The measurement of action potentials with electrodes placed on the surface of injured or irritated tissue.

excerpt from the Promorpheus
(all figures and diagrams are in the Promorpheus)

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In this report we review the detection and treatment of injured tissue. In our testing procedure we use measurements of multiple voltage potential, amperage potential, and resistance vectors. We can determine the potentials as normal or as diseased from the experiences of energetic medicine. Once detected the computer can then repair these injured tissue with proper electrical stimulation.

The potential difference seen by the potential indicator is zero. When the tissue has been excited electrically to the left of electrode A; when the wave of excitation reaches the region under electrode A, it becomes negative with respect to electrode B and the indicator rises. As the wave of excitation passes onward toward electrode B and occupies the region between the two electrodes, the region under A is recovered and that under B has not yet become excited. There is no voltage potential under these conditions. The first (upward) phase of the monophasic action potential is thus complete. While the wave of excitation occupies the region under electrode B, the excitation wave becomes negative with respect to A, and hence the potential indicator will fall. Recovery occurs as the wave of excitation passes B, the membrane potential is re-established. The potential indicator reads zero. The downward phase of the action potential is thus complete. The time between onset of the action potentials is set by the velocity of propagation in the tissue and the spacing interval of the electrodes. As we reduce the inter-electrode distance, the two monophasic action potentials will be closer to each other. The time factors are such that excitation occurs under electrode B before recovery is complete under A, so a smaller action potential results.

This applies also to an isolated single strip or bundle of irritable tissues having the same propagation velocity. If the tissue consists of a bundle of fibers having different velocities of propagation, then the waves of excitation will arrive under each electrode at varying times. So the wave form displayed by the recording instrument will be very complex. It must also be recognized that the activity of the tissues closest to the recording electrodes will contribute the most to the recorded potential. If we filter out interference, it becomes easy to diagnose traumatized or injured tissue.

Experimentally it is possible to provide verification for the preceding explanation for the wave form of potential variance, which is recorded by two electrodes on the surface of an isolated strip of injured tissue. The frog sartorius muscle consists of a bundle of very similar muscle fibers running parallel for the whole length of the muscle. The application of a stimulus to one end of the muscle (curarized) will cause a wave of excitation to travel along each fiber at the same
rate. The waves will reach the end of the muscle at the same time. By recording the response with two widely separated electrodes, the diphasic action potential can be obtained; a typical result appears. If the electrode spacing is reduced so that the monophasic action potentials overlap (i.e., excitation of the distal electrode occurs before recovery at the proximal electrode), the action potential is that predicted by the preceding analysis.

Our recorded diphasic action potential permits determination of the direction of the spread of excitation. When the electrodes are closely spaced, the direction of the initial deflection of the potential indicator still provides this information if its deflection is known in terms of the polarity applied to its terminals. The polarity convention chosen was such that when electrode A was negative to electrode B, the indicator of the potential-measuring instrument rose. So when excitation traveled from A to B, the first phase of the action potential would be upward. If the tissue were excited at its opposite end (i.e., beyond B), electrode B would become negative first and the initial deflection of the potential indicator would be downward.

Electrically we can find foci of brain disturbance or heart dysfunction from multi-probed EEG or ECG channels.

We see that the meaning of the polarity of the potential difference between the electrodes has been devoted to the case of the spread of excitation being in the same direction as a line joining the electrodes. The orientation of the electrodes with respect to the direction of excitation and recovery is important. It can be shown by placing the electrodes opposite each other on the tissue and causing a wave of excitation to be propagated. If everything is symmetrical, dipolarization and repolarization will occur simultaneously under each electrode. The potential indicator will not be deflected as excitation and recovery pass. Acupuncture meridian cascade can also be demonstrated by multi-channel measurement of acupuncture points on a meridian.

Some tissue (especially cardiac muscle) will have excitation in all the tissue before recovery occurs under either electrode. Sometimes recovery does not travel in the same direction as excitation. Therefore, the action potentials recorded from a pair of electrodes on the surface of such tissue are expected to be different from those previously discussed (see "Cardiology", by Dr. Nelson).

In the Promorpheus we diagrams strips of isolated irritable tissue in which excitation occupies all the tissue before recovery occurs under either electrode. Assume that the tissue has been stimulated to the left of electrode A and that excitation advances and occupies the region under electrode A, making this electrode negative with respect to electrode B; with the polarity convention adopted, the potential voltage indicator rises. Excitation advances will occupy the region under electrode B. Recovery will not have occurred under electrode A and because both electrodes are now over active tissue, the indicator shows no potential difference, and the first upward phase of the action potential will result. If the strip of
irritable tissue is uniform, recovery will follow in the same direction as excitation, occurring first under electrode A.

Excitation and recovery propagated at right angles to the axis of a pair of electrodes on an isolated strip of irritable tissue. Under this condition, electrode B is negative with respect to A and the potential indicator falls. As recovery occurs under electrode B, the potential indicator reads zero and the second (downward) phase of the action potential is completed as shown in the Promophues.

As we see, the two monophasic action potentials have special meanings. The peak of the first upward monophasic action potential indicates excitation under electrode A; the end of this action potential indicates that the whole tissue is active. A downward wave indicates recovery starting under electrode A and recovery under this electrode becomes complete when the peak of the downward action potential is reached. Completion of the downward action potential shows full recovery of the tissue.

If there exists a metabolic gradient in irritable tissue, the sequence of events will be different. If, when all of the tissue is active, recovery proceeds in the direction opposite that of excitation, the second phase of the action potential will be different. Recovery appears first under electrode B, resulting in electrode A being negative with respect to B (Fig. F). Thus the potential indicator will rise and the second phase of the action potential will be upward (i.e., in the same direction as the first). As the tissue covers under electrode A, the second (upward) phase of the action potential results.

As presented, the peak of the first upward phase described excitation under electrode A. At the end of the first monophasic action potential, when the indicator read zero, the whole tissue was active. The beginning of the second upward phase indicated the start of recovery under electrode B; total recovery occurred when the second upward monophasic action potential was completed. To summarize, in tissue that is totally occupied by excitation before recovery occurs anywhere, if the two phases of the action potential are in the opposite direction, excitation and recovery travel in the same direction. This implies general skin voltage readings, not acupuncture points. If the two phases are in the same direction, excitation and recovery travel in opposite directions. This can often be found in the heart of a cold-blooded animal and in homogenous tissue; the latter is characteristic of the mammalian ventricles. Acupuncture meridians show the characteristic voltage changes, but follow uncharacteristic impedance variance from other skin tissue. This phenomenon accounts for electroacupuncture.
Injured Tissue Effects On Action Potential

A surprising observation associated with the measurement of action potentials with extracellular electrodes, applied directly to injured tissue, is the appearance of wave forms that resemble, to a remarkable degree, those obtained with transmembrane electrodes. Many papers presenting such records usually state that one electrode was placed on uninjured tissue and the other was over injured tissue. This allows for the electrical location of trauma cases and a quantifiable means of rating the injury. Such a sophisticated instrument is manufactured by QXCI. This instrument can be passed down the spine to measure voltage, amperage, resistance, and temperature of the skin next to the vertebrae. From this we can measure spinal injuries quite accurately.

As we have demonstrated, if two electrodes are placed on the surface of a uniform strip of irritable tissue, a diphasic action potential is recorded when the tissue responds to a stimulus. Excitation and recovery under the first electrode are found in the first phase; the second indicates the same event under the second electrode. If the two electrodes are close together, the phases will be temporally closer. If one of the surface electrodes is advanced through the membrane into the cell, the membrane potential appears. If the cell is excited, the monophasic action potential will be recorded rising from, and returning to, the resting membrane potential. This shows two boundary conditions (i.e., both electrodes are extracellular), which give rise to the idealized diphasic action potential; when one electrode is extracellular and the other is intracellular, the idealized monophasic action potential results. Imagine a strip of irritable tissue, injured at one end (i.e., depolarized) by crushing at B as in Fig. G. The membrane potential is not fully maintained all the way to the site of injury.

Graham and Gerard (1946) used frog sartorius muscle and explored the potential along the membrane with transmembrane electrodes up to and within the site of injury. It was found that the potential between the exploring electrode was within 5 mm of the site of injury. As electrode B was moved toward the cut end, the potential decreased; at 2 mm from the site of injury, the potential was twenty-five percent of the membrane potential. Graham and Gerard placed one electrode on the intact surface of a muscle cell and another in the region of injury, comparing the potential difference so measured with the resting membrane potential. The injury potential was thirty to thirty-nine percent of the membrane potential. This accounts for electrical measurement of tissue.

At the site of injury the spatial distribution of membrane potential, whatever it may be, causes current to flow through the fluid environment. Thus in the fluid there will be established more electrical current, or amps.

This is necessary to provide greater electrical flow for rebuilding and reconstruction. Consequently, the potential measured between an electrode inside the cell and one at the site of injury will depend on the local conditions at the site of injury and the position of the electrode in the fluid environment. If this potential (the injury
potential) is measured under optimum conditions, it may amount to slightly more than one-third of the membrane potential. The same type of information developed by Woodbury and others (1951) demonstrated that if the diameter of an intracellular electrode is large with respect to the size of a cell, the potential measured is considerably less than the membrane potential and approximated thirty percent of the true membrane potential. It is apparent that a typical injury potential may be about one-third of the membrane potential. This will allow us to measure the probability of injury in the body.

This situation has an important implication when an action potential is measured with one electrode on the surface of an irritable tissue and the other in an area of injury. Suppose that before excitation, the resting membrane potential is -70 mV, that electrode A is on the intact surface of the irritable tissue, and that electrode B is in the site of injury. Under this condition the potential difference between the electrodes may be thirty-five percent of the membrane potential and amount to about -25 mV. Now if the tissue is stimulated to the left of electrode A, when excitation reaches this electrode the potential difference measured between the electrodes will be the algebraic sum of the potentials at the two electrodes. For example, assume that the membrane depolarizes and reverse polarizes to +20 mV; the potential difference was -25 mV just before depolarization and +65 mV at the peak of reverse polarization. It will then return to -25 mV when the wave of excitation passes the surface electrode. This sequence illustrates that a fair representation of the wave form of the transmembrane action potential can be obtained by injuring the tissue under one electrode. Important to note that, although the magnitude of the reverse polarization of the membrane amounted to only 20 mV, in the record it showed up as a much larger potential of +65 mV. This situation probably serves to explain the considerable reverse potential observed by Bernstein (1871) when he measured the nerve action potential with the rheotome (see Hoff and Geddes, 1957).

There is another point to consider when the action potential is measured with one electrode on an intact membrane and the other in a region of injury. Before excitation there will be a standing potential difference (the injury potential), whose magnitude will depend primarily on the location of the electrode at the site of injury. If electrode B is over the injured area, an appreciable percentage of the membrane potential may be detected; if it is moved a short distance from the site of injury and is over-excitble tissue, the steady (injury) potential difference between the electrodes will be less. Now if the tissue is excited and excitation and recovery passes under the surface electrode, the usual monophasic action potential will occur, superimposed on a baseline of the injury potential. If the strip of irritable tissue is long with respect to the time of propagation of the impulse and the amount of tissue occupied by excitation is small with respect to the inter-electrode distance, excitation and recovery will take place under the first electrode before it enters the region of electrode B, which is near the area of injury. Electrode B may also be close to uninjured tissue, and therefore detect not only the injury potential but also an attenuated action potential as it advances toward the area of injury. Thus the
resulting action potential measured between the two electrodes will be diphasic, consisting of a large monophasic action potential superimposed on the injury potential, followed by a smaller monophasic action potential in the opposite direction reflecting what electrode B detects from the depolarization and repolarization of normal tissue near the site of injury. This is a factor used by QXCI machinery to find improper reactivity or to correlate proper reactivity.

If we move the electrodes together, or if the area of the tissue occupied by excitation is great compared to the inter-electrode distance, the smaller downward phase of the action potential will be moved towards the upward phase. A type of this wave form is often recorded when a needle electrode inserted into active tissue is compared to another electrode on uninjured tissue (see Quantum Biology).

Multiple Measurement of Irritable Tissues. Previously we analyzed the situation involving the potential expected from electrodes on the surface of a strip of isolated injured tissue. We can predict the anticipated potential from electrodes on a bundle of isolated irritable tissues. In particular, this line of reasoning has value in explaining the action potentials recorded from the surface of a nerve trunk and the effect of injury determining the action potentials recorded from myocardial tissue. Sometimes the analysis is better performed by use of the dipole concept.

The injury and monophasic action potential.

Imagine a bundle of irritable fibers with similar propagation velocity. Place on the surface of the bundle one electrode, and place the other electrode at the cut (injured) end. Without excitation there will be a standing potential difference (the injury potential) between the electrodes. If we stimulate the fibers at the end opposite the cut, all the propagated excitations will pass by the surface electrode at the same time. The surface electrode will preferentially detect the action potentials in fiber 1, which is immediately under it. The action potentials in the more distant underlying fibers will also be detected, but the more distant fibers will contribute less to the voltage detected by the surface electrode. In accordance with Fig. H, the resulting action potential will be a combination of all the action potentials of the local and distant fibers. Because all fibers were chosen to be identical, the action potential will be a smooth monophasic wave; no action potentials will be detected at the site of injury.

If we do not stimulate the individual fibers simultaneously, as for example in skeletal muscle by nerve stimulation, the action potentials of the individual fibers will not pass under the surface electrode synchronously. The potential between the electrodes reflects this situation and the action potential recorded. The potential will still be unidirectional and polyphasic. The form of the potential will reflect the temporal pattern of excitation and the spatial distribution and velocities of propagation of the various fibers.

This is by no means uncommon in the routine measurement of bioelectric events with local extracellular electrodes. In nerve trunks, a spatial distribution of
fibers has various diameters. Velocities of propagation are related to fiber diameters. Larger fibers propagate excitation much more rapidly than the smaller ones. When we stimulate all the fibers simultaneously, we induce a larger time separation between the action potentials of the rapidly and slowly propagating fibers. Sequential action potentials can then be detected by a surface electrode. This is how the variances in nerve conduction velocity were found by Erlanger and Gasser (1937). Their Nobel Prize-winning study and experiments with some sample oscillograms are found in Fig. I. The investigators employed injured tissue to obtain unit activity. They proved that the propagation velocity in nerve is related to fiber diameter. Erlanger and Gasser demonstrated that the wave form of the action potential recorded by a surface electrode placed on a mixed nerve trunk, in which all of the axons are stimulated simultaneously, will depend on the propagation velocities and the distance from the point of stimulation to the active (surface) electrode. The electrode can detect the action potentials of the fibers below it. Electrodes in the more distant fibers will contribute less to the recorded action potential.

Transmembrane potential and current changes in the giant barnacle muscle in response to square-wave stimuli. The graded response to an increase in stimulus intensity is shown in C1; local spike formations produced by first decreasing the intracellular concentration of calcium and then varying the extracellular calcium concentration (20, 84, 338 mM).

The action potentials of a nerve trunk containing a population of fibers having different diameters and therefore different propagation velocities: (a) recording method; (b) action potentials from the fastest propagating fibers (A...), (c) action potentials B and C from the fibers with slower propagation velocity.

Action potentials of a mixed nerve recorded with a pair of surface electrodes during physiological activation of its neurones (or receptors) will reflect the asynchrony of activation of the axons. Also reflected are differences in their propagation velocities, and the electrode separation. Action potentials have a similar asynchrony as the activity of skeletal muscle is recorded. Here we demonstrate skeletal muscle where there is a spatial distribution of motor end plates. If all the axons were excited simultaneously by a single stimulus, all the muscle fibers would not be excited simultaneously. An electrode close to the end of the muscle will detect the action potentials of the individual fibers as they arrive at various times because of the distances from the end plates. Action potential recorded will be polyphasic. If motor neurones are activated physiologically, simultaneous excitation does not occur. There will be an added asynchrony to the arrival of the action potentials under the muscle electrode, and the electrical activity will consist of a train of action potentials.

Local potential changes under the cathode and anode with increasing stimulus intensity. Note that under the cathode, when the stimulus intensity reduced the local
potential to about 0.38 of the amplitude of an action potential, excitation occurred; excitation did not occur under the anode with increasing stimulus intensity

Electrophysical Interference

Previously we have dealt with the case of electrodes placed on the surface of isolated active tissue and in regions of injury. When both electrodes are placed on the surface of a bundle of fibers or group of cells, the electrical potential measured will show the time change factors of arrival of excitation to each electrode. The distances of the individual fibers from each electrode are also revealed. Algebraic summation over time is often called the interference theory, originating with Burdon Sanderson (1879). They explained the genesis of the QRS and T waves of the ECG from the monophasic action potentials recorded by each electrode. If a pair of electrodes is placed on a bundle of similar uninjured fibers that are excited asynchronously, or on a bundle of dissimilar fibers excited synchronously, then interference theory says that the action potential appearing between the electrodes will be polyphasic and complex.

The interference theory has value in explaining some electrocardiographic wave forms. This theory is particularly handy in explaining the contribution of injury to the ECG. The true form of ECG action potential was first recorded with transmembrane electrodes much later by Coraboeuf and Weidmann (1949). Sanderson showed that the addition of two temporally displaced monophasic action potentials recorded from the ventricle of a frog gave rise to the R and T waves. The interference theory in ECG is also posited by Lewis (1925) and Hoff et al. (1941). The dipole concept is a better way of viewing the genesis of some of the electrocardiographic wave forms, particularly when recorded with a "monopolar" electrode, but the interference theory is still helpful and may be applied to the situation in which a pair of electrodes are placed on the surface of cardiac muscle. Modification of this with modern fractal theory (QXCI) can peak electrical reactivity for medical use.

Assume that a pair of electrodes is placed on the surface of intact cardiac muscle and that excitation and recovery of each of the cardiac muscle fibers will contribute a potential to each electrode. The effect diminishes with distance. Experience shows the amount of potential contributed by fibers at different depths to electrodes A and B. We know that active tissue is electronegative to inactive tissue plus active tissue under electrode A moves the potential indicator in one direction and active tissue under electrode B will cause the potential indicator to move in the opposite direction. Thus the contributions of potential to the active fibers under electrode B are drawn inverted. Injury to tissue will generate irregularities in the heart beat. Thus the entire field of electro-cardiology is indeed an established energetic medicine.

The interference theory states that the potential difference recorded between terminals A and B is the algebraic sum of the temporal development of voltages provided by the active fibers under each electrode. A typical summation of these
potentials appears, which diagrams genesis of the R and T waves of the electrogram of simple ventricular myocardium. If recovery occurs earlier under electrode B than A, the duration of the monophasic action potential under B will be less and the T wave will be upward.

The potentials from electrodes placed on the surface of cardiac muscle.

If some of the myocardial fibers under electrode B are now injured, such as by ischemia, the electrical activity detected by electrode B will be altered. Figs. K.A and K.B show tissue injury under electrode B at the level of the fibers corresponding to depth 2. There will be no excursion in membrane potential in the region, and there will be a standing injury potential. The growing excitation over the myocardial fibers under electrode A will thus produce normal monophasic action potentials. Excitation passing under electrode B will produce monophasic action potentials in the uninjured fibers and nothing but a standing injury potential from the area of injury. The temporal summation of action potentials under electrode B will be less (Sum B), and the potential indicator will reflect the sum of the action potentials detected by electrode A (Sum A), the sum detected by electrode B (Sum B), and the standing injury potential.

Action potentials of injured cardiac muscle idealized by use of the interference theory.

The fractal calculus sum of these three components over time reveals that the R wave starts at the level of the injury potential and rises and falls, reaching a plateau of zero potential when all the tissue is depolarized; this is the S-T segment. When the injured tissue recovers, the T wave will end at the level of the injury potential. The elevation in the S-T segment (actually a depression of the diastolic baseline) is the principle sign of injury to the ventricular myocardium. Whether it appears as an S-T segment elevation or depression depends, of course, on the proximity of the injury to one electrode or the other. (See "Cardiology" by Dr. Nelson).

We have demonstrated that when electrodes are placed on irritable tissue, the potential measured reflects the excitatory and recovery process in the individual tissues as the active tissues are excited and the electrodes are strategically located with respect to the electrodes. We will know the presence or absence of an injury potential in the tissues. Whether the action potential will have upward and downward components will depend on whether one electrode is located in an area of injury or not and the sequence of recovery. Multi-channel equipment, such as the QXCI technologies, is needed to analyze such disturbances. How could anyone do energetic medicine with just one channel?

Dipole Effect. In the practical measurement of a bioelectric event it is often impossible to place both extracellular electrodes directly on the irritable tissue; one may be nearby and the other at a considerable distance, constituting a reference or "indifferent" electrode. The principal difference between this method of measurement and that featuring electrodes directly in contact with the irritable tissue is that the potentials measured reflect the flow of current in the conducting
environment surrounding the active region of the irritable tissue. Bernstein’s pupil Hermann (1879) first presented this; it was later extended by Craib (1927), Wilson et al. (1933), and Macleod (1938) to include cardiac muscle. Verification of its applicability to human electrocardiography has been presented by Hecht and Woodbury (1950).

Whenever a source of potential (a volume conductor) current flows, a potential field is generated. This illustrates the manner in which the potential field is distributed. The iso-potential lines (of which there is an infinite number) describe the potential measured by a “monopolar” electrode located anywhere in the environment of the dipole when referred to another electrode in a region of zero potential (i.e., at an infinite distance or on the zero iso-potential line passing midway between the poles of the dipole). Imagine now that a monopolar electrode starts from a remote point and is moved along a line (d = 1) parallel to the dipole axis (the line joining its positive and negative poles); the iso-potential lines are encountered in an orderly sequence and the potential will first increase, then fall to zero (when the electrode is over the midpoint of the dipole), then reverse polarity and increase magnitude, and then decrease as the electrode is moved further away. It should be noted that the same sequence will be measured if the electrode is fixed and the dipole moves. If the procedure were repeated by moving the monopolar electrode along another line parallel to the dipole axis but more distant (d = 2), the same sequence of events would occur, but the magnitude of the excursion in voltage would be less (d = 2). Quantic derivatives are not much different. They involve indeterminacy, probability and hermitian matrices. See Quantum Biology for more details.

The dipole and its field of potential: (a) potential distribution; (b) potential encountered by exploring electrode moving along lines (d = 1, d = 2) parallel to the dipole axis.

The dipole concept is illustrated in Fig. L, in which a shows a long strip of irritable tissue at rest. "Monopolar" is the term for the potential Vp at a nearby point P, which is measured with respect to a truly indifferent electrode. An indifferent electrode is one at an infinite distance in the conducting environment, the potential will be essentially zero. When tissue is electrically stimulated, the active region (which is negative to the resting region) will cause current to flow in the conducting environment and to establish a potential field. Because the boundary between the active and inactive regions is characterized by charges of opposite sign, the wave front of excitation are equal to a dipole with its positive pole facing the direction of propagation of excitation. Whenever the active region is in a large segment of the irritable tissue, we find that the potential changes appearing at the point P are those displaying the dipole accompanied by its potential field as it moves by. The potential difference appearing between a nearby electrode and a distant reference electrode is clearly diphasic (positive followed by negative) as the wave of excitation passes the nearby electrode. Even if the polarity chosen for the indicator goes up or down, which is controlled by the convention adopted.
Similar reasoning can be used to even the recovery diagrammed in Fig. M. Since the active area is negative to inactive tissue, recovery can be similar to a dipole with its negative pole facing the direction of progressing recovery. Therefore, passage of recovery by the nearby measuring electrode will produce a negative-positive variation in potential. Of greater concern is the phenomenon of electrical reactance. Reactance is defined as a change in capacitance to an inductance field. This produces changes in resistance over time. Thus we can easily interrupt the phenomenon of medication testing. Since there is a proven virtual biophoton field around all items, this field can produce a change in the bioelectrical pattern of the body. This reactance peaks on the acupuncture meridians; mostly near the wrist, ankles, fingers and toes. These acupuncture points are near the peripheral points of the body. Voltage drops with volume of material. So the points near the periphery have peak voltage. The interaction of medication reactivity and electrophysiology offers the world of medicine dramatic potentials.

From the foregoing it can be seen that when excitation goes by a nearby monopolar electrode a diphasic (positive-negative) potential change is recorded. If recovery passes in the same direction as excitation, a negative-positive diphasic potential change is measured. If the active region is small, the time between excitation and recovery will be brief. The two diphasic waves will be proximal and may indeed overlap, resulting in a complex positive-negative-positive wave form to signal passage of excitation and recovery. Fig. N clarifies this point by showing the effect of decreasing the width S of the active region.

The field pattern surrounding an active region of nerve on a conducting plane and its relation to the dipole concept and the action potentials recorded from different points on the conducting plane. (Redrawn after Lorente de Nú, A Study of Nerve Physiology. New York: Rockefeller Institute, 1947, Part 2. Chapter 16.

Lorente de Nú found that the dipole concept could be measured in vivo by femoral exposure of a branch of the sciatic nerve of a frog measured by antidromical stimulation, and then recording action potentials with a metal microelectrode placed at sites on the adjacent muscle. Fig. O, which shows the recording he obtained, demonstrates the two theorem results of this theory: 1) that passage of the wave of excitation and recovery gives a triphasic action potential, and 2) that the recorded amplitude diminishes with increasing distance from the irritable tissue (nerve).

The applicability of the dipole concept to human electrocardiography was presented by Hecht and Woodbury (1950). They utilized a monopolar esophageal electrode to record the action potential in excitation of the atria. The researchers compared this potential with those obtained by moving a dipole past a local monopolar electrode in a volume conductor. The signal was deflected positively by an upward deflection of the potential indicator. Hecht and Woodbury pointed out that the equivalent dipole of excitation is actually a band of dipoles in which there is a spacing between the poles that represents the transition boundary layer between active (-) and resting (+) tissue. Similar electrical dipole reactivity patterns can be demonstrated along acupuncture meridians. These patterns show a neurological
similarity to an acupuncture meridian where no nerves exist. Acupuncture yields a transfer of electrical patterns that moderate organ systems and make health possible. Electroacupuncture, with its tens of hundreds of thousands of practitioners, is indeed here to stay.

Extracellular action potentials recorded in situ from the stimulated (s) bullfrog sciatic nerve (n) on the right side of the animal. The numbers on the recordings in the vicinity of the nerve identify the locations of the monopolar metal microelectrode (tip radius 20'); the "indifferent (ground) electrode was placed on the left leg.

Dipole theory outlines that excitation and recovery are viewed as traveling dipoles. Recordings are made with a considerable spatial distribution of dipoles. Depolarization is rapid and the transition between active and inactive tissue occupies only a short distance. The wave form representing excitation usually adjusts to that predicted by a traveling dipole. Recovery time is much less, however, and it is unevenly distributed over a greater amount of tissue. The wave form representing recovery is usually less in amplitude and greater in duration. Macleod (1938) demonstrated this difference in studies using the dipole theory explaining the recovery (T) wave of an ECG that was recorded with an electrode pair. The pair consists of one active and one "indifferent" (reference) electrode. Macleod described an application of the dipole concept to cardiac muscle. This also explains why irritable tissue is to be considered in the practical application of the dipole concept. Macleod wrote (1938):

Muscle does not become active instantaneously. The active process spreads with a given velocity so that one length of muscle will be coming active, another will be fully active, and a third will be regressing from the active state. The lengths that are in transition are the distances over which the potential difference which exists between resting and active muscle must be distributed. It is possible to represent the potential difference either by a chain of doublets [dipoles] distributed along the transitional region or by a single positive and a single negative pole located at its beginning and end, respectively. Conversely the length of the doublet chain or the distance apart of the positive and negative poles measures the length of the transitional region.

The distances between the poles of the dipoles of excitation and recovery are expected to be different.

The dipole concept predicting the potential recorded with a monopolar electrode is obviously very greatly simplified. We must use caution in extrapolating it to all in vivo situations. It is extremely complex. Consider what might happen if both electrodes are in the environment of the active tissue (i.e., one electrode not in a region of zero potential). Realize that the in vivo environmental conducting medium does not extend to infinity in all directions and is constituted by inhomogeneous tissue. Thus a relatively complex wave form, reflecting excitation and recovery, can be detected by extracellular electrodes. Accurate prediction of
the wave form is impossible in many practical circumstances. But our theories generate an approximate "map" to guide us in our intervention.

Extracellular Potentials Across the Membrane. There is no easy way to relate the action potential detected by an external monopolar electrode (i.e., one paired with an indifferent electrode) to the transmembrane potential. No simple and constant relationship can be attained since there are environmental inhomogeneities of various kinds.

If an irritable tissue in a volume conductor becomes active, there is a current flow in the environment and a potential field results. A monopolar electrode detects the potential due to the flow of current through the resistance of the environmental material. The current surge starts the active region of the membrane, which experiences an excursion in potential. In the field theory (Lorente de Nú, 1947; Clark and Plonsey, 1968; Plonsey, 1969) and with the cable analog (Huxley and St_mpfil, 1949; Tasaki, 1959; Clark and Plonsey, 1966) we show that the membrane current does not have the same wave form as the excursion in transmembrane potential. The mathematical analysis puts forward the case of a cylindrical irritable tissue located in a uniform volume conductor, showed that the membrane current is proportional to the second derivative of the transmembrane potential.

Membrane~ Current~ = d sup 2 over dT~ (Transmembrane~ Volt.)

The cable analog for a long, cylindrical, irritable cell can be used to show that the external action potential detected by a nearby monopolar electrode in the environmental volume conductor is proportional to the second derivative of the transmembrane action potential. Allow the environment as a resistance having a value r/l/unit length; similarly, the resistance per unit length of the cytoplasm is designated r2.

During activity there is a current flow in the environment i_l, in the cytoplasm i_2, and through the membrane i_m. In Fig. P the currents are identified, along with the coordinate system in which x increase to the right. There is a decrement in current within and without the cell, and this decrement reflects the current i_m flowing through the membrane. Because of the current flow, at any point there are potentials developed: at a point outside the cell, a potential V_l will exist and within the cell a potential V_2 will exist.

Since the membrane current i_m is the decrement in the cytoplasmic and environmental current,

i sub m~ =~ {partial i sub 2} over {partial x}~~~ \and~~~ i sub m~ =~ {- partial i sub l} over {partial x}

Cytoplasmic and environmental potential gradients exist because there is current flow, therefore

{partial V sub 2} over {partial x}~ =~ i sub 2 r sub 2~~~ \and~~~ {partial V sub l} over {partial x}~ =~ i sub l r sub l

from which
\[
\frac{\partial^2 V_2}{\partial x^2} = r_2 \frac{\partial^2 i_2}{\partial x^2} \quad \text{and} \quad \frac{\partial^2 V_l}{\partial x^2} = r_l \frac{\partial^2 i_l}{\partial x^2}
\]

Now
\[r_2 i_m = \frac{\partial^2 V_2}{\partial x^2} \quad \text{and} \quad r_l i_m = -\frac{\partial^2 V_l}{\partial x^2}\]

Therefore
\[r_2 i_m = \frac{\partial^2 V_2}{\partial x^2} \quad \text{and} \quad r_l i_m = -\frac{\partial^2 V_l}{\partial x^2}\]

In Quantum Biophysics we can quantify these readings and show that at the cellular level these functions are quantic.

Because the transmembrane potential \(V_m\) is the difference between the potential outside \(V_2\) and inside \(V_l\) the cell,
\[V_m = V_2 - V_l\]

Therefore
\[\frac{\partial^2 V_m}{\partial x^2} = \frac{\partial^2 V_2}{\partial x^2} - \frac{\partial^2 V_l}{\partial x^2} = r_2 i_m + r_l i_m = i_m (r_l + r_2)\]

Now because the excursion in membrane potential is a wave that is propagated with a constant velocity \(u\) and without decrement, it can be represented by
\[V_m = \text{left}(t - \frac{x}{u}\text{right})\]

This expression satisfies the wave equation
\[\frac{\partial^2 V_m}{\partial x^2} = \frac{1}{u^2} \frac{\partial^2 V_m}{\partial t^2}\]

We thus have shown that the membrane current is proportional to the second derivative of the transmembrane potential with respect to time. Tasaki (1959) recorded simultaneously the membrane current and the transmembrane action potential of the squid giant axon. “The membrane current \(i_m\) was detected by forcing it to flow through a low value of resistance \(r\), connected to a small central pool of seawater 2 mm wide; on either side of this pool, and insulated from it, were two other pools containing electrodes joined together and connected to the other side of the resistor. The potential difference appearing across \(r\) was found to be proportional to the membrane current flowing during activity on the application of a stimulus (square wave) to one end of the nerve. The transmembrane potential of the central segment of the nerve was measured by inserting a micropipet into the axon.” The voltage appearing across \(r\) and that detected by the micropipet were applied to two amplifiers \(A_l\) and \(A_v\), whose outputs are shown in Fig. Q. The transmembrane
potential is a monophasic wave, but the membrane current has an entirely different wave form, and is, in fact, decidedly triphasic.

Our cable theory predicts that the membrane current varies as the second derivative of the transmembrane potential; the study carried out by Tasaki allows analysis. Our quantum matrix will allow us to properly chart out the electrical patterns of health and disease, and furnish a true energetic medicine.

Our comparison of the second derivative of the transmembrane potential b with the membrane current c reveals that they have the same general contour. The difference is probably due to experimental limitations. In the theoretical derivation electrode size and cell dimensions were not considered; potentials and currents were said to exist at various points. Experimentally, neither the axon nor the electrode pair was infinitely small; nor did the volume conductor environment extend to infinity in all directions. Still, with these limitations, there is a reasonable similarity between the wave form of the membrane current and the second derivative of transmembrane potential.

Since the wave form of the membrane current is proportional to the second derivative of the transmembrane potential, the potential detected by a local monopolar electrode should also be proportional to the second derivative of the transmembrane potential. An experiment was designed so that a specimen (2 x 1 mm) of dog Purkinje fiber was placed in a 3-ml beaker of oxygenated Krebs-Ringer solution and connected to a tiny bipolar simulating electrode that was connected to a stimulator having an isolated output circuit. An electrode was placed in the solution about 15 mm distant, and the potential developed in the solution (when the specimen was stimulated) was measured with a 1-' micropipet filled with 3M potassium chloride.

A single stimuli was administered as the tip of the micropipet was brought toward the specimen from a distance of about 3 mm and continuing until the tip of the micropipet penetrated the membrane of a Purkinje fiber F. A gentle increase in amplitude was obtained with almost no change in the wave form (A-E) until a cell membrane was penetrated. Then the transmembrane potential excursion could be measured (F), demonstrating a quite different wave form with a much larger excursion in potential. The second derivative of the transmembrane potential is very much like the extracellularly recorded action potentials A-E.

The membrane current is proportional to the second derivative of the transmembrane potential. Because the membrane current flows through the environment, the potential detected by a local monopolar electrode is believed to be proportional to the second derivative of the membrane potential. As the monopolar electrode is moved more distant, the wave form is the same, and the amplitude becomes diminished. However, reactance is released.
Reactivity, or reactance, is the key to medication testing. To maximize this phenomenon we must maximize the force of life in our patients. We must also analyze the variability and the indeterminacy of this process. There are statistical limitations to this phenomenon. To maximize medication testing, we must also:

1. Test substances singularly without energetic complications. Use QXCI technology.
2. Measure multiple channels.
3. Measure multiple electrical parameters beyond only resistance; i.e., voltage, amperage, capacitance, inductance.
4. Involve proper medical history and scientific reasoning.
5. Understand the flow matrix of quantic theory to chart out the electrical functions of the body.

As we have shown in other parts of our book, some of the factors of electromotive reactivity in the body have hormonal correlates. Catecholamines have a correlate with voltage, in that the different adrenaline-like compounds act as voltage stimulators, and thus, amperage regulators. The indolamines will act as amperage stimulators and voltage regulators. Thus the entire precept of the body in analyzing its hormonal and electrical components can be done through our quantic philosophy, as we understand how the cells unite to make multicellular organisms such as the human body.

When there are conditions of hypoadrenia, or deficiencies in the catecholamines, this will result in a parasympathetic dominance, a release of histamines, and a susceptibility to various swellings of the tissue that the histamines predominate. These histamines will cause alkaline shifts in the tissue, which is another electrical component; and thus accumulate water. So irritations of sinusitis, asthma, irritable bowel, hives, and other allergic symptoms can result. This involves voltage deficiency. Thus by adding volts to the body we do not correct the basic deficiency of the catecholamine weakness.

Depression is often a case of a deficiency of the indolamine compounds, which means that there could be a deficiency in the amperage quality of the body, and also voltage regulation. Thus by supplying amperage to the body we do not correct some of the deficiencies of the indolamine compounds. The inverse can happen in psychotic reactions, where there are too many brain hormones.

So here we can see some of the very basic diseases which can be detected by the overall measures of the human body, which also can detect and help to chart therapy courses for correction. The purpose of this book is to outline some of the basic science behind these technologies. Our further publications go into the correction factors of how these things must be dealt with in a medical setting. Let us recount that this book is to direct a new thought pattern away from the pure chemical
forces and into a chemical-electromagnetic, physiological, psychological, true, holistic medicine which can be analyzed from quantum physics.

The human beings have distinct electrical patterns. Each person has a trivector signature of voltage amperage and resistance profile. This sets up a band of capacitance and inductance bands for each person. The body has electron and subspace transport systems for communicating energy and information. The nerves are distinct control areas for the flow. Within the band of electrical dynamics of the nervous system the individual nerves act with more distinct electrical signatures. Thus if the parasympathetic system has a reactance band of 150 to 175 siemens, the vagus nerve might have a reactance band of 150 to 157. The resonant frequency of the nerve will also thus be more specific for each nerve versus the more general pattern of the nervous system it belongs to.

To measure these patterns we need to first measure the overall electrical pattern of the patient. This includes the resistance, impedance, voltage, amperage, capacitance, inductance, resonant and harmonic frequencies, pH, eh, reactance, polarity, evoked potential, etc. Evoked potential is the reactance pattern of a subject to an applied stimulus. Then we measure the individual nerval reactions of these patients in the context of the individual patterns. Then the specific nerval reactions can be measured in the same fashion. Attempts to measure just one parameter such as resistance or resonant frequency will be grossly inaccurate. Instead a fractal dynamics of nonlinear data analysis must be used for the best results. Then thousands of subjects need to be analyzed for pattern similarity. After 12 years of analysis a computer program capable of performing the vast numbers of individual analysis has been developed.

The end resulting computer program can now analyze and treat nerves and nerval systems. Only by systemic analysis of the electrical trivector signature can the patterns be best analyzed. The computer can set up an interactive handshake analysis. A cybernetic link can be established where the computer can treat check and retreat in a consistent loop till the energetic imperfection is abolished, corrected, or till the system refuses to respond. Any more therapy would be unwise. The old style systems where just one way therapies without cybernetic feedback. Simply put this computer can interact during therapy with the patient to adjust the therapy for individual needs. By using the mathematics in this chapter and the rest of this book anyone of superior intelligence and with 5 years of work could develop a device like the Quantum Med C.I.
**SUMMARY**

1. In this chapter we reviewed some of the uses and measurement factors of electro-medicine. We can see how some of the practical measures of electro-medicine have been used to develop electro-medicine systems. These and other analytical systems are now available in the Quantum Med C.I.

2. We further proved the need for an electro-medicine in biology to study the electrical factors of the human organism.

3. The allocation and need for development has been outlined for more research into the field of electro-medicine.

4. Outline of volts, amps, resistance, impedance, capacitance, inductance, and oscillation proves necessary for electro-medicine.

5. The varying electrophysiology of injured versus healthy tissue was reviewed. This was used in developing QXCI - related technology used in the Quantum Med C.I.

6. Reactance, or medication, has boundaries of measurement. There are ways to maximize the medication testing phenomenon.

_For a more complete information review get a copy of the Pormorpheus._