HEALTH AND STRESS

The Newsletter of
The American Institute of Stress

Number 12 1996

THE PULSE OF STRESS

KEY WORDS: pulse, ancient medicine, heart rate, sudden death, biofeedback, entrainment, autonomic nervous system

Prior to the present century, physicians had to rely primarily on a meticulous history and physical examination, to arrive at most diagnoses. Such skills have now been largely superseded by sophisticated laboratory procedures and imaging studies. These not only do not require a close personal relationship, but with the growing emphasis on cost containment, may preclude it.

This is in sharp contrast to the way medicine was practiced for millennia. The most proficient physicians were those who had sharpened their powers of observation, particularly with respect to physical diagnosis. This required an unusual sensitivity to abnormalities which could only be detected by sight, sound, smell, and touch. In ancient Chinese medicine, the patient's pulse was of prime importance, and proper examination was a complicated affair. The physician felt the right wrist and then the left, comparing the beats with his own, noting the rate, regularity, rhythm, and force. The time, day, and season were also important, since it was believed that these had various effects. In some cases, it might take hours to detect subtle deviations, and determine the effect of varying the pressure of the palpating finger on the strength of the pulse, the speed with which it reached maximum intensity, and/or declined, etc.

Every pulsation had three distinct divisions, each of which was associated with a specific organ, as well as separate attributes that were further sub-divided into dozens of varieties, so that hundreds of different combinations were possible. It was believed that by painstaking analysis of the pulse alone, it was possible to diagnose the nature and source of no less than 37 different types of disease. In the *Muo Ching* treatise, ten volumes were necessary to describe these intricacies. Another early Chinese medical compendium, *Nei Ching*, stated that the blood flowed continuously in a circle, and that "all the blood is under control of the heart", thus anticipating William Harvey by several thousand years. However, it does not appear that blood vessels were considered to be any kind of a contained system, and certain ones were thought to carry air, or some vital spirit. The word artery literally means air tube.

Pulse chart from a 1693 edition of *Secrets of the Pulse*, originally written by Pien Ch'iao in the 6th or 5th century B.C. describing how different readings could reflect the condition of a particular organ.

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ALSO INCLUDED IN THIS ISSUE

Health and Stress: The Newsletter Of The American Institute Of Stress is published monthly. Annual subscription rate $35.00 (U.S.), $45.00 (Foreign).

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The Greeks, And The Heart As The Seat Of Emotions

Although the ancient Greeks were unaware of how blood flowed throughout the body, Galen noted that the heart and the arteries pulsated with the same beat. He described how this could best be felt in the wrists and the feet, and how variations in the hardness of the wall of the vessel influenced the strength of the pulse. He told his students, "now you must remember what a normal pulse is like, and if you find an abnormal pulse of excessive breadth you should term it 'broad', and if of excessive length 'long', and if of excessive depth 'deep,' and in like manner, the opposite of these 'narrow,' 'short,' and 'shallow'; and a pulse that is in all these dimensions abnormally diminished is termed 'small', and one that is abnormally augmented 'large'.

In addition, he emphasized "a fifth variety, depending upon the pauses between the beats. For such is the term usually given by medical men to the space and time between the beats, within which the artery expands and contracts. The two terms I shall use are the pulsation and the pause. By the pulsation, I mean the feeling of the arteries striking against the finger as it is expanded. By the pause I mean the period of quiescence between the pulsations according to the length of which normal pulses are rapid, slow, or medium. By these, you will determine the length of the pause". Thus, it would appear that the importance of heart rate variability was recognized at least 2000 years ago.

The Greeks believed that the pulse itself represented some internal energy or spirit, which increased and decreased in a rhythmic fashion. Certain characteristics were associated with each of the four humors, and specific patterns were thought to cause different disorders. A quick and forceful pulse produced a "hot" disease, while slower pulses could cause "cold" conditions. The physician's function was to correct any such departures from normal. A hot regimen, which included hot tasting foods, was employed to raise slow pulses, while medicines, foods, and activities considered to be cool, were used to lower the pulse rate, to treat hot diseases. Stress and powerful emotions caused the pulse to quicken, and Galen suggested that this "pulsific power" might possibly emanate from the heart, which was generally considered to be the source of feelings and emotions, rather than the brain.

The pulse was similarly considered to be a cause, or at least an indicator of disease, in other early cultures. However, its origin was equally obscure, and the abdominal aorta, and/or vena cava, were also apparently considered as sites. The *Vagadasastir*, a very old Indian collection of medical knowledge, placed the source of the pulse in a reservoir located behind the umbilicus. This was described as being four fingers wide by two long, and divided into 72,000 "canals" which distributed their contents all over the body. It would appear that little distinction was made between the functions of arteries and veins, until William Harvey elucidated this, and showed that the circulation of the blood was due to the pumping action of the heart, rather than its purported function as a heat engine. Harvey confirmed Galen's suspicions, by proving that the pulse rate was entirely congruent with and dependent on the heart beat, and demonstrated that its strength was determined by cardiac output and the degree of arteriosclerosis.

Probing The Potential Of The Pulse

The ability of ancient physicians to appreciate subtle nuances in the pulse is quite amazing, since they had no way to accurately time rate or record rhythm, much less measure force. It was not until the beginning of the eighteenth century that this began to change. John Floyer, a British physician, who had studied the contributions of the Chinese, and all of Galen's writings on the pulse, was convinced that a more accurate appraisal could improve his diagnostic skills. Initially, he tried constructing a sand clock that would run for exactly one minute, similar to the conventional hour glass. Although it had markings that indicated certain fractions of a

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minute, it was not very satisfactory. Various factors affected any consistent or predictable flow of the grains of sand, and the agreement between different models was erratic. He therefore decided to devise a watch, which in addition to displaying the minute and hour, also had a hand which made a complete revolution every minute. Each elapsed second could be clearly identified, and the advantages of this new timepiece were explained in his "Physician's Pulse Watch", published in 1707. Second hands have been on watches ever since.

Subsequently, the ability to correlate certain changes in the pulse with specific cardiovascular abnormalities, explained many peculiarities which had previously been observed. Stenosis or narrowing of the aortic valve produced the *pulsus parvus et tardus* (poor and late), because the blood pressure rose more slowly, and the pulse was smaller or weaker. If its peak was prolonged, a "plateau pulse" might result. In some cases, a protracted and very gradual increase in force might be interrupted for a fraction of a second, giving the impression of an additional wave, or an "anacrotic" (notched) pulse. Conversely, insufficiency of the aortic valve caused an abnormally larger and stronger volume of blood to be ejected, which rose and fell rapidly, or *pulsus magnus and celer* (strong and quick). This can be dramatically seen in the forceful throbbing of the carotid arteries (Corrigan pulse), felt by the forceful knock of the "water-hammer pulse" on palpation, and hearing a "pistol shot" sound, when listening over the femoral artery.

Normally, the pulse becomes faster and stronger during inspiration, but pericardial effusions, and certain chest tumors can cause *pulsus paradoxicus,* which is a weakening of the pulse, or even its complete disappearance during inspiration. In *pulsus alternans*, there is a regular alteration in the size and timing of the beats. This is due to the fact that cardiac output and blood pressure vary with alternate beats of the heart. It can sometimes be readily seen in the arteriosclerotic arm artieries of elderly patients, and also usually indicates extensive heart damage.

Following the advent of the electrocardiogram and long term monitoring capabilities, advances in appreciating the nature of rhythm disturbances accelerated rapidly. Heart rate changes due to premature beats, fibrillation, and flutter could be readily identified, and distinguished from the normal changes due to respiration. Subsequent enhancements, such as spectral analysis of heart rate fluctuations, have revealed additional naturally occurring oscillations in healthy individuals, especially during sleep.

Heart Rate Variability And Sudden Death

Expiration *Inspiration*

As illustrated in the above electrocardiogram, the heart rate ordinarily speeds up during inspiration, and slows down with expiration. This variation, which is referred to as sinus arrhythmia, causes the pulse to be slightly irregular, but is perfectly normal. It can be demonstrated not only in animals, but even primitive forms of life, such as the horseshoe crab, which evolved over 200 million years ago. Sinus arrhythmia can be exaggerated by taking a very deep breath and holding it, or exhaling completely, and not taking a breath for as long as possible. These changes are due to the physiologic interplay of sympathetic stimulation, which increases heart rate, and parasympathetic input via the vagus nerve, which has an opposing effect. This automatic response enables the autonomic or involuntary nervous system to maintain homeostasis, and is an indication that things are working smoothly. Indeed, failure to detect significant fluctuations in heart rate with respiration, was described as an indication of impaired cardiac function seventy years ago.

Numerous recent reports have now clearly demonstrated that decreased heart rate variability (HRV), predicts increased risk for sudden death. This observation was first made by Stewart Wolf's neurocardiology group at the University of Oklahoma in the early 1960s, and I am indebted to him for the background information on these seminal studies. They were derived from a ten year prospective project designed to identify physiological and behavioral factors that might contribute to sudden death due to cardiac arrhythmia in patients who had suffered a myocardial infarction. It was found that neither age, serum cholesterol, good and bad cholesterol ratios, or treadmill testing results had any significant prognostic power. The only predictive indicators for mortality were specific electrocardiographic changes reflecting diminished HRV, when compared to survivors. These preliminary findings were submitted to several medical and cardiology journals, but were rejected by all, with one reviewer commenting, "we have known about heart rate for centuries. The authors' findings concerning variability of heart rate could hardly have significant medical importance".

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It was not until 30 years later, that Wolf was able to publish the complete results of this study, in a paper entitled, "Oscillatory Functions Affecting Outcome of Coronary Heart Disease: The Hazard of too Much or too Little Stability". In a masterful summary, he pointed out that particular periodicities are peculiar to all living systems, ranging from cells to civilizations. His net conclusion was that "proper physiologic balance requires some degree of instability, but not too little or too much". He noted that Walter Cannon, in his initial description of homeostasis, had credited the French physiologist Charles Richet for proposing this principle in 1900, when he wrote "The living being is stable... in a sense, it is stable because it is modifiable — the slight instability is the necessary condition for the true stability of the organism." This means the ability to adapt to various stresses so as to maintain the status quo, a hallmark of health implicit in Claude Bernard's concepts of the internal environment (*milieu intérieur*), and the importance of maintaining its stability.

Heart rate variability can be due to influences other than respiration in healthy individuals. There are intrinsic rhythms in various body systems and organs that can either augment or diminish the effects of breathing. A regular three per minute contraction cycle occurs in the stomach, and there is a six per minute frequency fluctuation in blood pressure, lymph, and cerebrospinal fluid pressure. In the absence of breath holding, the greatest magnitude in normal HRV is seen when individuals breathe at a rate of six times a minute that coincides with this. It is therefore of interest to note that at the November 1996 meeting of the American Heart Association, Israeli researchers reported on a "new" simple breathing test to predict people at high risk for recurrent heart attacks. It consisted of having them take exactly six deep breaths in one minute, during which their electrocardiogram was monitored. An abnormal response, which was defined as a heart rate change of less than 10 beats/minute due to paced breathing, was seen in 65 patients. The test was performed 4 to 28 days following an initial heart attack in 185 consecutive patients. On 16 month follow-up of the 10 patients who died from cardiovascular causes, nine had shown a change in heart rate of less than 10 beats/minute.

Although sinus arrhythmia literally means without rhythm, it really refers to a regular fluctuation due to respiration. Other naturally occurring oscillations can be superimposed on this, and sinus arrhythmia is also seen in some nervous system lesions. Not much is known about these contributions to heart rate variability.

Stress And Heart Rate Variability

It has been well established that intense emotional stress is a prime cause of sudden death, most likely from ventricular fibrillation due to excess sympathetic nervous system stimulation and adrenaline secretion. Severe anxiety is also a risk factor for heart attacks, and a particularly powerful predictor of sudden death. The prognostic potential of measuring HRV in such high risk patients was corroborated in a recent Harvard report of almost 600 men with phobic anxiety. Anxiety symptoms were rated using a questionnaire shown in previous prospective studies to strongly predict sudden cardiac death. HRV was assessed by several methods, including paced deep breathing at six breaths per minute. Men with higher levels of anxiety had higher resting heart rates, but even after adjusting for this, age, and other possible confounding factors, those reporting higher levels of phobic anxiety still had lower HRV by all criteria utilized. Patients with panic disorder similarly demonstrate decreased HRV.

Type A behavior is another risk factor for heart attacks and sudden death. Such individuals have greater than normal sympathetic nervous system responses when challenged. In one study conducted during the stress of an important examination, Type A women had higher blood pressures and heart rates, and lower heart rate variability than Type B controls, consistent with increased sympathetic nervous system activity. Patients who succumb to sudden cardiac death while being monitored, frequently show reduced HRV just prior to the fatal event, that is often associated with some stressful experience. Beta blocker drugs are used to treat performance anxiety and other stress related problems, because they blunt the effects of adrenaline and sympathetic nervous system stimulation. In addition, they lower the likelihood of heart attacks and sudden death. Since they can also restore reduced HRV to normal ranges, this might be one mechanism to explain their protective potential.

Studies of sudden death due to stress in experimental animals, indicate that these benefits are mediated via beta blocker effects on the brain, rather than peripherally. Evidence of cerebral cortical influences on HRV comes from other research that has largely been ignored. Sinus arrhythmia was reported to be reduced or abolished following severe brain injury or lesions in the forebrain over 80 years ago, and similar disruptions of autonomic nervous system control of heart rate can be caused by coma, anesthesia, and certain cerebrovascular accidents. Reduced HRV has been reported in infants

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who subsequently died due to sudden infant death syndrome. This usually occurs during sleep, when there can be significant changes in brain wave activity that affect heart beat rhythms.

While the role of increased sympathetic nervous system stimulation has attracted most attention, it is the altered balance of the autonomic nervous system that is crucial. Either an excess or not enough parasympathetic input can contribute to sudden death, even in healthy hearts. There is normally a diurnal effect on HRV, due largely to parasympathetic activity, but this circadian rhythm was found to be absent in post-infarction patients who survived an episode of cardiac arrest. Decreased parasympathetic activity is not uncommon following an acute myocardial infarction, especially in patients with hypertension and heart failure. Those with lower HRV were at greatest risk for premature death. Indeed, vagal, or parasympathetic tone has been described as a "physiologic marker of stress vulnerability". Hostility has been found to be associated with decreased parasympathetic activity, as well as heightened sympathetic tone, and this combination could explain why it is considered by some as the most damaging Type A trait. Patients with severe depression, another risk factor for coronary heart disease and sudden death, also tend to have less variability in heart rate. The above observations may have important clinical implications.

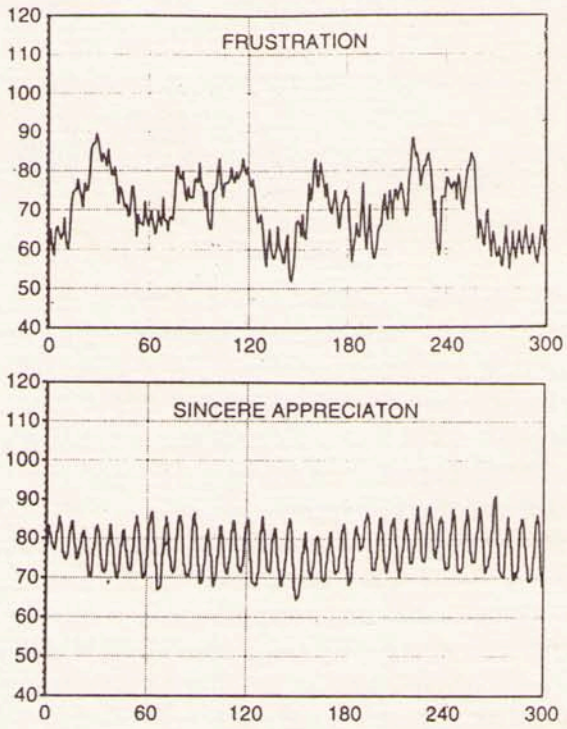
Harnessing HRV With Biofeedback And Entrainment

Until recently, HRV was primarily of interest to researchers investigating cardiovascular electrophysiology. Measurement methods varied, and were complicated and time consuming, because of the irregular nature of the signals being analyzed, and assorted artifacts. Computerized enhancements which allow direct recording of successive interbeat intervals instead of conventional Holter monitoring, advances in the application of chaos theory, power spectrum analysis, and a recently reported mathematical "wavelet" approach, which obviates complex Fourier analyses, have resolved many of these problems. Instead of taking 24 hours, results can be obtained in less than 20 minutes, and for some methods, instantaneously.

The autonomic nervous system regulates close to 90% of body functions. Since HRV has become a readily accessible, as well as an accurate indicator of its stability and tone, numerous applications have been reported. HRV helps predict mortality not only following myocardial infarction and congestive heart failure, but also during coronary angiography. It can evaluate disorders ranging from diabetes and neurologic diseases, to sudden infant death syndrome, monitor how patients are responding to certain medications, and predict risk of rejection for heart transplants.

Since stress causes significant disruption of autonomic nervous system balance, HRV would appear to be a particularly effective way to assess its effects, and forecast adverse consequences. More importantly, if higher centers in the brain can affect HRV, are there conscious interventions capable of correcting patterns that predict danger or death? Can the efficacy of stress reduction strategies be evaluated by measuring their beneficial effects on HRV patterns? Could such information be utilized to improve stress reduction approaches?

The effect of stress on heart rate variability patterns can be illustrated by contrasting the haphazard, irregular waves seen during frustration, with the symmetrical synchrony of sincere appreciation.



The above graphs are from studies presented at our previous Montreux Congresses by researchers from the HeartMath Institute in California. The technology utilized allows seeing the changes in heart rate variability on a monitor as they are taking place, and demonstrates how you can instantly influence this by consciously evoking specific feelings and emotions. This forms the basis for their Freeze-Frame technique, in which subjects learn to recognize stressful states, and how focus-

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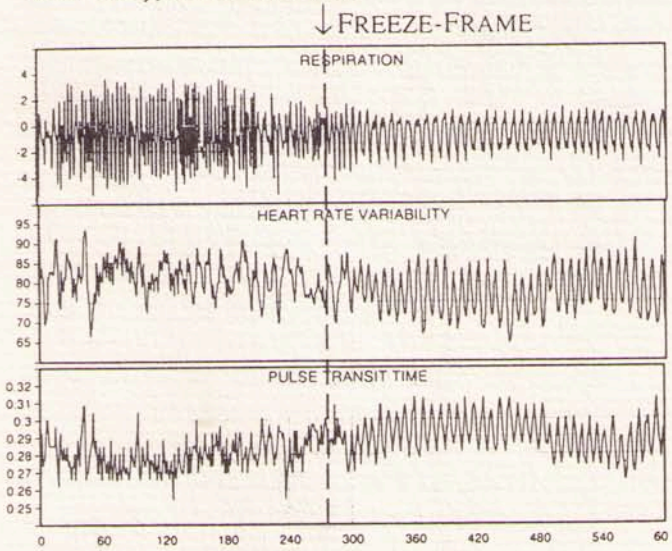
ing on feelings of love and sincere appreciation, while shifting concentration to the area around their heart, can correct disorderly and potentially dangerous cardiovascular patterns. Additional information can be obtained when HRV data is mathematically converted into power spectral densities, which dissect out and display sympathetic and parasympathetic influences.

Following Freeze-Frame, jerky disruptive patterns in other body processes also become more organized and orderly. This includes respiration and pulse transit time, (a method of measuring blood pressure with each heart beat), as shown below.

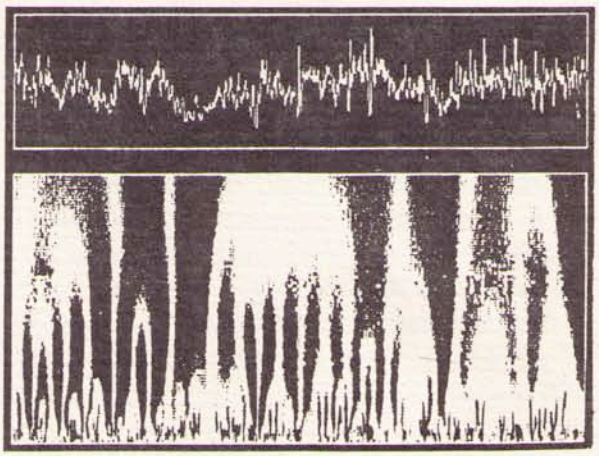


The ability to link systems such as those above, as well as brain wave activity, all of which oscillate at different frequencies, is known as entrainment. This internal coherence appears to provide not only physiologic benefits, but emotional and spiritual rewards, including improved creativity and insight. It is sometimes achieved by experienced meditators, certain types of music or rhythms, and EEG biofeedback. However, Freeze-Frame appears to accomplish this more consistently and efficiently, and has now been shown to represent a very effective stress reduction technique, that could have important applications in the workplace.

I was anxious to learn more about this, but the meeting for the HeartMath Scientific Advisory Board of HeartMath coincided with a birthday party that my family had planned. It seems there is always some conflict, and since last year, it was an important meeting in Russia, I had promised to stay home. However, the Program seemed so exciting, and the opportunity to see old friends and make new ones was irresistible. It was well worth this visit to their magnificient setting in the heart of a redwood forest. The research studies reported were indeed fascinating, and the impressive results in reducing job stress and increasing productivity will be reported on at our next Congress. In addition, as in Moscow, a very thoughtful birthday party had been planned, featuring Dom Perignon and my favorite Havana cigars (see photo at the end of the Editorial).

Israeli researchers have developed a different biofeedback approach which melds cardiopulmonary as well as brain wave activity. It instantly recycles HRV data via very low frequency audio visual signals that are simultaneously heard through earphones and displayed on a monitor. They refer to this as "Non Cognitive" Biofeedback, since it requires no effort, training, mental concentration, or active participation. It is accomplished by converting chaotic information from different rhythmic body functions, into a single signal that can be readily perceived. This is thought to trigger an automatic self learning process that instinctively and unconsciously promotes a "natural" entrainment. As a result, disturbances in autonomic nervous system balance are corrected, and mind-body synchronicity is improved. Studies over the past decade in more than 30,000 subjects, have shown that this method, which is called "Bio - Tuning", is useful in treating a variety of stress related disorders, including depression, premenstrual tension, obesity, and hyperactivity.

The newest development in HRV technology is the "wavelet" transform technique. As described in a very recent issue of *Nature*, it is a mathematical method for finding hidden patterns in any sequence of beat-to-beat intervals. This makes it possible to identify surprisingly large scale patterns, even when signals change due to varying artifacts and background influences. The top part of the following illustration shows values derived from six hours of ECG data. As noted in the bottom portion, these correlations are manifested as arches in the wavelet analysis of a healthy heart, but are absent in the presence of disease.



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Other advances include the small, ultralight, portable Series 2000 Mini-Logger, which measures millisecond differences between successive heartbeats. This provides immediate HRV data, that can instantly alert the wearer to any abnormalities.

This has been a difficult Newsletter to write. It deals with a highly technical and confusing topic not likely to appeal to the average reader. Alternatively, those interested in the complex two way conversation between the brain and the body, and particularly, the role of stress and emotions in sudden death and other disorders, may correctly complain that much has been left out or oversimplified. So why pick such a problematic subject for a Newsletter?

One reason is its consistency with the theme that many time honored practices that are disregarded or disdained because they can't be explained, but eventually are found to have merit. This has been illustrated in previous Newsletters dealing with acupuncture and magnets, and will be further developed in a future issue on homeopathy. It is also congruent with the belief that there are basic energies and rhythms in body systems about which we have scant knowledge. Nevertheless, there is growing evidence that these are not only interrelated with each other, but also with equally obscure oscillations and forces in Nature. It is likely that it is only when all of these are in harmony, that we can experience optimal physical, mental, emotional, and spiritual health.

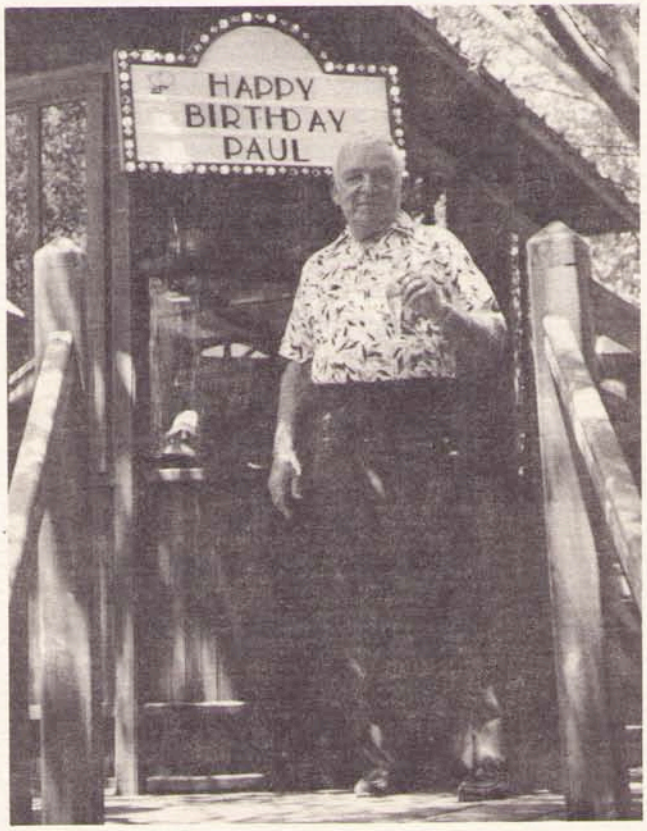
This is hardly a new concept. It can be found in many ancient teachings and philosophies, possibly because thousands of years ago, people were more in tune with their bodies and with Nature. It is synopsized in Juvenal's concept of true health as *mens sana in corpore sano*, a sound mind in a sound body, and the recognition that the two are inseparable. Understanding the intricate rhythms that contribute to heart rate variability could provide important clues to achieve this.

As indicated in the following Book Review, although feeble environmental electromagnetic fields should not have any biologic effects according to the laws of physics, it is clear that they can have powerful influences. It is not unlikely that similar forces generated within the body have similar capabilities. We view the brain as the anatomical location of our feelings and emotions, and a complicated switchboard, that is constantly receiving and sending electrical and chemical messages. However, the early Chinese, Greeks, Egyptians, Indian yogis, and even Paracelsus, wrote that the seat of emotions, as well as imagination, resided in the heart. Astrologists linked it with the sun sign Leo, the flaming, golden lion of courage, generosity, and love.

We still describe people as broken hearted, faint hearted, stout hearted, having a heart of gold, stone, etc., etc. It is only recently that the heart has been found to be capable of sending, as well as receiving chemical messengers that reflect different emotions. It is also the body's most powerful electrical generator, with a 2.5 watt output that is over 50 times greater than energies emanating from the brain. And each heart beat is accompanied by an electrical signal that can be detected throughout the body, and anywhere on its surface.

Is there some reason for this? Could the ancient Chinese pulse doctors have sensed such electrical as well as physical forces? Is "taking the pulse" of the nation a mere figure of speech, or does it correctly imply an accurate and unusual sensitivity to various feelings and phenomena not readily obtained by other means? What does "feeling" your pulse really signify? How does it reflect your own inner self? One answer may have been suggested by Thoreau, in his Journal entry for February 25, 1859. "*Measure your health by your sympathy with morning and spring. If there is no response in you to the awakening of nature - if the prospect of an early morning walk does not banish sleep, if the warble of the first bluebird does not thrill you - know that the morning and spring of your life are past. Thus may you feel your pulse.*

Paul J. Rosch, M.D., F.A.C.P.
Editor



Surprise birthday party in the heart of redwood country.

Book Reviews • Meetings and Items of Interest

Book Review

Electromagnetic Fields: Biological Interactions and Mechanisms, Martin Blank, Editor, American Chemical Society, Washington, D.C., 1995, 550 pgs., $116.95

As the Editor points out in the preface to this meaty volume, there has been considerable controversy about the biological effects of electromagnetic fields. Very high frequency fields capable of breaking chemical bonds, can obviously alter cellular structure and physiology. Lower energies, like microwaves, while not strong enough to break bonds, produce heat and also have biologic effects. Presumably, this is not true for athermal energy fields, since there would be no plausible mechanism of action. Yet, it is well established that such feeble energies, can accelerate the healing of fractures and soft tissue injuries, and even some suggestion that permanent magnet emanations may have similar properties. Low Energy Emission Therapy, which is probably the most effective and safest treatment for insomnia, employs an energy source in the range of the CB radio. There has also been considerable controversy over such things as the possible carcinogenic effects of high power lines and cellular phones, and increased birth defects following the use of electric blankets during pregnancy.

This volume provides a basic science background that is helpful in explaining the biological effects of electromagnetic fields, and elucidating mechanisms of action. An impressive array of authorities in different disciplines have contributed some 26 chapters, in sections entitled Physical characteristics of environmental electromagnetic fields, Intrinsic biological fields, Health related aspects (with emphasis on therapeutic applications), Biophysical aspects of transduction mechanisms, and Cellular mechanisms.

The Editor has had a particular interest in the influence of weak electromagnetic fields on protein synthesis. As noted in a chapter devoted to this, the response mechanism seems similar to that for heat and other stressors, and which could have important health implications. Of particular clinical interest are chapters which offer a possible explanation for the biological effects of very weak electromagnetic fields, and the use of such energies to accelerate healing. This book is surprisingly up to date, well referenced, and a valuable compilation of cutting edge and relevant contributions to this rapidly expanding and exciting field. Highly recommended.

Meetings and Items of Interest

Feb. 21-23 Stress, Immune Disorders, sponsored by East Synthesis West, Dana Point, CA, call (310) 420-6090

Mar. 3-8 Art and Science of Health Promotion Conference, "Health Promotion: What's the Impact and What Works?", Hyatt Regency, Hilton Head Island, SC, call (810) 682-0707

Mar 12-18 Association For Applied Psychophysiology And Biofeedback Annual Meeting, Better Living Through Applied Psychophysiology: Surfing the Wave of Technology, for info: AAPB, 10200 W. 44th Avenue, Suite 304, Wheat Ridge, CO 80033-2840

Mar. 20-22 American Psychosomatic Society 55th Annual Scientific Meeting, Hilton of Santa Fe, Santa Fe, NM, call (703) 556-9222

April 4-5 Thirty Years of Modern Electrotherapy, Sponsored by The Shealy Institute, The Crowne Plaza, Branson, MO, call (417) 865-5940

ISSN # 1089-148X

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