms for each time period.

Further analysis was performed through frequency analysis of the recorded waveforms. Fast Fourier transforms (FFTs) were made of the selected waveforms at each time period for each subject. Discrete wavelet transforms (DWTs) decomposed to 6 levels were also made of these waveforms. The DWT process results in a 6 level decomposition of the pressure wave into "approximations" and "details" with the "approximations" representing the low frequency

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components of the signal being analysed and the "details" represent the high frequency components of the signal [5].

#### Results

Fig 1 shows the pressure waves from each time period during the day. The selected pressure waves from each subject were averaged to obtain one wave that is representative for each time period.

Figure 1. PPWs from each time period of the day.



There are obvious differences between the pressure waves at each of the time periods. The upstroke of the pressure waves are quite similar, but the decline from peak differs at each time period. There is a rapid decline from peak at 9:00am and 12:00pm, and a slower decline from peak at 3:00pm and 6:00pm. Also, the incisura (secondary oscillation) is more pronounced at 9:00am and 6:00pm compared to 12:00pm and 3:00pm. Finally, the slope from the decline from peak till the start of the incisura is greatest for 9:00am, followed by 6:00pm and then 12:00pm and 3:00pm.

Table 1 depicts the mean aSSDs relative to b-bDs at each time period. The aSSD between PPWs at 9am and 6pm, relative to b-bDs, was 7.2 (p=0.06). This means that the PPW at 9am was not significantly different to the RPW at 6pm relative to b-bDs. For all other time periods, there were significant differences between PPWs relative to b-bDs. The largest difference was found between 9am and 3pm with a value of 8.2 (p=0.02).

ANOVA revealed that there were no significant variation in MAP or cycle length over the day and the variations in PPWs were independent of mean arterial pressure and cycle length.

Table 1. Mean aSSDs between PPWs recorded at different times in the day relative to b-bDs. Values are calculated by dividing aSSDs by b-bDs and averaging all the results for each time period.

time of the day being compared	Mean aSSDs / b-bDs	P value
9am-12pm	6.2	0.02
9am-3pm	8.2	0.02
9am-6pm	7.2	0.06
12pm-3pm	4.8	0.04
12pm-6pm	4.7	0.03
Зрт-брт	5.2	. 0.04

Fourier analysis of the selected PPWs revealed that most of the waves exhibited the same frequency components with consistent peaks at 0.7812Hz and 3.1250 Hz in all subjects at most time periods.

The pulse is transmitted through the circulation at around 60 beats per minute and thus the peak at 0.7812 Hz observed from the PPWs may simply represent the heart rate frequency.

Analysis of the PPWs using DWTs revealed that pressure waves recorded throughout the day all had the same low frequency components up to 3.125Hz, whereas pressure waves recorded at 9am and 12pm had a strong component in the middle frequency range of  $\sim 3.125 - 25$ Hz and pressure waves recorded later in the afternoon at 3pm and 6pm had a strong component in the higher frequency range of  $\sim 25 - 50$  Hz.

These observations may be explained by variations in the physiology of the circulatory system. Diurnal variation of the sympathetic nervous system may alter the compliance of vessels over the day so that pressure waves exhibit lower frequency components in the morning and higher frequency components in the afternoon.

#### Conclusion

This study demonstrates that there is a significant diurnal variation of arterial blood pressure waveforms which suggests that there may be a rhythmical cycle of PPW contours over the day and that these differences are not due to variations in mean arterial pressure or cycle length.

The finding of this study supports the suggestion within TCM that there are changes in PPW throughout the day which may reflect changes in arterial compliance and possibly organ function.

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# THE ABSORPTION OF PULSED INFRARED LASER LIGHT AT ACUPUNCTURE POINTS.

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#### Abstract

We examined the relative absorption of near infra-red laser light (3mw, 780nm) using different pulse repetition frequencies at acupuncture points compared to non-acupuncture points. Our results revealed that at pulse frequencies below 10 Hz, absorption was greater at acupuncture points compared to nearby non-acupuncture points. At higher pulse repetition rates this difference was negligible. This suggests that acupuncture points do in fact have different absorption properties to non-acupuncture points and that there is a correlation between the skins' electrical conductivity and absorption of laser light.

#### **Introduction**

According to traditional Chinese medicine, the health of an organism is an energetic balance between its internal and external environments. It is possible that acupuncture points are sites of energetic exchange which serve as an interface between the internal and external worlds. This energetic exchange may occur in many forms including mechanical, thermal, electrical or electromagnetic including visible and infra-red light all of which may be applied to acupuncture points to alter biological function clinically<sup>1</sup>.

#### **Unique Electrical Properties of Acupuncture Points**

Although acupuncture points are anatomically similar to surrounding skin, studies have found that these points have unique electrical properties. It has been well documented that the skin resistance over acupuncture points is lower than surrounding skin  $^{23}$ . On average, dry skin has a DC resistance in the order of  $200K\Omega - 2M\Omega$  while at acupuncture points this resistance drops down to as low as  $50K\Omega^1$ . Furthermore while human skin has been shown to have a resting potential across its epidermal layer from 20 to  $90mV^4$ , acupuncture points have been found to have a potential difference 5mV greater than surrounding skin<sup>2</sup>. Due to the higher conductance at acupuncture points, these points tend to short circuit the "skin battery" thus acting as a path of least resistance for currents driven by the resting potential across the skin surface <sup>3</sup>.

### Low Level Laser Therapy

Low level laser therapy involves the stimulation of acupuncture points with either or both visible and infra red laser radiation. This form of therapy produces photo-biostimulation with effects that include analgesia, accelerated wound healing and the treatment of soft tissue injury and arthritic conditions<sup>5</sup>. Generally points are irradiated with between 0.1 and 4J<sup>5</sup> with different frequencies of laser radiation having different absorption into tissue, producing different biological effects<sup>7</sup>. There is also evidence to suggest that some bio-molecules preferentially absorb only certain size packets or pulses of radiation and that the pulse repetition frequency may be an important factor in enhancing photo-biomodulative effects<sup>8</sup>

# Laser-Tissue Interaction

There are two important modes of light interaction with tissue during laser treatment procedures: absorption and scattering. Absorption results in the transformation of light energy into some other form of energy, while scattering may be defined as a change in the direction of the propagating light.

The interaction between light and tissue may be considered at three levels<sup>7</sup>:

1. Atomic - Interaction occurs in the high frequency X-ray and Gamma-ray bands of the electromagnetic spectrum.

2. Molecular - Light absorption mainly occurs at this level. Electron bonds within biomolecules may become excited which can result in the breakage of larger molecules. Such change may be either reversible or irreversible depending upon the intensity of the irradiation and the nature of the bonding. Macroscopically, the excitation of atoms to higher modes of oscillation or rotational stages within biomolecules can be seen as temperature elevation.

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3. Macromolecular and Microstructural - Interactions of this type result in scattering<sup>7</sup> or absorption<sup>9</sup>.

Laser - Tissue Penetration

The depth of Laser penetration into tissue depends upon both scattering and absorption. It has been shown that it is also wavelength dependent<sup>5</sup>. Individuals' optic properties vary significantly so only approximate value are given in table 1.

Table 1. Approximate penetration depth in tissues of different wavelength.

	Wavelength (nm)	Depth of penetration (mm)
U.V	150-380	< 0.1
Violet - Deep blue	390-470	Approx. 0.3
Blue - Green	475-545	арргох. 0.3 - 0.5
Yellow - Orange	545-600	approx. 0.5 - 1
Red	600-650	approx. 1-2
Deep-red to Near I.R	650-1000	2-3
Near I.R to Mid I.R	1000-1350	3 - 5
I.R	1350-12000	< 0.1

#### <u>Aims</u>

The unique propeties of acupuncture points along with the success of low level laser therapy with different pulse repetition frequencies at these points suggests that acupuncture points may respond differently to laser light than surrounding skin. This study aims to determine the absorption of pulsed infra red laser irradiation at acupuncture points compared to non-acupuncture points and to examine the effects on absorption with changes in pulse repetition frequency.

#### <u>Method</u>

The source of infra red light used was a single mode laser diode manufactured by Sharp Corporation. The LT026MD has a maximum output power of 5mW at 780nm. However, the output power of the diode was regulated to 3.0 mW using a constant current source with a bias current of 65mA. Any minor current fluctuations due to thermal effects and bias current drift of the laser diode and bias circuitry was eliminated using specially designed feedback circuitry. This circuitry monitored the laser's output power directly via the photodiode incorporated within the diode itself and also through a number of current sensing resistors at appropriate locations in the bias circuitry.

The complex VSIS structure of the laser semiconductor material provided an elongated radiated pattern with a  $\theta$ // of 16 deg and a  $\theta$  for 36 deg. See Figure 1. Focusing optics were thus employed to focus and collimate the beam to a spot size of approximately 1mm in diameter.





Pulse repetition frequencies were controlled using additional circuitry. This circuitry was capable of providing a 50/50 duty cycle square wave with a resolution of  $1Hz \pm 0.0000005$  up to 100Hz. It was directly interfaced via the parallel port of a personal computer and controlled using software written in Borland C++. Pulse repetition frequencies of 1, 2, 5, 10 15 and 20 Hz were used.

Laser light was applied to the acupuncture point large intestine 4 (LI4), as well as to a nearby non-acupuncture point from a constant distance of 150mm. The acupuncture point was defined both anatomically by traditional acupuncture charts, as well as electrically by locating points with a reduced skin resistance using a multimeter. The Point was chosen based on convenience of experimental set up and reliability of detecting low resistance points. The non-acupuncture point was defined as a point 1 - 2 cm away from the acupuncture point with a higher electrical resistance than the acupuncture points. It was found that the acupuncture points generally had an resistance one order of magnitude lower than the non-acupuncture point<sup>1</sup>. In both cases care was taken to avoid obvious skin blemishes or moles that may have altered the reflective properties of the skin.

Reflected radiation was collected and focused onto an infra red sensitive receiver via a protected gold plated concave mirror (99.6% reflective co-efficient to infra red light). The receiver had a 7.5mm active region with peak response at 940nm. Daylight filters were used to minimise fluctuations due to ambient lighting. The photodiode provided a current proportional to incident light upon the active region. This current was converted into voltage, which was sampled and digitized using the Biopac biopotential amplifiers and data acquisition system. Signal analysis was carried out using the accompanying Acknowledge software





#### **Results**

Preliminary results revealed that at a pulse repetition rate of 1 Hertz there was a lower reflected signal and therefore a greater absorption of laser at the acupuncture point than at the nearby non-acupuncture point (Figure 3a). Results also showed that as the pulse repetition rate was increased the difference in the reflected signal between the acupuncture points and near acupuncture points was reduced (see Table 2). At pulse repetition frequencies above 10 Hz there was no detectable difference between the two signals.

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Table 2 Mean positive ( $\mu^+$ ) a	and negative (µ <sup>-</sup> )	difference in amplitude l	between acupuncture and non-acu	puncture points (	(in Volts).
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Frequency (Hz)	μ <sup>+</sup> (volts)	μ <sup>-</sup> (volts)	Absolute (volts)
1	0.749	0.772	1.521
2	0.471	0.918	1.452
5	0.146	0.813	0.959
10	NA	NA	NA
20	NA	NA	NA

• NA (not applicable) as no measurable difference was observed.

Figure 3. Absolute difference in volts between acupuncture and non-acupuncture point versus frequency.





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#### DISCUSSION

These preliminary results suggest that acupuncture points could in fact have different absorption properties to non-acupuncture points and thus the unique electrical properties of acupuncture points coincide with unique optical characteristics. The fact that there was less difference between the absorption of infra red light at acupuncture points and non-acupuncture points at higher pulse repetition rates suggests that the point may have a refractory period. The limited number of pulse repetition rates used in this study however, do not allow us to elaborate on the absorption - frequency characteristics of acupuncture points. This will be the subject of ongoing research.

The fact that lasers of different frequencies have different penetrations into tissue and may have different bio-photostimulatory effects suggests that lasers of different frequencies will have different absorption characteristics. It would be interesting to asses which frequencies of laser light have the greatest differential absorption at acupuncture points. This could lead to a determination of the tissue depth of these points as well as suggesting optimal stimulation frequencies for low level laser therapy. It is also possible that specific acupuncture points will have different responses to stimulation by laser light of different frequencies as well as different pulse repetition rates.

#### **CONCLUSION**

This study suggests that acupuncture points could in fact have different absorption properties to non-acupuncture points and thus there are optical correlates of the unique electrical properties of acupuncture points. Further work is required to elaborate on these optical characteristics.

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# Engineering Research in Acupuncture

Dr Marc Cohen

# Abstract

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The system of acupuncture points and meridians can be seen to relate to a functional description of how the body has been engineered. While it is difficult to find anatomical correlates for points and meridians, it is possible to identify them electrically. Research into the electrical basis of acupuncture mainly focuses on the basic sciences of biophysics and bioelectronics rather than clinical research. Research in this area includes; the development of different techniques and devices to measure the electrical impedance and resistance of acupuncture points, studies on the propagation of signals along the meridians, the properties of needle-tissue interactions, and the bioelectric and physiological effects of needling. Other more clinical studies include the examination of the pulse using pulse plethysmography and studies looking at the use of diagnostic devices such as the Vega testing and Rodoraku. This research may not only help to validate the use of Traditional Chinese Medicine principles, it may also lead to the development of new diagnostic and therapeutic devices that can combine ancient Chinese wisdom with the latest in Western technology.

# SCIENTIFIC CONGRESS ABSTRACTS Thursday continued

techniques or therapies and it enhances medical treatments. It is preventative, easy to use and safe. Through the initiations or attunements of *Reiki* comes a re-awakening, a re-opening of the healing channel within all of us. *Reiki* accelerates mental, emotional, and physical healing as well as spiritual growth. *Reiki* will be an individual experience. Some people relate to it as dance, music, light, love or coming home. In a *Reiki I* class, persons are attuned to the energy and learn ways to use *Reiki* in their own lives and in service to other. In a *Reiki II* class, persons who have completed *Reiki I* training are given methods for sending *Reiki* at a distance, furthering the mental, spiritual and emotional healing processes.

# REFLEXOLOGY - THE NEW FRONTIER: CROSSING UNCHARTERED TERRITORY GUIDED BY MERIDIANS AND THE FIVE ELEMENTS

# Inge DOUGANS

Founder of the Revolutionary Vacuflex Reflexology System and the International School of Reflexology and Meridian Therapy, PO Box 68283 Bryanston 2021 South Africa

The concatenation of ancient, classical Chinese philosophy and Western ideology has added a powerful dimension to the understanding of the disease pathway by utilizing the remarkable diagnostic aspects of the meridian network and man's inter-relationship. With the Five Elements. Modern technology, too, has made its invaluable contribution with the Vacuflex System, combining the ancient practices of acupuncture and reflexology in one treatment; its unique "diagnostic" feature being the visual impressions left on the plantar region of the feet, which appear as colors, and are then interpreted by the practitioner as states of chronic and acute congestion, the accuracy of which the case histories predicate. It is vital to incorporate in our work the astonishing union of technical competence with spiritual force that is the embodiment of Chinese Medicine, integrate its unifying concepts so as to enhance our practice and render a cessation to the process of fragmentation that is characteristic of our times.

# WESTERN SCIENCE, EASTERN PHILOSOPHY AND INFORMATION THEORY: TOWARDS AN INTEGRATED THEORY OF PAIN

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Eastern and western medicine are currently divided by different world views with the eastern view being more holistic and subjective and the western view being more reductionist and objective. Both approaches, however, attempt to reduce pain and suffering which appear to transcend this division. Information theory can also be seen to transcend this division for any description may be expressed as 'information', which can be reduced to 'bits' (the smallest quantifiable unit), or expressed qualitatively through the concept of 'entropy'. Like pain, the concept of entropy bridges the gap between objective and subjective descriptions, and while life is dependent on 'negentropy' in order to grow, learn, and evolve, entropy represents a threat to life that may be perceived as painful. By viewing pain as 'biological entropy', the eastern view of 'life is pain' can be seen to relate to the fact that homeostasis is never perfect and life is necessarily an entropic process. Furthermore, the concept of information may be compared to the concept of 'chi' or 'prana', and the eastern concept of Bisease arising from a blockage of chi can be seen to parallel the second law of thermodynamics which describes a universal tendency towards disorder in any isolated system. The concepts of information theory apply to descriptions at all levels ranging from biochemical interactions to cognitive and behavioral aspects, as well as to philosophical and social issues. Information theory may thus help to integrate knowledge from many diverse areas and produce a single body of knowledge aimed at the relief of human suffering. (144)

## COMMUNICATION: HOW PATIENTS PERCEIVE WHAT WE THINK WE SAY

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Patients who are ill, in pain, traumatized, or anxious perceive information as if they were in an altered state of consciousness. Communication is, therefore, often misunderstood and difficult, both for the caregiver and the patient. It is important for us to understand this phenomenon, why it occurs, and how best to deal with it in order to minimize further suffering and to improve patient care. Awareness of hypnosis and the manner in which the subconscious processes information helps us to counterbalance these intrusions more effectively. This paper will address some of the common misinterpretations and offer suggestions for clarification. Trigger words and phrases, body language, and spontaneous ideomotor responses will be discussed. (151)