THE BIOPHYSICAL PROPERTIES OF THE TRANSDERMAL MEASUREMENT

[White Paper] *by Prof. Dr. Charles McWilliams*

- **Electrodermology asserts that skin resistance micromeasurements are diagnostic.**
- **Most all internal disturbances also affect the skin by topographical electric changes and patterns on micropoints in the skin.**
- **The transdermal measurement is a complicated state of affairs as this paper will point out.**

Introduction

The skin is the body's largest organ made up of a complex mosaic of three layers, the epidermis, dermis and subdermis. It accounts for 12-16 % of body weight. The skin provides a number of vital functions including protection, interaction with the environment, production of hormones (vitamin D), movement of electrical forces, and homeostasis. It keeps the body at a constant temperature and envelopes a volume conductor and resonant cavity.

The skin of an adult weighs an average 4kg and covers an area of 2 m2. Water accounts for 70% of the chemical composition. Skin appendages include nerves, hair, nails, sebaceous and sweat glands. Skin deforms and reacts neurologically in response to the application of forces and when removed, recoils. This helps the body interact with its environment. When these abilities are altered by trauma, disease or ageing, the skin is altered or compromised. Therefore, a thorough understanding of both normal and abnormal skin presentations provides necessary support for clinical diagnosis and treatment.

The human body is full of electrical signals which can be picked up on the skin and analyzed. These signals come from metabolic respiration, nerve impulses [GSR], muscle contractions [EKG, EMG], piezoelectric effects of bone and skin; and brain activity [EEG]. Voltages range from microvolts (brain waves and some muscle contractions) up to around 2 millivolts (peak-to-peak). Certain conditions such as nervousness or exercise can increase voltages further. Electric flow currents tend to be no more than a couple microamperes.

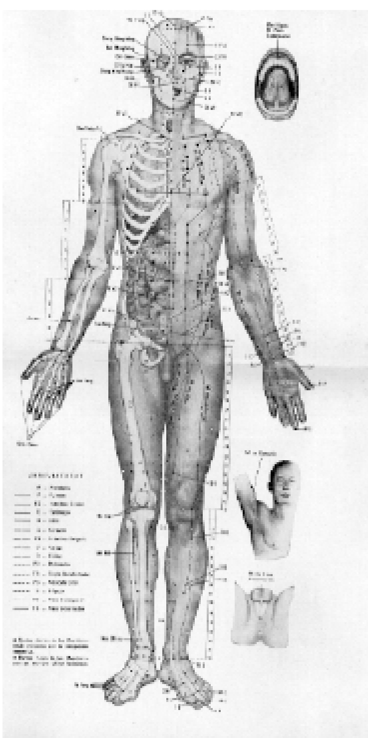
Voltages, thermal and photon emssions are also caused by the sum total of organic activities, namely cellular respiration. Respiration is a fundamental process of life, characteristic of both plants and animals, in which oxygen is used to oxidize organic fuel molecules [sugars, fats, and proteins], providing a source of energy as well as yielding carbon dioxide and water. Heat is a principal by-product of respiration, which provides us with thermal measurements and imagining as a diagnostic tool. Organic electrical discharge is another by-product, but is not leaked out as random electrons as one would suspect, but also travel through skin pathways first identified by Chinese medical theory.

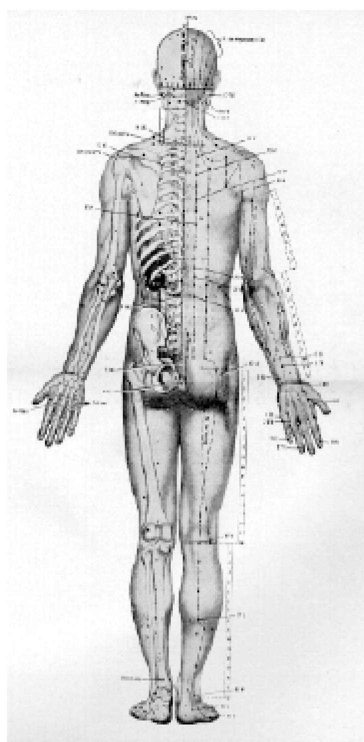
Body electric signals can be picked up and analyzed non-invasively through the use of an array of skin electrodes. This is the foundation of electrodermology. Because skin resistance is high (usually in the near mega-ohm range), special amplification devices are required to make these electric signals visible. Special electrodes, conductive pastes and gels are often used to make it easier to pick up these signals.

It is the varying VOLTAGES that are picked up and analyzed. These voltages are amplified greatly (typically by a factor of 1000 X on EKG and around 10,000 X for EEG). The output then can go to a meter, video monitor, paper plotter, radio transmitter, or digital recording system for analysis.

Electrodermology asserts that skin resistance micromeasurements are diagnostic. Many internal diseases are known to distinctively affect the skin, hair and nails by visible manifestations such as vascular changes, autonomic responses, etc. Anginal pain often travels through the dermatome of the left arm. Ridges running up and down the nails indicate a tendency to develop arthritis and premature ageing. Spoon nails indicate iron deficiency anemia. Erythema nodosum is marked sudden appearance of painful nodules on the extensor surfaces of the lower extremeties. Blaschko's lines are topographical patterns assumed by many different naevoid and acquired skin diseases. **However, most all internal disturbances also affect the skin by topographical electric changes and patterns on micropoints in the skin.**

Electrodermal measurements of widely distributed points numbering in the thousands, yields diagnostic criteria by their conductance, reactance and resistance. Electrodermal screening requires that the practitioner have a fundamental understanding of the skin's histology, basic electrical properties of measurement devices, and biophysical properties of the skin as this foundational paper points out. Electrodermologits also benefit by a basic understanding of Oriental Medical Theory and other reflexotherapies.





As can be seen from the above diagrams, the meridians run along major parts of the body and terminate or begin at the tips of the fingers or toes. These must not be construed with the anatomical nerve channels. Each meridian is associated with an internal organ of the body, such as the lungs, heart, kidney, etc. Thus one speaks of the lung meridian, heart meridian, kidney meridian, etc.

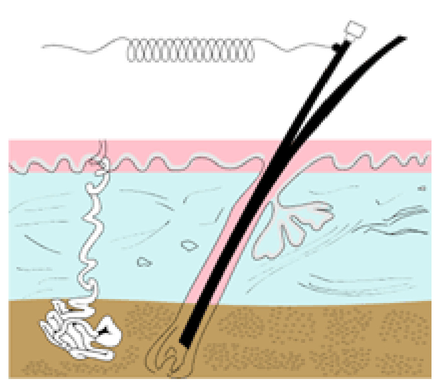
Skin Electrical Measurements, Relevant Details

The technique for electrially measuring skin resistance of the body, is obtained by a conductance (or resistance) measuring device. Originally, a scientific method to demonstrate the validity of acupuncture theory, but now after fifty years has evolved into its own domain of a specific device and technique. Commonly known and accepted by convention, the voltage discharges of the heart and brain are detected by highly sensitive amplifiers which pick up minute voltages that surge to the surface of the skin with lightning speed since the body is a huge volume conductor. Contradistinctly, skin electric measurements are made with an ohm meter where an external, surface DC voltage is forced through the skin structure and picked up at a remote location, centimeters away. The body as a volume conductor poses least to no resistance. The skin however, poses a lot of resistance by a rather complicated set of circumstances and structures. **The transdermal measurement is a complicated state of affairs as this paper will point out.** An adequate description of the electrical characteristics of skin must take into account the spatial heterogeneity of this diverse structure, its electrical properties, and its temporal variability, characteristics which permit it to serve in the preservation of internal homeostasis in the face of marked variations in surrounding conditions.

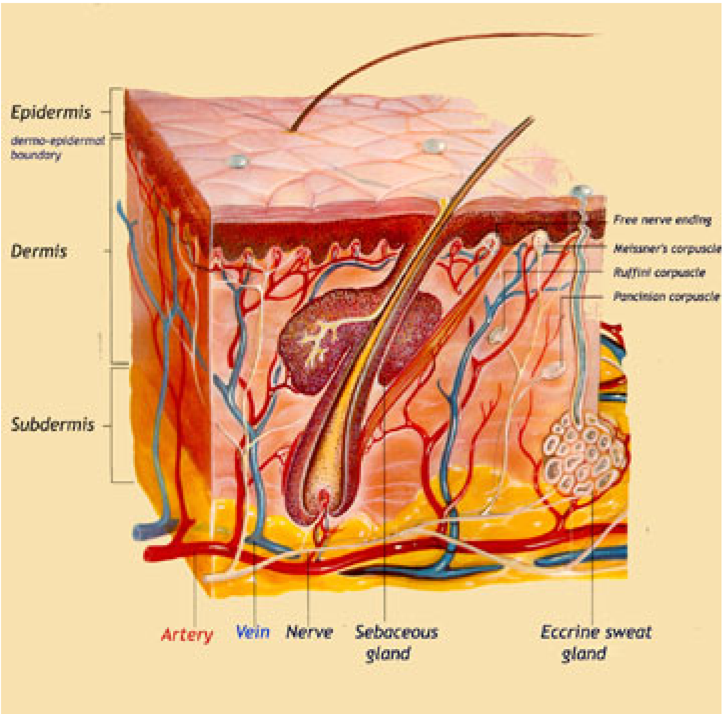
The skin has a principal role in thermoregulation and water-balance. Arterio-venous shunts and perspiration from eccrine sweat glands provide important temperature regulation. Latent heat build up from cellular respiration is required to evaporate from sweat maintains body temperature. The impermeable stratum corneum prevents the loss of water, electrolytes and macromolecules from the deeper tissues.

The skin is also a vital tactile sensory organ, and its mechanical characteristics greatly influence the nature of the neural patterns which occur where it makes contact with an object. Neural mechanoceptors (corpuscles) combined with piezoelectric properties detect superficial and deep pressure such as brushing, vibration, flutter, and indentation. Temperature (thermoreceptors) and pain (Noiceptor), are detected by different sets of electric receptors. These skin sensors, along with muscle/joint position awareness or proprioception (proprioceptors), make up the mosaic of somatic senses. Receptors convey this information to the spinal cord and brain, by transducing, or converting, mechanical, thermal, or chemical energy into electrical signals. Skin receptors also modify the resistance of the skin to pressure and abrasion. These roles are intimately associated with the activity of the sweat glands whose neurally controlled secretion influences both thermal balance through evaporative heat loss as well as mechanical characteristics by hydration of the corneum.

Hair Follicle



An additional dynamic aspect of skin function is seen in the activity of the vasculature of the dermis. A central nervous system thermostat in the hypothalamus regulates the function of the eccrine glands and the cutaneous vasculature. Perspiration is controlled by sympathetic nervous system via the cholinergic fibres that innnervate the sweat glands. Heat is the primary stimulus to the eccrine glands. Electrical signals from the skin reflect the level of sympathetic nervous activity [known as the galvanic skin response - GSR], the state of the blood vessels of the corium, and the state of one or more living cell layers in the dermis.



At the bottom of the dermis lies the basal layer where mitosis, cell division, supplies the epidermis with new skin. The new cells generated migrate upwards in a cycle that lasts about 28 days (one lunar cycle). As the new cells rise, they change from soft columnar cells of the basal layer to hard, flat (keratinized) cells of the corneal layer. From there they eventually slough off. Small attachment plaques called desmosomes bind each cell to each other, forming a continuous, water impermeable layer.

Topical electricity migrates within the dermo-epidermal boundary layer. [28]

Since thermoregulatory and tactile requirements vary in different parts of the body, it is to be expected that the electrical characteristics of skin may show a topographical specificity and varied electrical conductivity. The epidermis is derived from the surface ectoderm of the embryo, but the dermis and hypodermis arise from mesoderm, specifically from the dermatome region of the somites [one of the paired, metamerically arranged cell masses formed in the early embryonic paraxial mesoderm]. The epidermis is typical epithelium, totally avascular and without nervous structures. It is a barrier proper and can be an obstacle to dermal measurements yielding a lot of resistance, especially if hornified as in callosities. The dermis proper contains the vasculature and different kinds of sensory receptors (cells) that respond preferentially to various mechanical, thermal, or chemical stimuli, and is the surface layer of the body's volume conductor.

Moreover, in view of the changes in response to seasonal variations of cold and heat, it is not surprising that electrical properties of human skin should also show an annual periodicity. In addition to short-term (phasic) variations and longer (periodic) variations in electrical properties, there are also changes [dehydration, cross linking, wrinkling] as a function of age. The obvious change in the appearance of skin with development and ageing shows that the concomitant electrical changes are related to structural and neural factors that directly affect skin conductance.

Skin tenting test: When normal skin and subcutaneous tissue are lightly pinched, raised up, and released, it returns to the flat position without delay. Return to the flat position is delayed when the individual is dehydrated. The return becomes progressively slower as the skin ages and subcutaneous elastic tissues decreased and become cross-linked. Thus, the test for tenting can be used as a rough index of the aging process and state of hydration.

Vascular perfusion test: When a fingernail or toenail is forcibly compressed to express blood and quickly released, one can time the period from blanching to capillary refill. Normally, blood should return within 2 seconds. Refill time longer than this reflects poor perfusion of the extremeties and thus may reflect developing arteriosclerosis or other cardiovascular disease.

Finally, because of the dependence of electrical properties of the dermis and epidermis on morphology and functional state, the electrical properties change with:

- cutaneous pathology, i.e. atopic dermatitis, psoriasis, eczema, dyschroa (discoloration of the skin), stasis dermatitis, etc.
- neural pathology, i.e. dysesthesia (impairment of sensation); paresthesia [abnormal sensation, such as of burning, pricking, tickling, or tingling]; dysaphia (impairment of the sense of touch); dysarteriotony (abnormal blood perfusion, either too high or too low); hyperkinesia (excessive muscular activity); hyperpathia (exaggerated subjective response to painful stimuli); paraparesis (weakness affecting the lower extremities); etc.

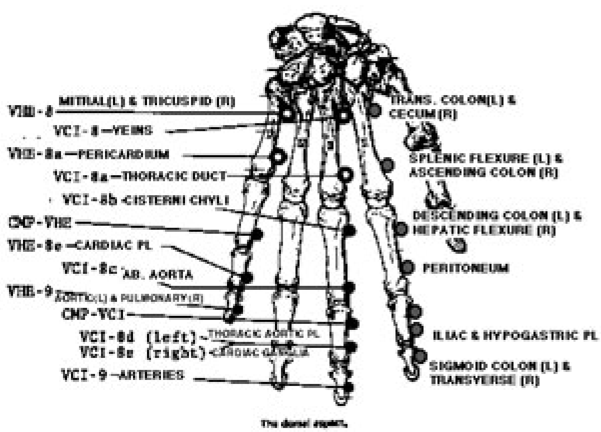
In the light of the dynamically changing characteristics of skin, the understanding of its electrical properties should appropriately focus upon their relation to the individual's functional state as well as structure of skin type. Such a perspective is intimately related to the physiology of the skin, in order to provide a basis for rational interpretation of topographical electrical measurements.

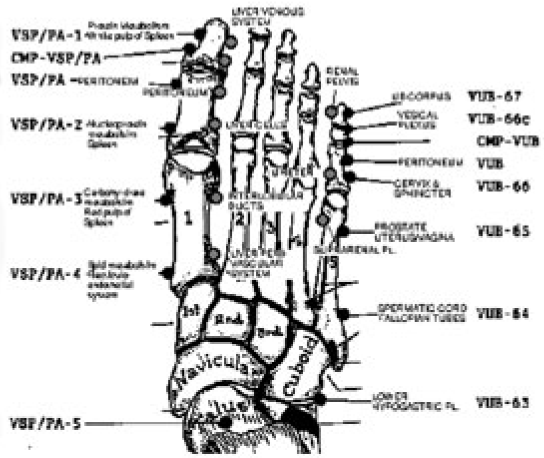
MORPHOLOGICAL AND FUNCTIONAL DETERMINANTS OF SKIN ELECTRICAL PROPERTIES

Resistance or Conductance ?

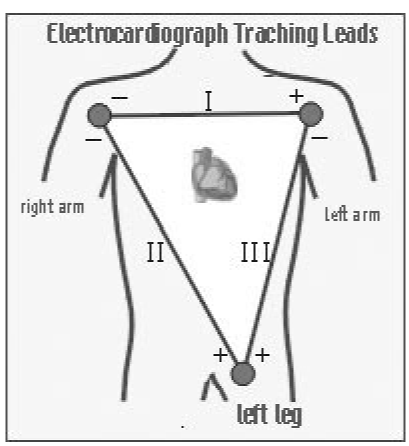
Skin is a mosaic in which relatively uniform laminated layers are perforated by structures having markedly different conductance characteristics. The skin of the face and scalp shows least resistance, whereas the skin of the forearm shows markedly more resistance. Skin resistance is markedly reduced by the sweat ducts and hair follicles. When the sweat glands are activated, say by emotions, neural discharge is increased and water, sodium and chloride ions are released and naturally resistance is decreased and conductance is increased. This is the basis of the lie detector test.

The simple psycho-galvanometer [the basis of the polygraph] was one of the earliest tools of psychological research. A *psycho-galvanometer* measures the resistance of the skin to the passage of a very small electric current. It has been known for decades that the magnitude of this electrical resistance is affected, not only by the subject's general mood, but also by immediate emotional reactions. Although these facts have been known for over a hundred years and the first paper to be presented on the subject of the psycho-galvanometer was written by Tarchanoff in 1890, it has only been within the last 25 years that the underlying causes of this change in skin resistance have been discovered. This serves to point out to the electrodermal practitioner that those emotionally "charged" topics which pass through the subject's mind, either consciously or subconsciously, are best excluded or avoided by the medical history and interview. Fortunately, dermal measurements where there are least sweat glands are only nominally affected and provide of large basis of some of our best measurement loci, namely the acupuncture points of the dorsal side of the hands and feet.





The electrocardiagram, or ECG (also known as EKG, abbreviated from the German word), is a surface measurement of the electrical potential generated by electrical activity in cardiac tissue. Current flow, in the form of ions, signals contraction of cardiac muscle fibers leading to the heart's pumping action. As the heart undergoes depolarization and repolarization, the electrical currents spread throughout the body because the body acts as a *volume conductor*. The electrical currents generated by the heart are commonly measured by an array of electrodes placed on the body surface and the resulting tracing is called an electrocardiogram (ECG, or EKG). The conduction to the surface has been surmised as that of the speed of light.



The electroencephalogram (EEG) arises from thousands of synchronized pyramidal cells of the cortex firing in unison, and reaches the scalp again by volume conduction. The tissue lying between the generating pyramidal cells and the recording electrodes through which the electrical current must flow - brain, cerebrospinal fluid, skull bone, and scalp - forms an electrical volume conductor. This is a fundamental concept to the electroencephalographer since EEG signal abnormalities do not always take place directly over the pathological attack site.

The various layers of skin itself, however, differ in their electrical properties as shown by volumes of research, and some of which can only be surmised from indirect evidence and the experience of the electrodermologist. These dermal resistance characteristics account for at least 90% of the resistance measured between any two electrodes, as close as 1 to 2 cm2 in area, placed at any two spots on the body surface. In this respect, we have a ground mass held in the hand or placed below the sole of the foot, with measurements taken by a 3 mm-pointed electrode upon the digits and extremeties.

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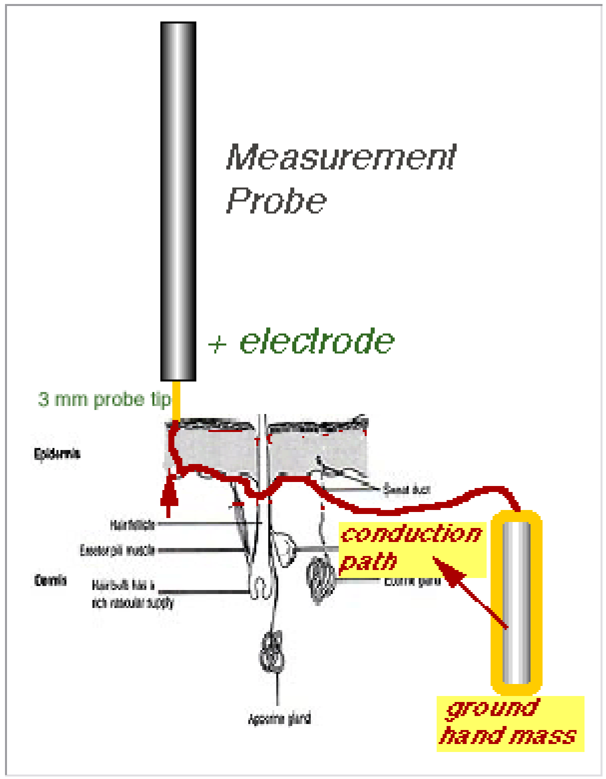
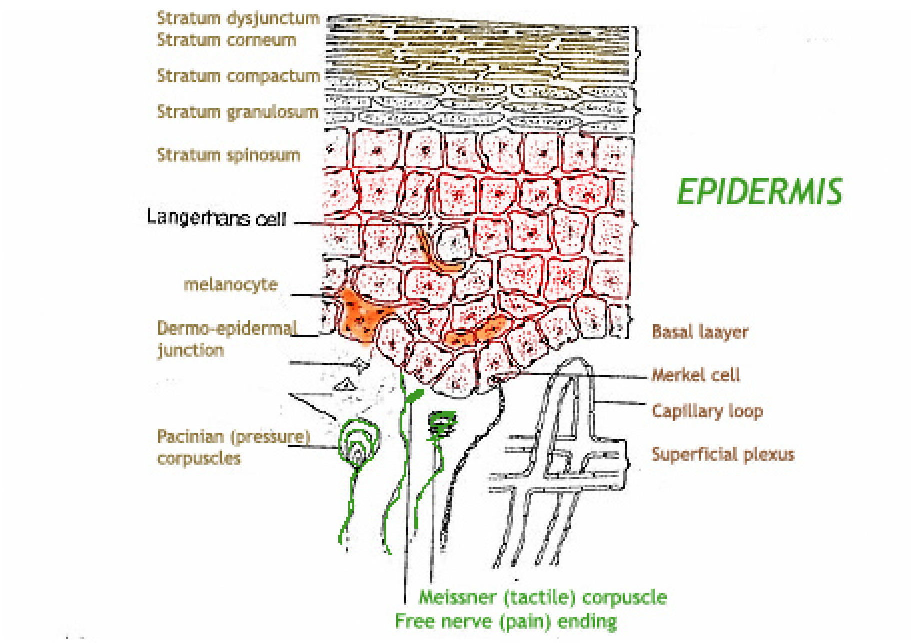
If the electrode probe tips are considerably larger than our standard 3mm, the skin's resistance becomes a proportionately smaller fraction of the total since the deep tissue resistance, which is the basis of electrodermal testing, is essentially of constant magnitude, while the skin's surface resistance decreases with increasing electrode area. Thus, the larger the point [positive-active] tip, the less accurate and less constant the measured values.



Skin tissue accounts for most of the potential difference measured between two transdermal electrodes. Puncture of the skin at each electrode site reduces the resistance to a small fraction of its original value and essentially obliterates the potential difference between the two sites. Thus, our old term - *electroacupuncture* - is a misnomer and should be abandoned.

Morphological and Functional Determinants of Electrical Properties of Skin Conductance & Stability of the Transdermal Measurments

The electrical conductivity of any bodily structure is directly related to its ionic content and permeability. Essentially, the internal body itself being composed of more than 60% water and free ion electrolytes is a volume conductor. The impermeable stratum corneum of the skin prevents the loss of water from the deeper tissues. It also acts as the principal dielectric by its insulative properties, acting as the first topical barrier. Dry corneum is a poor conductor and the conductivity of the stratum disjunctum is markedly altered by the state of its hydration [7]. A dramatic demonstration of this may be observed if one touches a dry microelectrode tip to the skin surface. Resistance may be above 10 Megohm for a 10 micron [needle] tip. If one now places a microdroplet of saline beside the tip, resistance promptly drops to 1-2 Megohm. These observations imply that the corneum must contribute appreciably to total resistance.

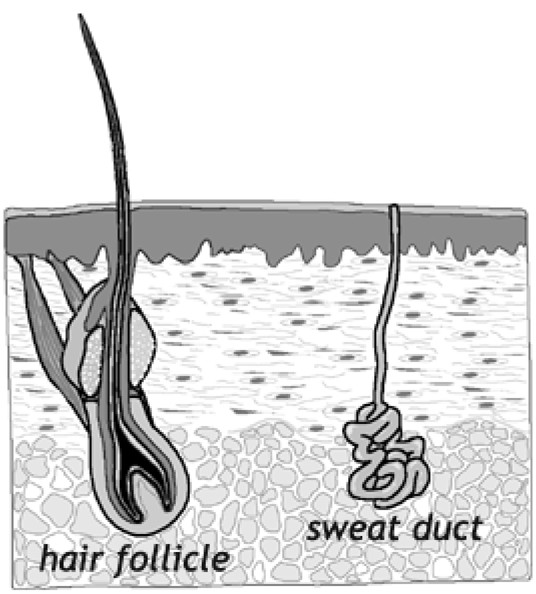


Observations by several investigators indicate the existence of a second barrier in the region of the dermo-epidermal junction at the basement membrane of the germinating layer or the basal cell layer itself. Witten and his coworkers [2] had already shown that after longer exposures (48 hr) to thorium-X without iontophoresis, radiation tracks may be found in the germinating layer but not in the dermis. The dermo-epidermal boundary thus appears to be an effective barrier against this ion as it is against some inorganic compounds [3]. These findings reinforce the conclusions reached by Pease [4] using electromicrographs that there is an intact skin membrane made up in part of basal cell membranes that separates the dermis from the epidermis [dermato-epithelial layer]. Fleischmajer and Witten showed that although thorium-X does not diffuse passively through the stratum conjunctum, it does, if driven iontophoretically. The fact that iontophoretic driving did cause penetration of the basal cell layer [the deepest layer of the epidermis, composed of dividing stem cells and anchoring cells- germinative layer, palisade layer, stratum basale] in the experiments would indicate that this is a route which mainly contributes to the final route of conductance of the skin in conventional electrodermal measurements.

The innermost layer, the corium [dermis] is relatively rich in intercellular spaces through which ions may pass freely. Its ready permeability to ions has been observed by Papa and Kligman [7] who found that the cationic dye, methylene blue, when driven into the sweat gland by strong electrical currents, migrates down the duct to the level of the dermis where it passes laterally (horizontally). Once the ionic current has reached the dermis, one may regard it essentially as being inside the body. Free passage through this volume conductor means that most of the potential drop in the current path occurs in the layers above the dermis. This is confirmed by microelectrode observations. Once the electrical barrier has been "punctured," as by an acupuncture needle, further penetration of the dermis has little effect on total Resistance. The dermo-epidermal boundary thus appears to be the main basis of the electrodermal measurement.

Other than hair follicles, the sweat glands constitute a major conductive path through the barrier layer. The lumen of the duct and secretory portion is a good conductor when filled with sweat, so that a secreting sweat gland affords a freely conducting current path from the surface to the secretory portion deep in the corium. This path is in series with the epithelial cells of the duct at the dermal level and of the gland proper. The cells of the duct wall where it spirals through the stratum corneum are permeable to ions since they are nonliving. Contrary to earlier belief, the spiral duct does have a well-defined wall [5]. The portion of the duct passing through the germinating layer is also permeable to ions, at least when a driving potential is applied as shown by Suchi's experiments with iron sulfate iontophoresis [FeS04]. The duct lining in the corium is also ion-permeable as demonstrated by the observation of movement of methylene blue from the duct into the connective tissue. [7]

The hair follicle undoubtedly constitutes a low-resistance pathway through the skin. It is commonly recognized that this structure represents a preferred route for penetration of the skin by various solutes [6]. Moreover, the scalp was found to be the most conductive of a large number of tested areas on the body surface, its conductance being four times as high as palmar skin and more than ten times as high as the volar forearm [12]. Since the forehead also has a relatively high conductance, up to four times the conductance of the forearm, there is some question as to whether one may attribute all of this high conductivity to hair follicles. Additional evidence for the high cranial conductivity through the forehead is confirmed by high Betawave activity seen on electroencephalograms performed by the author on hundreds of subjects. Thus, the author concludes that brainwave voltages contribute significantly to measurements points upon the cranium since betawave activity is indicative of high stress, problem solving type cranial processes.



The skin surface is normally electronegative with respect to the inside of the body, the palmar and plantar surfaces being most negative. The mean transcutaneous potential at the palm was found to be -39.0 mV [12]. The mean value for forearm was -15.2 mV. The difference between these values, -23.8 mV, is typical of commonly made measurements between the hand, having slightly higher values, and arm having slightly lesser values (especially with relatively dry skin) over the course of a typical electrodermal measurement routine.

A wealth of experimental evidence leads to the conclusion that the electrodermal measurement is modified to an increase in sudomotor activity under the influence of cholinergic sympathetic fibers. The electrical reactions of these nerve movements leads to the formation of sweat. As sweat rises up the ducts and reaches the surface, highly conductive pathways from the surface to the body of the sweat gland are opened. Skin potential becomes more electronegative when the sweat glands are active, an observation consistent with the greater negativity and higher sweat gland concentration of the palmar surface as compared with nonpalmar surfaces. These observations together with microelectrode measurements of potential at the sweat pore and on the nearby corneum [14] lead to the conclusion that the sweat gland is a source of negative potential. The nearby epidermal area is also negative with respect to the inside of the body, but less so than is the sweat gland proper. It is of importance that while areas rich in sweat glands (the palmar and plantar surfaces) become more negative with increasing activation, other areas of the body may become more positive. This could mean either that the sweat glands in these areas are qualitatively different or that potentials originating in nonsweat gland areas of the skin become more positive with sympathetic activation. Thus in many cases of hyperhidrosis, we can still be able to effectively measure points in the dorsum of the hand and foot.

The vascular plexuses of the dermis may also be thought to contribute to the electrical properties of the skin measurements. Since these are freely permeable to salts and are highly conductive, vasodilation causes a slight decrease in the resistance of tissue and conversely vasoconstriction causes a slight increase [8]. The maximum change, however, is usually less than 1 kilohm [9]. Since internal-tissue resistance, including the corium, is less than 1 kilohm out of a total resistance which may be 20 kilohm per cm2, the maximum vascular contribution to variation in skin resistance is small [but important] as compared with the dermo-epidermal boundary contribution.

Evidence for this is seen in the vasomotor activity in the skin and electrical conductance changes [10, 11]. When a drop in conductance occurs as a result of pressure reflex activity [repeated measurement of the same point], the cutaneous vessels commonly constrict. Thus, any contribution from probe pressure activity would tend to reduce (within physiologic tolerance) rather than increase the conductance measurement. This artifact may be induced by a local potential change of mechanical origin or by a repeataed change in contact at the electrode-skin interface. This is known as the false medication testing 'fudge factor' to the author.

The above descriptions in a general way pertain to skin as it is found over most of the body. The chief topological measurement variants are the thickness of the stratum corneum; the presence or absence of the stratum lucidum [the layer overlying the stratum granulosum and is apparent only in thick skin of the palms and soles of the feet]; the concentration and activity of the sweat glands; betawave brain activity over the cranium; and the presence or absence of hair, all of which influence the electrical resistance properties.

As can be seen, not all differences in electrical properties are to be attributed to structural effects since neural activity also influences the values of the various electrical measurements, and efferent neural activity varies considerably over various parts of the body. Consider points on the cranium which are consistently higher in conductance than points on the digits. This only makes sense as the brain produces up to half of the body's entire voltage with its summary electrical signals constantly pulsating through the cranial volume conductor into the scalp. Thus the ratio of resistances from two different sites on the body may change over the course of an hour, for example, from a ratio of 1.5 to 1 to a ratio of 0.8 to 1. Surface potential relations between loci may likewise vary over time and activity. However, since these ratios are usually small in controlled clinical conditions, the electrodermologist can easily ascertain the importance or irrelavance of these values.

Resistance or Impedance ?

The resistance of the skin up to this point has been treated as an ohmic resistance, that is, one in which the voltage generated by the current is a linear function of current strength and independent of frequency. In fact, neither of these two requirements hold so easily for the transdermal measurement of the skin. Gildemeister [24] held that the resistance of the skin is largely a reflection of a counter-EMF (electromotive force) generated by the measurement current itself as a result of membrane polarization - a result of differential mobilities of oppositely charged ions resulting in capacitance and increased resistance. This illuminating view requires examination in more detail as the 'indicator drop' in conductance measurements is a well known phenomena in Voll's electroacupuncture, and generally the most important diagnostic criteria.

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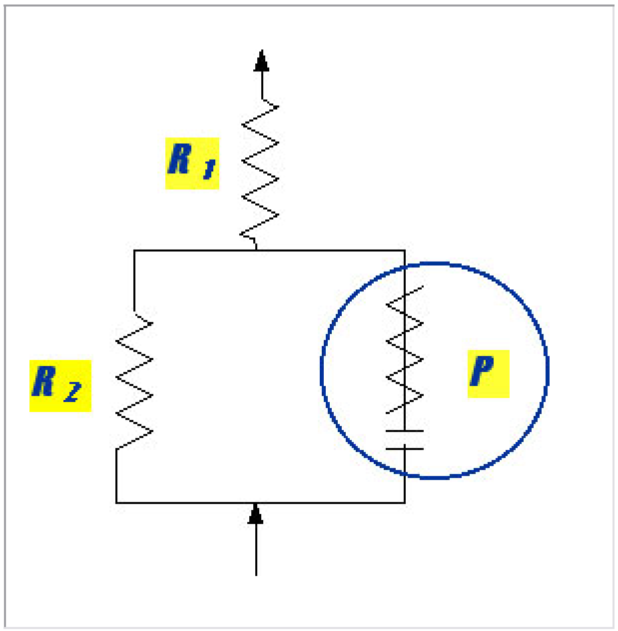


The skin's electric circuit: an increase in counter-EMF is proportional to an increase in current. A capacitor is part of a polarization circuit [P] - a capacitor in series with a resistor. The capacitance and resistance of the polarization element vary with frequency such that the ratio of reactance to resistance remains constant. If the capacitance of the skin is static, and the current low, very little counter-EMF is generated and essentially is not seen during the measurement. The static capacitance will behave as purely ohmic resistance. At higher currents of conductance, a charge of capacitance builds up and resistance increases, as seen by the indicator drop.

Although a potential difference exists at the phase junction between the dermo-epidermal boundary, a relatively fixed charge influences but does not constitute the whole potential difference measured between the surface of the skin and the inside of the body, from epidermis down to periosteum. The measureable potential differences across the skin are presumably membrane potentials and, although they could in special cases originate in an oriented-dipole layer, they typically arise from diffusion processes in which ionic and electric components possess different mobilities. They may develop at the interface between two layers of tissues [stratum basale epidermidis (dermo-epidermal boundary), stratum subcutaneum (piezoelectric properties of fasciae] of different concentration or composition, but the interposition of a membrane usually enhances the differences in ionic or electric mobilities either by virtue of the fixed charge on the membrane structure, piezoelectric effects or due to steric effects.

Piezoelectricity is the property of certain crystalline or ceramic materials like bone, fascia and skin to emit electricity when stretched. Piezoelectricity has been demonstrated in many kinds of connective tissues and even in blood vessels. Pressure over connective tissue and even massage are known to generate piezoelectric currents. [12] Research has shown that the connective tissues are capable of communication, connection, and energy conduction in the form of electron transmission. Thermoelectric properties, pressure-activated responses that result in tissue change and thus functional changes, piezoelectric currents, and a variety of properties have all been discerned. The connective tissues are an amazingly plastic, malleable, changeable, and highly functional group of tissues.

Piezoelectricity ("pressure electricity") was discovered in 1880 by Pierre and Jacques Curie.

An electric voltage is produced by certain crystals and by a number of ceramic materials when they are subjected to pressure. This voltage is called piezoelectricity. That is, when certain crystals, such as quartz, are compressed in certain directions, an electric polarization (and a corresponding voltage) is induced due to the displacement of charged atoms along the same axis. This voltage is directly proportional to the amount of strain and changes sign when the compression is replaced by an elongation.

The piezoelectric effect has many applications. The conversion of mechanical vibratory energy into electric signals and vice versa can be achieved by this effect, and so piezoelectric crystals are used in microphones, sonar transducers, and ultrasonic sound generators.

Steric hindrance is the interference with or inhibition of a reaction because the size of one or another reactant prevents approach to the required interatomic distance. Thus, larger ions may be disproportionately retarded. Since diffusion potentials can develop even in the absence of a membrane, it becomes apparent that structures not ordinarily viewed as membranes, may by virtue of a selective action upon the ionic population, behave as "semipermeable" membranes. Thus the barrier layer of the stratum corneum, although a mass of compacted dead cell proteins [carcasses], may exert a degree of selectivity if some of its channels are so narrow as to offer steric hindrance to ionic passage. If the channels are too wide to offer significant steric impedance they may still exert a selective action as a consequence of the fixed charge on the solid structure, whose electrostatic effects extend some distance out into the aqueous channels. Such a "membrane" would behave much like a collodion membrane in that potentials could develop across it, but these would depend passively on the concentration of the external and internal medium and not upon any dynamic processes which may modify the concentration gradient and which may transiently alter the characteristics of the membrane as occurs in the case of nerve, muscle, or epithelium. In short, overly dry skin or overly moist skin does not lend itself to reliable diagnostic criteria.

Other "passive" structures across which diffusion potentials could develop would be the spiral portion of the sweat duct, the stratum lucidum and the granular layer [3-5 layers of flattened polygonal (often diamond-shaped) cells that contain numerous membraneless keratohyalin granules]. Membrane potentials could develop across active living-cell layers in the secretory portion of the sweat gland, its duct up to the level of deeper regions of the corneum, and finally the basal layer of the germinating layer. All of these latter structures are innervated and the permeabilities of these sites can be altered by neurosecretory activity, thereby producing an alteration of the diffusion potential.

Moreover, active ionic transport mechanisms in these membranes may generate electromotive capacitance forces which would contribute to the overall membrane potential. It is noteworthy that microelctrode measurements by Schula and her co-workers [13] showed the lumen of the sweat duct to be about 40 mV negative with respect to the surrounding dermal tissue. The smooth muscle of the blood vessels, the myoepithelial cells and the piloerectile cells, when they contract, may set up dipoles in the dermis such that a contribution to surface potential may be made.

All of these factors point out that the transdermal measurement is not a simple, straightforward measurement. The are many contributions both locally and distally to explain how reflex points on the extremeties may reflect an internal condition and why empirical observations and recordings are so important in our art.

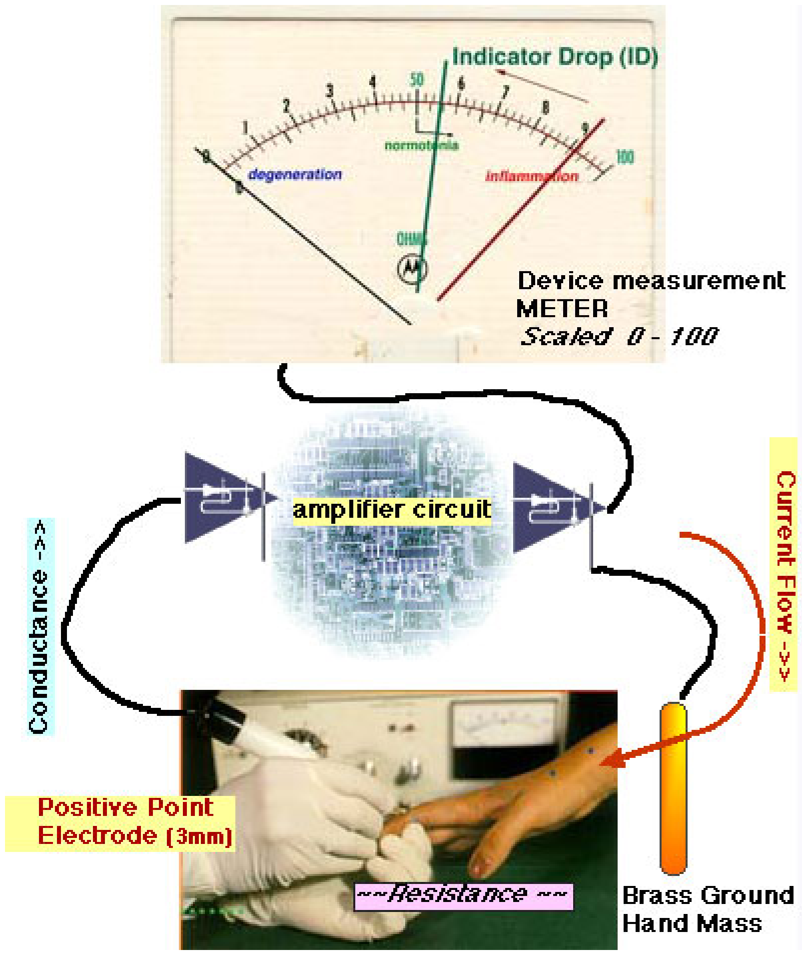
CAPACITANCE IN ELECTRODERMAL MEASUREMENTS

Capacitance is the quantity of electric charge that may be stored upon a body per unit electric potential, expressed in farads. The presence of a capacitance in the skin presents a great complication but also a great insight into the interpretation of electrodermal measurements, since there are a number of electrical-tissue arrangements which may have a common equivalent resistance and capacitance in a parallel or series-parallel arrangement, and it is difficult to identify the actual circuit arrangement in the skin. Attempting to locate the site of capacitance (the indicator drop, ID) is just as difficult to locate the actual site of the acupuncture point. We can measure it, but we cannot see it, from epidermis down to periosteum.

Capacitance in tissue may arise when a thin structure in the current path interrupts the flow of ions, but, because of its dielectric property and thin dimension, allows interaction of the electrical potentials on either side of it. Frequently, in living tissue, sites of capacitance are in parallel with ohmic, DC conductance pathways. Such a condition can exist at numerous loci, even in the corneum, where aqueous sweat channels are distributed in a reticular arrangement within a nonconducting material, the hornified dead cells. These nonconductive materials possess an appreciable dielectric constant, and can constitute effective separators between the "plates" which are in the aqueous areas below the stratum basale. These miniature condensers are in parallel with other portions of these aqueous channels and are sometimes in parallel with each other, sometimes in series, as implied in Tregear's model [23]. However we consider their importance as minimal, except in skin pathologies like psoriasis, where there is profuse exfoliation.

One major source of capacitance in biological systems is polarization capacity which is not due to the static dielectric properties of structures in the current path, but is generated by the effect of measurement current itself by passage upon ionic distribution, called counter-electromotive force. In other words, the applied DC current of the measurement device itself sets up capacitance. To this effect, Ryodoraku equipment was notorious for degenerating measurement values as the voltages and currents used were very high. Voll redifined the ohmic current to 1 volt, but the operational amplifier was not sensitive and required considerable probe pressure which itself lead to stray capacitance currents by irritation of free nerve endings, pacinian corpuscles, compressed fascia, etc. This problem was easily overcome by the author by the use of a more sensitive op amp, while keeping measurement voltage to a low of 1.25 volts, and 14-15 microAmperes.

The increase in this counter-EMF is proportional to the increase in current, and, therefore, behaves much the same as the potential difference generated across an ohmic resistor, that is, as a capacitor in parallel with a resistor. Gildermeister's [24] assumption that the dc ohmic skin resistance is actually a counter-EMF measurement, since membrane polarization would by its very nature be associated with a polarization capacitance. Support for the view that the resistance element of the skin is purely ohmic when making the *stabile measurement* is too simplistic in light of dermal anatomy and physiologic characteristics. In this instance, the skin measurement maintains a steady reading (ohmic resistance) but capacitance is always present. At very low currents, membrane polarization does not appear to occur [or occurs very little], and a measurement of membrane resistance in terms of the voltage generated by the current yields a stabile measurement, meaning that as the probe is held over the point, the reading does not degrade in value (drop).



When measurement current reaches a high value, and if the membrane channels [meridians] become saturated with ions, a measurement of membrane resistance is generated by counter-EMF, and the meter begins its decay in value. The voltage developed across the membranes between point-probe and ground hand mass increases resistance displaying our all too familiar *indicator drop.*

The Physical Basis of the Acupuncture Points

The most basic question concerning acupuncture is whether there is a physical basis for the system of points and meridians. Such a foundation would provide a potential explanation for the reported effects as well as a logical framework for further studies. Otherwise, one would be left only with theories based on hypothesis or suggestion, as has been the case for all of the 20th century. Attempts to correlate the acupuncture meridians and points with the human nervous system have been inconclusive: some investigators have claimed that many acupuncture points correspond to known concentrations of sensory receptors, while others see no relationship to the anatomy of the peripheral nervous system. Becker [25] constructed many experiments and concluded that energy transmission and communication with the meridian system is based on semi-conduction along the perineural glial cells that support the nervous system. He demonstrated that these slow moving DC currents were totally independent of nerve activity.

It is established now without much question that acupuncture points are distinguishable by their lower DC electrical (ohmic) resistance. Some novice investigators have said that this phenomenon is largely due to experimental artifact caused by exertion of greater pressure on the measuring instrument over the sites of supposed acupuncture points. This can be easily ruled out using any one of the scores of acupuncture point sensors on the market today. The author has conducted hundreds of workshops teaching students acupuncture topographical anatomy using these 'point locators' as well as having measured points on over ten thousand patients over the last 25 years.

In terms of a physical correlate of the acupuncture point, Professor Kim Bong-han of Pyongyang University (Korea), raised controversy in the medical community in 1963 when he announced that he had found that skin cells along the pathways of the acupuncture meridians were different than surrounding tissue and that the acupuncture point itself were clusters of unusual kind of cells [26]. His findings which have been quoted (Lawson-Wood, 1973) as proof of a material basis for meridians, have only been validated by Heine. His research could not be verified and was later rumored that Professor Kim had committed suicide.

Later, Japanese physiologist Y. Motoyama [27], did an experiment peeling off the epidermis (horny, insulative layer) of the skin and concluded that only 30% of the resistance of the electrodermal measurement was derived from that tissue. The author's own observations is that it is even less than 30%. Motoyama assumed that 70% of the conductance at the location of the acupuncture point is located in the dermis proper, but as this paper points out, it is primarily at the dermo-epidermal boundary layer, and secondarily contributed to lower structures from dermis to periosteum.

Many have sought an explanation of the increased conductivity at the acupuncture point from a neural or vascular perspective. However, the problem for the explanation of the nerve or vascular activity is that both the nerves and blood are immersed in a rich environment of electrolytes that offer least to no resistance to electical currents. Were it not the case, then the electrical signals of the heart would never provides us with electrocardiograms as the voltage discharge of the heart readily reaches the skin in microseconds. The same could be said for the electroencephalogram. Thus, we have little to no basis of explaining skin conductance based strictly on neural or vascular structures, although as we have seen can contribute to conductivity. The electrodermal response is primarily dermato-epithelial boundary phenomenon against a background of neural, vascular, and piezoelectric forces.

In 1987 H. Heine histologically pointed out the morphology of the acupuncture points as perforation of the connecting tissue-vessel-nerves of the superficial fascial of the body and facilitated this way a physical explanation for the electric measurement of acupuncture. Thereby the relation between skin points and distant organs could be understood. Further examinations in 1990 and 1993 completed by several other universities followed (M. Eggerbacher, 1991, Vienna; Zerlauth, 1992, Munich).

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 surfaces of cells and even into the cells themselves. They have been shown to exhibit piezoelectric properties. This latter concept is a relatively new way of visualizing connective tissue. It has arisen because of the discovery that every cell has within it types of connective tissue consisting of rigid, flexible, and contractile elements. Moreover, it has been discovered that this cytoplasmic system is linked to the extracellular connective tissue via specific structures that traverse the cell membranes from the inside to the outside all the way up to the dermis. Thus we have innumerable pathways in which deep, organic voltages can contribute to topical charges which yield our electrodermal measurements.

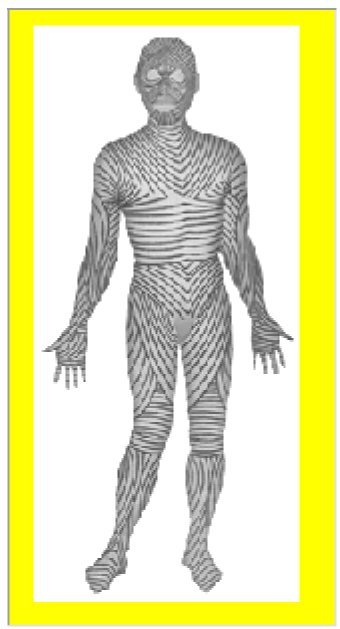
It is quite feasible that the meridians described by Chinese medicine as migrating voltages in the "lining" (the superficial fasciae) can pass internally to the surface of the body and back to the interior, to any organ as it has been stated in historical texts.

There is also a close anatomical relationship between the fascial sheets and the autonomic nervous system, to the extent that the autonomic ganglia are embedded in fascial planes. The precise physiological significance of this has not been given adequate attention.

Electric Meridian Theory

Most researchers do not take seriously the idea that meridians have a material form. Instead they are generally held to represent a set of functional relationships between active points on the surface of the body. However, there are some valid reasons to investigate specific dermal and subdermal structures as contributing to the electrodermal response. Skin tension is mainly dependent on the network of elastic fibers in the dermis, resisting movements of the body, and variations in the bulk of the tissues covered; these skin tensions dictate the behavior at cleavage lines (Langer's lines) of the skin and also conductivity and piezoelectric forces as pointed out earlier. Human epidermal tissue (skin) is compliant, and generally classified as a viscoelastic material. There are directional effects of skin, which are explained by Langer's cleavage lines. The stress-strain relationships in uniaxial tension show skin to be stiffer along Langer's lines than across the lines. As a result, surgical skin incisions perpendicular to Langer's lines gap more (cicatrice) than those parallel to the lines. Good surgeons are know to respect these lines. An incision in the cleavage line results in a hairline scar, almost invisible. An incision across the lines will heal with either a wide or heaped up scar.

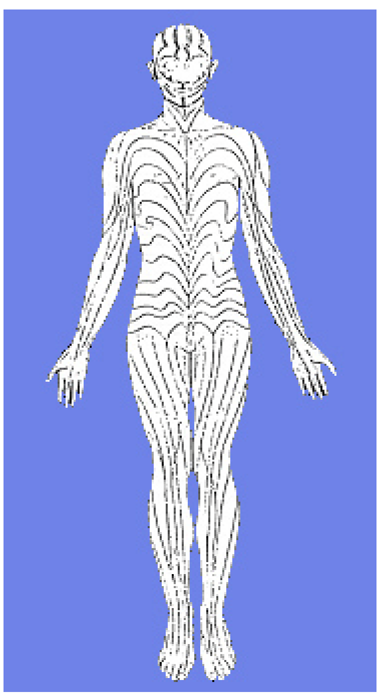
Langer's lines, or cleavage lines, are lines which can be extrapolated by connecting linear openings made when a round pin is driven into the skin, resulting from the principal axis of orientation of the subcutaneous connective tissue (collagen) fibers of the dermis; they vary in direction with the region of the body surface.



Voigt's lines or Futcher's line are a dorso-ventral line of pigmentation occurring symmetrically and bilaterally for about 10 cm along the lateral edge of the biceps muscle, seen in some blacks is widely recorded in medicine. Beau's lines are transverse depressions on the fingernails following severe febrile disease, malnutrition, trauma, myocardial infarction, etc. Owen's lines are accentuated incremental line's in the dentin thought to be due to disturbances in the mineralization process. The scrotal raphe or Vesling's line is a central line, like a cord, running over the scrotum from the anus to the root of the penis; it marks the position of the septum scroti. Stocker's line is a fine line of pigment in the corneal epithelium near the head of a pterygium.

The notable evidence of pathological meridian phenomena was a monograph of the German dermatologist Blaschko in 1901, who showed that linear and zoniform eruptions are not a unitary phenomenon, but may be subdivided into categories. He was among the first to note that the zones of eruption of herpes zoster correlated with dermatomes. These are areas of skin supplied by cutaneous branches from a single spinal nerve root. Since herpes virus infects nerves, this would seem logical. However, he was unable to offer an explanation for the peculiar distribution of many other rashes.

Blaschko lines today show genetic mosaicism, characteristically present in peripheral blood lymphocytes and/or skin fibroblasts cultures. Chromosomal aberrations may conclude in abnormalities of pigmentation as a result of the altered expression of genes in the pigmentary pathway which map to a number of different chromosomes. Geneticists postulate that in this case the pigmentary anomalies may have resulted directly from the altered expression or gene dosage effect of specific pigmentation genes or regulators of pigmentation localised on chromosome 10.



Blaschko's lines
Cutaneous lines of embryogenesis

Description:
The pattern assumed by many different naevoid and acquired skin diseases on the human skin and mucosae. The cause of the pattern of Blaschko lines is unknown; they do not follow nerves, vessels, or lymphatics. In 1901, on the occasion of the 7th Congress of the German Dermatological Society held in Breslau, Blaschko presented his observations on various linear dermatoses. He pointed out that the lines described by these conditions did not only not correspond to any known anatomical basis, but were remarkably consistent both from patient to patient and even from one disease to another. Blaschko proposed an embryonic origin for these lines, but did not elaborate. The lines may represent a clinical expression of a genetically programmed clone of altered cells, perhaps first expressed during embryogenesis
A. Blaschko:
Die Neven-verteilung in der Haut in ihrer Beziehung zu den Erkrankungen

	der Haut. Beilage zu den Verhandlungen der Deutschen Dermatologischen Gesellschaft VII Congress, Breslau, 1901.

Analysis of Blaschko's cases	Herpes Zoster	Congenital Nevi	Acquired Rashes
linear distribution	1	5	35
patchy distribution	55	55	15
Equivocal	3	20	10
TOTAL	59	80	60

Type of lesion	Number of cases	Number obviously linear
Lichenoid	18	13
Unamed	10	6
Eczema	8	6
Scleroderma	8	1
Psoriasis	7	4
Purpura	3	0
Miscellaneous	8	5
TOTALS	62	35

Blaschko derived an abstract set of lines by drawing the rashes of his cases on a doll and then transferring them schematically onto charts. Subsequently numerous hypotheses have been advanced to explain them: lines may run superficial to the course of blood-vessels or lymphatics, or peripheral nerve-trunks, they may correspond to the distribution of a particular cutaneous nerve, or spinal nerve; they may follow the boundaries of distribution of nerves (Voight's lines) or the lines of junction between dermatomes; they may he related to embryonic patterns in the skin, such as the dermatomes, lines of cleavage of the skin (Langer's lines) or hair-stream lines. None of these holds up to serious inspection. In contrast to our anatomical understanding of herpes zoster virus attacking the dermatomes, no theory explains all of Blaschko's lines and the distribution of the majority of linear rashes remains unexplained. In the Conradi-Huenermann syndrome (CDPX2), an X-linked dominant disorder characterized in females by a variable combination of bilateral and asymmetric shortening of long bones; punctate calcification of epiphyses, trachea, and larynx; segmental cataracts; there are patches of ichthyotic skin that typically follow the lines of Blaschko [Happle, 1979]. The skin abnormalities usually improve spontaneously, but often leave either residual pigmentary abnormalities in a streaked pattern or areas of atrophic, hairless skin. Porokeratosis is a genetically determined skin disorder characterized by circular lesions with distinct peripheral ridges that histopathologically correspond to a parakeratotic column. Among the different types of porokeratosis, linear porokeratosis is rare and distinct because of the characteristic linear distribution of the lesions and increased susceptibility to malignant transformation. The pattern of distribution of the lesions are often consistent with Blaschko's lines.

Blaschko pattern running over the pericardium meridian.

A young boy with linear tan warty papules on the volar forearm near the wrist crease which were noted at birth. With increasing age the eruption had extended along the pericardium meridian and many of the papules had become more elevated.

In ***acquired blaschkolinear dermatoses*** there are c**ongenital and/or nevoid skin disorders following the lines of Blaschko and** may have a delayed onset after birth. They have to be differentiated from acquired dermatoses exhibiting the same linear pattern. In common, dermatoses such as psoriasis or lichen planus, lesions in a blaschkolinear distribution most often occur together with scattered lesions, but occasionally they may be isolated. Less common self-limited dermatoses such as lichen striatus and adult blaschkitis always present in a blaschkolinear fashion. In these diseases, or some other conditions occasionally distributed along these lines (chronic graft versus host reaction, fixed drug eruption, lupus erythematosus, atopic dermatitis...), the cause of the disease may lead to the unmasking of tolerance to an abnormal keratinocyte clone which remained hidden in these lines. In addition to epithelial cells, other cells may be involved in the occurrence of acquired blaschkolinear dermatoses. In linear atrophoderma and linear fibromatosis, the histogenesis seems to involve hypothetic dermal clones. The extension of an acquired dermatosis on a preexisting linear nevoid disorder is an argument in favor of **an early embryonic somatic mutation of a skin cell line.** The genetic mosaicism, proved in a few blaschkolinear nevoid or X-linked diseases, has been demonstrated in only one case of lupus erythematosus whose lesions were arranged along the lines of Blaschko (abnormalities of chromosome 18).

Historically, a more common explanation of how the idea of meridians arose concerns *de qi*, the *propagation sensation* associated with needling acupuncture points. Sometimes this is a feeling of a flow of electric energy or peculiar sensation in the body; that's course often to follow the meridians concerned. The sensation of propagation has been recorded in China as being slower than 40 cm per second as is obviously slower than signal transmission of nerve fibers. There have been a few reports (Nagahama, 1950) of individuals who have an exaggerated experience of de qi, for example following a strike by lightning. It has even been possible to map the whole meridian circuit via such subjective reports. It may be argued that the subjects (being Japanese) had prior knowledge of the meridians and so imagined the feelings. Yet it also occurs in patients who had no knowledge of the meridians. The author has seen this clearly in some patients for years.

Dr. Becker's Works

A somatic information and control system using direct current (DC) analogue electrical signals which runs in connection with the nervous system has been postulated to explain how an acupuncture might work by Robert Becker, a retired Professor of Orthopaedic Surgery working in New York State. His hypothesis is based on work with limb regeneration in amphibians and on the phenomena of the current of injury.

His interest in acupuncture arose out of the concept of the electrical control system regulating growth and healing. Such a system would receive and transmit signals that indicated the occurrence of injury. Injury signals are usually equated with the perception of pain, but pain may be merely the consciously perceived portion: the major portion may be addressed to the integration areas that govern the DC system where it would elicit an appropriate output electrical signal, directed towards the area of trauma, that would produce the cellular stimulation necessary to initiate healing. Since the relief of pain is a major effect produced by acupuncture, he theorized that the points and meridians might play a role in the DC control system. If so, they should have electrical characteristics that differ from random control points. He undertook a series of controlled laboratory measurements to study this possibility.

Using a system designed to exclude pressure artifacts, Becker and Marino found that approximately one-half of the points measured were locally resistive minimal when compared to the surrounding tissue. The shapes of the points were not spherical as acupuncture point charts simply show, but behave as irregular boundaries from a few to several millimeters as we would suspect due to the skin's mosaic and diffusion patterns.

In later studies, they found that AC impedance also differed: the equivalent series resistance between acupuncture points was lower than between control points, while the equivalent capacitance was higher. Furthermore, the resistance between two meridian (but not acupuncture) points was lower than that between two control points. Thus, both acupuncture points and meridians exhibited electrical characteristics that differed from those of random control points and dermal areas.

Reichmanis, Marino, and Becker studied the AC impedance of a length of the Heart meridian on the arm not containing any classical acupuncture points. It was studied by means of Laplace plane analysis of the time domain response to an input voltage pulse. The ensuing frequency domain data were compared to the results of an identical analysis for two anatomically similar controls on either side of the meridian. The resistance of the meridian was significantly lower than either control indicating that the meridian of Chinese medical theory in fact acted as a dermal conductive path.

Becker proposed that the signals in the DC system are carried via the neuroglia which are cells surrounding nerve fibres. Currents known to be produced by injury are said to be produced by this glial system, which is associated with growth and repair. The integration of the glial system with acupuncture was proposed by Becker with acupuncture points considered to be analogous to booster stations along the meridians, which are lines connecting acupuncture points, and these meridian lines are likened to transmission lines for these DC signals. Acupuncture points in meridians do show specific electrical properties, and changes in these characteristics can be used for diagnosis.

According to Becker, acupuncture points appear to have little or no electrical activity when the tissue or organ which they represent is healthy. This is not the finding of the author. When an injury takes place, or disease occurs, a current is produced locally on the skin pertaining to that damage. At the same time the properties of the related acupuncture point change, and there are also some possible changes in polarity of the acupuncture points in relationship to the surrounding skin. Corresponding acupuncture points are usually distant to the site of the injury.

A number of conventional electrical circuits can be fitted to this model, and Becker's diode gate is the best explanation. A diode gate is one of the basic building blocks in micro-processors. It seems that in painful conditions a semi-conductor effect blocks the free flow electric charge, thereby leading to a build up of charge, and therefore pain. Gildemeister [24] held that the resistance of the skin is largely a reflection of a counter-EMF (electromotive force) generated by the current as a result of membrane polarization (i.e., as a result of differential mobilities of oppositely charged ions resulting in capacitance and increased resistance). Both properties may be present.

The diode gate theory also helps explain are well known *indicataor drop.* If the load or the specific tissue under ohmic measurement is healthy then the acupuncture point registers no abnormality by a fairly linear conductance, having the same relative resistance as many other points both locally and distallly. If the acu-point load is injured in some way, then a current of injury is produced, the ion channels quickly fill, and an indicator drop (decay) is evidenced as counter-EMF builds up during the measurement load from 10 to 60 seconds in time. This energy also blocks the flow of current into the affected area. As a result the current flow from the body's metabolism (current source) backs up and the acupuncture point becomes electrically active.

The fact that semi-conductor properties are present in acupuncture points can be shown by taking the reading over an acupuncture point with a simple voltmeter. If the electrodes are reversed, and if ionic conduction was solely responsible, then the reading would remain the same but would have a different polarity, ie, from negative to positive. In practice this rarely happens and the second measurement with the electrodes the other way round is often different in varying degrees to the first orientation of the electrodes. This indicates a partial, or in some cases total, semi-conductor effect. The early Ryodoraku [Japanese for "good electro-permeable points"] instruments utilized the point-probe as the current source, in which case the acu-point was heavily loaded with electron flow. This quickly filled the local tissue channel ions, and subsequent measurements would be ultimately higher and higher, upon each successive measurement. Voll logically reversed these currents, wherein the current source is the ground-hand-mass, and the point-probe representing the positive electrode. Thus, the acu-point least disturbed yet able to be repeatedly measured.

Findings by Other Scientists

Chinese physicist B. W. Zhang found that the acu-meridian is a channel conductor for waves of 1359 megaHertz. His experimental research postulated that the acu-meridian is a type of 'wave-guide'. He developed the idea of 'group speed of waves' as early as 1959, long before the recognition of *disspative structures* in the scientific community (described below).

In the 1970's, William A. Tiller, Ph.D. at Stanford University in California discovered that acupuncture points had an optimal resistance in a healthy person. During illness, the resistance changed. Dr. Tiller called these new low resistance points information access windows.

Zablotsky and Spitkovsky reported at the 1989 Provisional Research Collective 'Otklik' in Kiev [Ukraine], proof of the existence of the chinese meridians of acupuncture by an elaborate study. Using electrodermal measurements, they used probing intensities from 20 KHz. to 150 MHz. at 1 mKampere. They worked out a dry electrode configuration and a method for registering skin surface electrical characteristics. They discovered areas of lower electroresistance that corresponded to the chinese meridian topographies as has Becker and the author. Their probing intensities also showed them that measurements yielded diagnostic criteria for evaluation of the functional state of the organism.

Preliminary research done by Dr. Motoyama in Japan has shown that a person emits very small amounts of visible light. The amount is so small that a photon counter is needed. Dr. Motoyama found that photon emission is higher at certain acupuncture points compared to a region of skin with no acupuncture point. According to unpublished research done by Dr. Motoyama in Japan, there is some indication that emission at certain acupuncture points is increased for persons with psychic abilities. He also developed a method using a small vibrating plate above the acupuncture point, D. Motoyama was able to use an effect called capacitive coupling to measure the true potential of the acupuncture point. This method of measurement was refined in an equipment called the potential probe. This equipment can be used to monitor the electrical activity of an acupuncture point while an experiment is performed.

Review

We have reviewed the following dynamics in terms of the ohmic-DC transdermal measurement:

1. Skin is a mosaic wherein the transdermal ohmic measurement (conduction path) is primarily a dermo-epidermal pathway.

2. The mass biologic, respiratory discharges of photons and electrons is not random, but flows out in mesenchymal and dermal pathways more or less congruant with the meridians of chinese acupuncture.

3. The transdermal measurement is not a straight, DC measurement (ohmic resistance), but in fact generates capacitance and counter-EMF through various layers of the fascia and skin. There is also some flow over the neuroglia.

4. Most acupuncture and other reflex points on the skin are evidenced by increased electrical conductance or decreased resistance. Other reflex points may be associated with motor nerve roots in deeper tissues.

5. Electrodermal type point measurements that display a rather linear measurement encounter little to no counter-EMF and are stable.

6. Inflammatory [hyperfunctional] measurements are stable but show decreased resistance.

7. Degenerative [hypofunctional] measurements are unstable and show increased resistance and capacitance by the *indicator drop.*

8. The transdermal measurement is exaggerated by sympathetic discharges acting upon the sweat glands and hair follicles; and somewhat by skin thickness, hydration and dryness.

9. Localized phenomena, such as pressure and stretch response can increase measurement resistance and in essence constitutes a 'fudge factor,' often utilized by novices and lay practitioners as a form of diagnosis and 'medication testing.'

Dissipative Structures

Conventional electromedical physics has for decades considered the body as a volume conductor. However, in the last two decades with advances in physics, biophysics, and instrumentation, it has become obvious that the body is also a resonant cavity. The body produces a heterogenous distribution of high frequency waves - radio, thermic and optic - which generate interference patterns. It is well known that the holographic phenomenon is a basic characteristic of any interfernence pattern.

As we move about the planetary surface in our daily activities, we are generally unaware of the vast information exchange occurring in the atmosphere, within our human body structure, and of how our individual mind, organs and cells continually communicate with a myriad of forces. When simultaneous electromagnetic measurements are performed for the detection of brainwave and heartwave signals, it is found that there are many synchronous frequencies detected.

All matter is in constant vibration; the building blocks of the physical body - the atoms, the subatomic particles, electrons, protons, gluons, quarks- are all in constant motion; all are receiving, transmitting and reflecting the ions, electrons and electromagnetic vibrations which sweep through all matter at light velocities. Consider further that within atoms there are electron packets of energy that are vibrating throughout your brain/body, as well as the Earth, Solar system and Universe. The body in now way is the closed system as once thought.

The energies of the human body receive and transmit the spectrums and resonances of radiowaves, thermal and optical electromagnetic waves. Complexities of Electromagnetic vibration stream into and out of the cellular and skeletal structures. Some have likened our skeletal system to a ground wave antenna. Our eyes are optical antennae. Our ears sonic antennae. Our skin optical, acoustic, electrical and thermic antennae. We listen to the Infrared, Microwave, Radiowave, Visible and slow driven Extremely Low Frequencies produced by the earth's resonant cavity [Schumann's resonator, the natural oscillations of the Earth's ionospheric cavity]. The cells move visibly in response to these electrical pulses by stimulating glands, triggering the heart muscles, and setting our overall moment to moment environment, beating of our hearts, etc.

The human organism maintains its functioning balance by a dynamic information exchange between its various systems and the environment. Information exchange occurs at all levels within the organism. Electromagnetic radiation may be seen as electrical and magnetic waves of information moving through space, atmospheric and the Earth's environment [Schumann's resonator]. They create a resonant coupling between atoms in biological molecules that allows them to move together in response to this very low amplitude of electromagnetic noise. The cells whisper and vibrate together as they receive these faint vibrations within and outside the body's resonant cavity.

A resonant cavity is an enclosed chamber that gives an electromagnetic presence a high Q factor, a relationship between stored energy and the rate of dissipation, in order to perpetuate the energy system. Without this ability to reintegrate energy, an energy system would simply burn out in chaos. Massive dissipative structures, like our bodies, should be called massive dissipative/replicative structures, for the property of replication [regeneration] of its microstructures has been largely deemphasized in "living" massive dissipative structures such as the human body. According to Chinese medical theory, our energies regroup and circulate by meridians, transversing the thorax, extremeties and head.

Resonant cavities are found throughout the human body. There are soft-walled cavities inside the human head, nasal cavity, etc. that contribute to the voice. The brain is a resonant cavity that generates an ensemble of frequency bands seen on an EEG. The electrical voltages generated by the brain summate into repeater bands as they migrate through the volume conductor to the scalp.

What sounds like ocean wave noise when you hold a shell up to your ear is actually just the movement of air across and through the shell traveling into your ear, also a resonant cavity. You could hear similar sounds if you were to hold any kind of bowl or container up to your ear. Try just cupping your hand up to your ear and you can see what I am talking about. In other words, you are really just hearing ambient noise within a resonant cavity. The sounds you hear will vary depending on the shape, size, and any convolutions over which the air flows to produce sound.

The functioning of cell membranes entail very great sensitivities both to vibrating electric fields and to molecular stimulation at extremely low energy levels. The cellular processes cooperate to bring about high amplification of these weak stimulus frequencies as a resonant cavity.

Recent research has shown that electromagnetic fields in the ELF (extremely low frequency) spectrum can change the characteristics of hormone, antibody, neurotransmitter and cancer-promoting molecules at the cell sites. These modulating actions of electromagnetic fields show highly cooperative processes within the biologic systems. The cells move visibly in response to electrical pulses which set the cellular surfaces move nutrients, electrolytes and wastes back and forth.

In the viewpoint of the interference patterns, the slow speed of needle sensation propagation, or Zhang's 'group speed of waves' within a wave guide begin to make sense. These naturally-occurring information signals bring about changes within the human body energy pathways, restructure body water resonances, modulate the DNA processes and stimulate other circadian rhythm entrainments. We are at a new beginning of our understanding of the body's energies.

Kuhn aptly pointed out that we have a situation where the observed phenomena no longer fits the paradigm, so a 'scientific revolution' might be imminent (1970). Are we are about to discover something new about a paraphysical physiology, which we can integrate with the prevailing paradigm, or do we create a new one? Empirical evidence over the last fifty years can no longer be discounted as subjective or without merit. The author has had many scientists and doctors sit in clinical residency watching me make amazing diagnoses that would take days under ordinary, clinical and hospital circumstances. The future for electrodermal diagnosis is brilliant, to say the least.

Conclusion

At present, two points have been clearly established: first, the classical acupuncture system, at least in part, has unique electrical characteristics which establish its objective physiological reality; and second, the points of Voll and the author have consistently proven a relative degree of accuracy to reflect the status of internal and regional organs and tissues in three modes:

1. Normotonia, healthy tissue;
2. Hypertonia, inflamed tissue; and
3. Hypotonia, degenerating tissue.

In a classic study at the University of Munich, Voll Electroacupuncture as a diagnostic method of the objectivity so-called focuses was regarded as a method by Sonnabend, Kurz and Redl, the authors summarized their critical experiences in a study as a relevance, which was a technique distant to orthodox medicine. They could indicate possibilities of electro acupuncture, but they pleaded clarification by intensive research. The summary of our results is represented in illustration:

· In 59 % of cases the results of the electroacupuncture test were congruent with positive, clinical and roentgenologic test.

· In 26 % of the cases negative electroacupuncture findings, clinical, roentgenological and electroacupuncture test were congruent, i. e. in 85 % of the cases corresponded.

· In 9 % of the cases there was a clinical and roentgenological test, but not electroacupuncture, and in 6

% the result was exactly opposite.
For the author, there are no doubts concerning the meaningfulness of this method of examination because of the considerable correlating results by 85 % showed by the researchers, and the two decades of summary experiences of the author.

The article "Case Findings from a Family Practioner's Office Using EAV" from the "American Journal of Acupuncture", (Vol. II, N1, 1983, page 23 - 29) by Prof. J. Tsuei and F. Lam describes eleven patients with different diagnosis tested by acupuncture of Voll. The internal specialists tests affirmed the found disorders (laboratory, roentgen, histology etc.). Six found melanomas were treated with operation and orthodox medicine, with metastatic condition shorten the life span of patients in five cases would seize already early stage of the diseases and thereby long time positive results could be attained.

In another EAV study, [Evoked Electrical conductivity on the Lung Acupuncture Points in Healthy Individuals and Confirmed Lung Cancer Patients] Sullivan, Eggleston, Martinoff, and Kroenig, at the U. C. L. A. School of Medicine, Los Angeles, tested 30 patients in comparison of x-ray picture and mesurement by electroacupuncture on the lung point on the hand between 26 "healthy lungs" and four carcinoma patients in a blind test dividing screen with limited view of the hands. It showed a clearly positive correlation between the measuring points and the pathologies. Several other works about special skin points with less electrical resistance were referred in this study.

L. Klinger, Heidelberg, in 1987 measuring with EAV points could make significant distinctions between patients with healthy and diseased lungs as TBC and lung carcinoma. (Z. Allg. Med. 63.563-567) The measuring points as the basis of EAV here could be documented positive.

· "Study on Bioenergy in Diabetes Mellitus Patients" Am. J. of Acupuncture 1989, 17 (1) 31 - 38 by *J. Tsuei, F. Lam and Z. Zhao*
Comparing measurement of 95 patients without Diabetes mellitus and 55 patient with Diabetes mellitus. The pancreas measuring points showed by hightened value and falling indicator with high accuracy for the disease. Therefore the EAV is considered as an effective and worthful method of diagnosis. These same results are recorded in the author's patient records of hundreds of diabetic patients. Pancreas Voll point 3 is most useful for Diabetes type II, while measurement point VXP often pinpoints the brittle diabetic.

In a clinical field study about conductivity measurements in EAV (Magazin for orthodox medicine 1979, 52, 304 - 311) by Siegfried Häussler, Wolfgang Köpcke and Karl Überla, where 18 established medical doctors took part in a study with 609 sick patients. The measurement conductivity was determined by the doctor and the physician's assistant, that the exact procedure of measurement could be affirmed. The exactness of the conductivity definitely is sufficient and is in same range like regular standard examination, i. e. the measurement of the blood pressure, vital signs, etc. The correlation of the point conductivities was provable. Furthers examinations are necessary to substantiate further hypothesis and to examine the clinical relevance according to the authors.

· Statistic evaluation by Rossman of measurement by EAV, Biological Medicine 4 (1985) shows the improvement of the measurement value of a standardized measuring protocol, which corresponds to the improvement of the patient's condition. H. Rossmann, Popp: Statistic of EAV, 1 & 2. Ärztezeitung f. Nat. 1 and 9, 1986; H. Rossmann: Is EAV to be proved statically? Accupuncture theory and praxis 4 (1986)

· In the cases of 116 chronic patients the results of EAV were compared by Fonk with those of laboratory. The laboratory results, assuming an intact immune system showed two cases with bacteriological cystitis were missed. On the other hand the EAV as diagnostic procedure independent from the immune reaction brings a lot of data. This is not only a diagnosis but a systematic therapy, whereby the extent of therapy depends on the ability of the immune systeme to regenerate. A typical case of chronic posterior uveitis was presented. Independently from the respective symptoms it is possible to prove a case of a typical constellation of findings. A common characteristic is the infections susceptibility and a triade disturbance in the ENT, intestinal, kidney and urological system. Overall symptom is a weakness of susceptibility of these patients is discussed, as a consequence of therapy with dominant suppressive medicine. Fonk, Ingrid: Seronegative Toxoplasmose. What the modern laboratory is able to do in case of insuffency of immune system? In: Voll, R.: New results of research by EAV. ML-Verlag, Uelzen, 1987

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