Report

HAROLD BURR'S BIOFIELDS MEASURING THE ELECTROMAGNETICS OF LIFE

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ABSTRACT

In 1937, Harold Saxton Burr, Ph.D., a Professor of Anatomy at the Yale University School of Medicine, began a series of experiments that sought to measure and characterize the "bio-magnetic field" associated with living organisms. Burr steadfastly believed that life not only *exhibited* electromagnetic properties, but that these same properties were, in his words, "the organizing principle" that kept living tissue from falling into a chaotic state. He provided incontrovertible evidence for this belief both with sophisticated electrical measurements, and also by being the first person to demonstrate the extraordinarily significant hypothesis that the appearance of physical illness (cancer, in this case) occurs *after* a measurable change in the organism's electric field. This paper reviews Burr's electromagnetic measurements from the perspective of its author's background in electrical engineering. It provides an overview of the many technical challenges Burr had to overcome in making precise electrical measurements ofbiological systems using technology that is considered primitive by today's standards. The instruments that Burr devised are remarkable for their time, rivaling in their pioneering genius Burr's revolutionary contributions to the scientific understanding ofthe organizing principles animating all life.

KEYWORDS: biofield, bio-electric field, embryo development, electromagnetic measurement, salamander egg, cancer

Harold Burr, in 1937, set out to address four fundamental questions about the electromagnetics of living systems:

1. Do living organisms possess steady state (i.e., direct current) voltage levels?

2. Can these voltage levels be assessed in a manner that is free from the usual ambiguities of electrical measurement such as random variations in the electrical resistance and flow in the specimen being measured?

3. Are voltage level fluctuations random or are they related in such a way as to produce definable electrodynamic fields?

4. If such fields are present, are they merely by-products of biochemical processes, or do they exert an influence on those biochemical processes and on the patterns of organization found in living entities?[1]

To put into perspective the challenges Burr confronted, it is first necessary to grasp the infinitesimal variations in voltage levels (physicists refer to these as *potential differences*) that must be measured to amply investigate the electromagnetic properties of living systems. A wall outlet in North America produces an electro-motive force (voltage) of 110 volts. A flashlight battery produces 1.5 volts, or 1.36% of the voltage in the outlet.[2] The voltages Burr worked with were measured in microvolts. A microvolt is one one-millionth of a volt. If you took the voltage of the flashlight battery and divided it into 1 million parts of equal size, each one of those parts would be 1.5 microvolts. That is, 1 microvolt = 1×10^{-6} volts. In brief, you would need an instrument far more sophisticated than any voltmeter available from Radio Shack to measure voltages this small.

So before Burr could even test his hypothesis that life exhibits electromagnetic properties, he had to first overcome the technical challenges of crafting an instrument sophisticated enough to do the job. In addition to needing to measure extremely weak voltage fluctuations, another technical challenge was for Burr to measure the voltages of his specimens with as little effect on them as possible. A voltmeter measures a voltage by drawing a small amount of electrical current from the sample being tested. As the current flows through the meter, it records the corresponding voltage. While this is fine if the test sample is made of mechanical or electronic components, it becomes highly problematic if the sample being studied is a salamander egg. Burr had to measure voltages in the microvolt range without drawing any appreciable current from the sample. If this measurement drew current from the salamander egg, it could alter the very voltages he was trying to measure or even destroy the egg.

The only way to accomplish all of this was to contrive a volt-meter that had extremely high electrical resistance. Whenever a connection is made to a voltage source (whether it is a battery or a salamander egg), a current is going to flow from the voltage source through the connection, and in this case, to the meter. The amount of current that flows is directly proportional to the voltage level but inversely proportional to the resistance of the connection. The greater the resistance of the connection, the smaller the current flow.[3]

In Burr's apparatus, the greater the electrical resistance of the meter, the less current flow the meter draws from the sample. Making the resistance of the meter on the order of 100 megohms would mean that a current of one 100 millionths of an ampere would cause the meter to register one volt.[4] Burr's meter drew on the order of 1×10^{-12} ampere, or one-trillionth of an ampere from the specimen being measured.

While this amount was small enough to not harm the egg or distort the reading, it raised yet another challenge. Meters this sensitive are notoriously unstable. The meter will tend to react to any voltage it senses at its input terminal; not just the voltages that are meant to be measured. An extremely stable meter was needed that would only respond to voltages that were intentionally measured.

THE BURR-LANE VACUUM TUBE MICROVOLTMETER

At the time Burr was setting out to make his measurements, the transistor hadn't yet been invented, but its predecessor, the *vacuum tube*, was available. Transistors are solid state devices that can be used for amplification, switching, voltage regulation and countless other applications. Despite its larger size, the vacuum tube could perform the same functions as the modem transistor. Burr and his colleagues connected a pair of vacuum tubes in an electrical circuit in such a way that any voltage presented to the input side of the tubes would result in a resistance change on the output side of the tubes. This resistance change was directly proportional to the measured voltage and was recorded on an analog meter. Configuring the electronic circuit in this manner allowed for a highly stable instrument (it would repeatedly give the same reading under the same conditions) with a measurement sensitivity of 10 microvolts/millimeter (for every ten microvolts presented to the input terminals, the analog meter needle would deflect one millimeter).

To position the salamander eggs for the voltmeter reading, Burr suspended them in a saline solution. But this introduced yet another problem. If two different materials are brought into contact with each other, a very small voltage (several hundred microvolts) develops at their junction due to the difference in their atomic structure, a property of dissimilar materials known as *galvanic action.* Since Burr's voltmeter would respond to a voltage difference of this magnitude, it would skew any measurements made on the actual specimen. To work around this complication, Burr and his colleagues crafted a custom set of measuring electrodes that minimized the galvanic action between the probe and the saline.

To create such a probe, a silver/silver chloride electrode was formed by chemically depositing silver nitrate and sodium hydroxide on a platinum wire. The result was an electrode that exhibited less than 20 microvolts potential difference (voltage developed due to the galvanic action) between the electrodes and the saline solution in which the specimen is suspended. This galvanic voltage was easily compensated for in the calibration of the meter.

THE FABLED SALAMANDER EGG MEASUREMENTS

Once Burr had succeeded in creating a viable apparatus for recording the microvolt voltage levels to test his hypotheses, he needed a suitable specimen for taking the measurements. He chose the salamander because it is "easily obtained and can be observed from the egg stage up to adult form; and the changes in the form as it grows and develops can be observed and described with great accuracy."[5]

The first measurement Burr made was on an unfertilized salamander egg. He noted that, indeed, there were several points of differing voltage around the equator of the egg relative to the vegetal or south pole of the egg. In fact, there was one point in particular that had a higher voltage than all of the others. Further, as he moved the electrodes towards the egg he noted an increasing voltage at distances of up to ½mm away from the surface and increasing in voltage until the electrode made contact with the egg's surface. This would seem to indicate that the source of the voltage was from the egg itself; either inside the egg, or in the cell membrane.

However, he wanted to be absolutely sure that the voltage was coming from the salamander egg and not from some artifact of the test set up. To do this, he set the pipette containing the egg and the saline solution on a rotating disc whose rotational rate was controlled by a motor. Holding the probes near the egg atop the spinning disc he recorded a sinusoidal voltage waveform whose period was the same as the rotational rate of the motorized disc. He then removed the salamander egg from the pipette and repeated the measurement on a pipette containing only the saline solution and sitting atop the rotating disc. The result: flatine—no voltage recorded.

To further prove that it was the egg that was creating the voltage and not any part of the apparatus, he crafted what he referred to as a "robot" that was simply a tiny piece of copper wire dabbed with solder on each end. The dissimilarity between the solder and the copper, he reasoned, would produce a voltage analogous to that measured from the egg. He introduced his micro-robot into the saline-filled pipette and repeated his measurement with the rotating disc. The result was a sine wave voltage of the same frequency but with a slightly different voltage magnitude, as one would expect. Removing the robot from the pipette and repeating the measurement once again yielded zero voltage measurement.

Another very interesting discovery was made in comparing the voltage of the robot with that of the egg. Over time, the voltage of the robot dropped to zero. This would stand to reason when you consider that, once the galvanic action between the copper and the solder has depleted the charge across the junctions of the dissimilar metals, there is no longer a voltage difference. The egg on the other hand, exhibited a steadily *increasing* voltage after it was fertilized and throughout the development of the embryo. This would seem to imply that the process of developing life and an increasing electric field proximal to the living organism are somehow intimately linked.

Returning to the voltage differences on the unfertilized egg, Burr noted that there was one particular point on the equator of the egg that had a higher voltage than all of the other measured points, and another point 180 degrees along the equator that exhibited a minimum voltage. Using micro-surgical instruments he marked the point of maximum voltage on the egg's surface with a dot of Nile blue sulphate and then fertilized the egg. As the embryo developed, the location of the point of maximum voltage never changed but proved to be coincident with the location of the salamander's head. The lowest voltage location developed into the salamander's tail. The amazing conclusion that Burr drew was that the maximum voltage location in the unfertilized egg was a blueprint for the alignment of the fully-developed salamander's nervous system! This measurement was repeated with a control group of about 100 salamander eggs, all with the same result. Burr then repeated this experiment on a control group of frogs' eggs and on the extracted chick embryo; all with the same results.[5,6] The location of maximum voltage seemed to dictate the alignment of the grown specimen's nervous system (head and tail).

So, it appeared that Burr now had his evidence of an organizing field that accompanied the normal growth of embryos. Now he could explore the implications of his discovery.

BIO-ELECTRIC PROPERTIES OF CANCER

Burr reasoned that, since normal biologic growth and development was accompanied by a bio-electric field that appeared antecedent to the beginning of development (i.e. before the salamander eggs and frog eggs were fertilized), abnormal growth would likely be preceded by the appearance of an abnormal bio-electric signature.

To test this new hypothesis, Burr and his colleagues "initiated a series of studies designed to investigate the bio-electric properties of an organism before, during, and after the onset of cancer." The animals chosen for this study were from two different genetic strains of mice. As Burr explains: "Each strain has been inbred for many generations so that the genetic constitution of each animal is as nearly like that of others of the same strain as is possible. One strain was bred for relative immunity to adenocarcinoma of the mammary gland (breast cancer). The second strain has been inbred so that approximately 90 per cent of the population of breeding females acquire mammary cancer during their normal lives."[7] Thirty-nine mice from each strain were used in this experiment.

Briefly, starting at the age of 150 days and continuing until the end of the mouse's life, Burr made measurements on each of the mice every two weeks. At the 150-day point, all of the mice used in the experiment were free of cancer. Using the microvoltmeter described above, voltages were measured between

1. the center of the lower part of the sternum (xiphoid) and the joining point of the two pubic bones (symphysis) for an axial voltage
2. across the groins
3. across the chest
4. the xiphoid and each groin
5. the xiphoid and each side of the chest

Thus, the body was roughly triangulated.[7]

For the cancer-susceptible mice in which cancer appeared before the 260th day, the voltage across the chest of the mouse increased by several thousand microvolts between ten days and two weeks in advance of the malignant tumor being detected by palpation.

Based on these findings (drawn from more than 10,000 measurements), Burr concluded the appearance of abnormal tissue in the organism was preceded by an abnormal distribution of voltages in the affected area of the body relative to the voltage distribution found in mice that exhibited no palpable cancer.

Burr made hundreds of other studies of the bio-electric field as it relates to normal and abnormal processes in living organisms. These studies include, but are by no means limited to

- voltage fluctuations antecedent to ovulation in rabbits, Rhesus Monkeys and humans
- bio-electric concomitants of growth and differentiation in the healing of wounds of guinea-pigs and of humans
- the effect of drugs on the electrical potentials in rats
- correlation between the integrity of the peripheral somatic nervous system and voltage differences measured on the surface of the arm or leg of a human
- detection of malignancy of the human female genital tract

SUMMARY

Burr was able to demonstrate an accurate, stable, and repeatable technique for measuring the microvolt levels of living organisms. Using this technique he was able to verify his hypothesis of the existence of a bio-electric field that appeared to accompany, or even precede an organism's biochemistry and patterns of organization. He then extrapolated his hypothesis of the organizing nature of the bio-electric field to the development of cancer in mice. He demonstrated that malignancy was accompanied by a bio-electric voltage that was aberrant relative to the voltage exhibited in specimens known to be cancer-free.

Burr's pioneering work is frequently cited by scientists as well as practitioners who are concerned with the role of energy and energy fields in healing, a specialty that has come to be known as energy medicine.[8] But because Burr's original papers, from the 1930's and '40's, are not readily available, many of his admirers are not fully aware of the rigorous technical challenges he overcame or the absolute genius of his contributions. This paper has attempted to provide a glimpse into both.

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2. While the outlet produces AC or *alternating current* voltage and a battery produces DC or *direct current* voltage, the comparisons here are of magnitudes only, to give an idea of the scales involved.
3. Think of a hose. Electrical quantities of voltage, current, and resistance are analogous to pressure, water flow rate, and resistance moving through the hose. The amount of pressure used to drive the water through the hose is analogous to voltage; the rate at which water flows through the hose is analogous to current; and the resistance of the nozzle to the water flow is analogous to electrical resistance.
4. An ohm is a measure of electrical resistance, the propensity of an electrical circuit to resist, or impede, the flow of current. A simple electrical circuit carrying a current of one ampere and being impressed with a voltage of one volt is said to have a resistance of one ohm. A *megohm* is one-million ohms.
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8. D. Feinstein & D. Eden, Six Pillars of Energy Medicine: Clinical Strengths of a Complementary Paradigm, *Alternative Therapies*, **14**, 1 (Jan/Feb 2008)

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