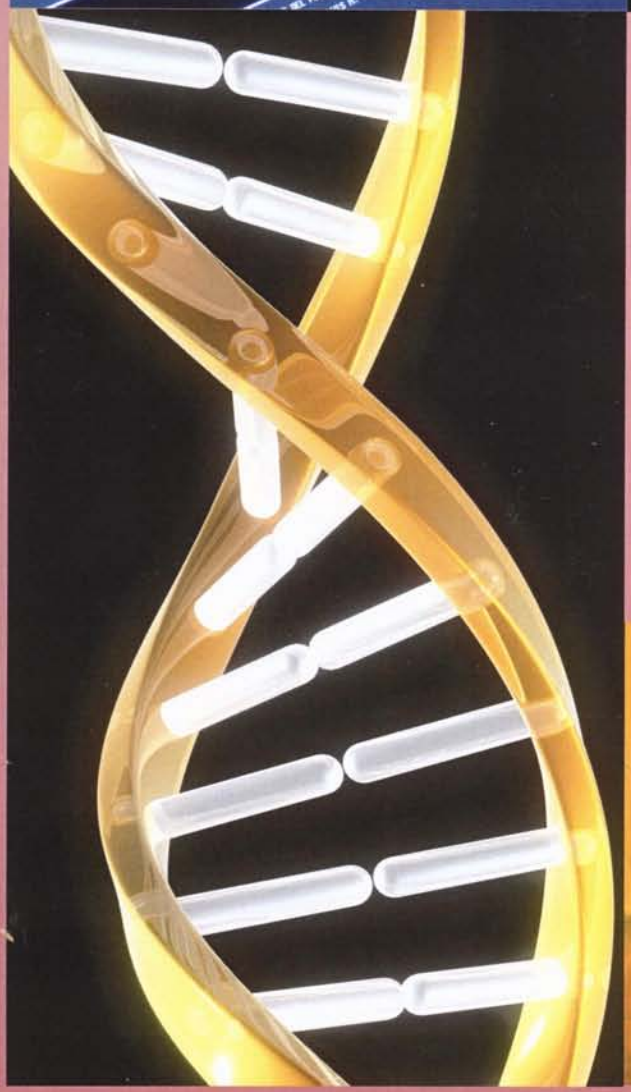
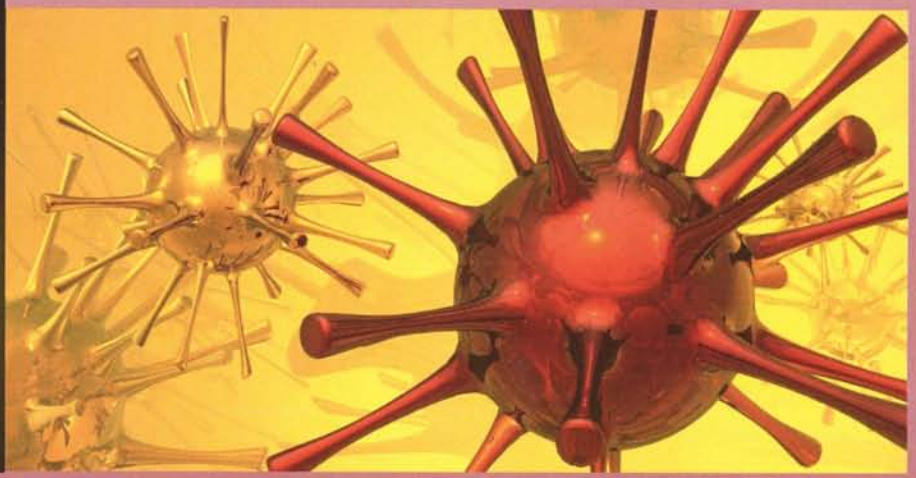


Anti-Aging Therapeutics Volume XI



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Chapter 33

Mitochondria and Cellular Aging

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ABSTRACT

Physics defines "energy" as the ability to do work. This definition can be used to follow the flows of energy through the human body. For example, a single photon of light has enough energy to do the work of changing the structure of a pigment molecule in the retina so we can detect light, leading to a nerve impulse to the visual cortex. Gravity does the work of damaging tissues when we fall down. Sound causes hair cells in the inner ear to vibrate so we can hear. The chemical energy from adenosine triphosphate (ATP) does the work that enables nerves to conduct messages and that powers the migrations of white blood cells to a site of injury. In terms of anti-aging medicine, we are interested in the factors that can restore and maintain adequate energy supplies and the circulation of energy within our bodies so that vital processes can continue to function optimally throughout our lives. This article considers the biochemical and biophysical aspects of energy production and utilization in the human body, the ways energetic "deficiencies" arise, and how they can be corrected. One focus is on providing metabolic energy to all parts of the immune system to maintain and even amplify the body's natural defense and repair processes. A second topic is the possible role of protons and electrons in energizing cellular processes. Finally, we consider the possible role of electrons in resolving chronic inflammation and maintaining the "inflammatory preparedness" of the organism.

Keywords: longevity, energy metabolism, mitochondria, inflammation, living matrix, physiological balance, electron transport

INTRODUCTION

Physicists define "energy" as the ability to do work. We all know what it is like to simply feel like we don't have any energy to do what we wish to do, just like the woman shown in Figure 1. A variety of factors can go into creating this feeling. It can be a consequence of over-exertion, inadequate nutrition, a lack of exercise, insufficient rest and recovery, emotional upset, depression, illness, injury, imbalanced structure (posture), and so on. In this article we take a deeper look into biological energetics in order to examine the factors that can compromise our physiology and accelerate the aging process. We will also look at preventive steps that can be taken to maintain our energetic integrity and thereby maintain our natural state of longevity.

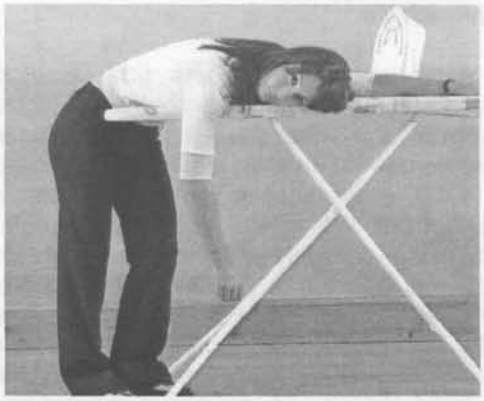

Figure 1. Physics defines energy as the ability to do work. We all know what it feels like to have no energy.

BIOCHEMICAL PATHWAYS

A major focus of modern biochemistry is to define the pathways that provide energy for the various processes that are essential to life. Some important questions:

- How do cells get the energy needed for protein synthesis?
- How do organs get the energy to carry out their functions, such as detoxification by the liver, the formation of the urine by the kidneys, digestion, and so on?
- How are muscles supplied with the energy for contractions that lead to movements of the body?

Muscle contraction is one of the most important of the energetic systems in the body, and has therefore been the subject of much research. A brief history of muscle energetics follows.

Albert Szent-Györgyi began fundamental research on muscle contraction in Szegred, Hungary in 1931. To learn how muscles change their shape and size, and the chemical substances involved, he extracted myosin from rabbit muscle, drew it into a hypodermic syringe, and then pressed it out into fine threads. When Szent-Györgyi added adenosine triphosphate (ATP) to his myosin preparation, the threads rapidly contracted to one-third their original size, just like a muscle fiber does when it is tensing. Previous work had shown that the mitochondria produce the ATP which is the immediate source of energy that powers cellular activities. Szent-Györgyi received the Nobel Prize in 1937 for his research that identified some of the chemical intermediates in energy metabolism. His early work on muscle represented the first time a fundamental physiological process, muscle contraction, was carried out using isolated molecules, *in vitro*. His discoveries paved the way for future research in the field of muscle biochemistry. Szent-Györgyi and his research team went on to discover that muscle tissue contained a second protein, actin, which combined with myosin to form interlocking fibers. We now know that both actin and myosin are found in virtually all cells, not just in muscles. In 1954, Szent-Györgyi received the Lasker Award for his contributions to understanding cardiovascular diseases through basic muscle research. Of his early observations on isolated muscle proteins, Szent-Györgyi said:

> *To see these little artificial muscles jump for the first time was, perhaps, the most exciting experience of my scientific life, and I felt sure that in a fortnight I would understand everything. Then I worked for twenty more years on muscle and learned not a thing. The more I knew, the less I understood; and I was afraid to finish my life with knowing everything and understanding nothing. Evidently something very basic was missing. I thought that in order to understand I had to go one level lower, to electrons, and – with graying hair – I began to muddle in quantum mechanics. So I finished up with electrons. But electrons are just electrons and have no life at all. Evidently on the way I lost life; it had run out between my fingers. I do not regret this wild goose chase – because it made me wiser and I know, now, that all levels of organization are equally important and we have to know something about all of them if we want to approach life.*[2]

On the basis of this early work, researchers first developed a "contracting filament hypothesis" in which the muscle filaments themselves contract. Electron microscope observations, however, did not support this hypothesis. Neither the actin nor the myosin filaments shortened when the muscle contracted. Only the degree of overlap between thick and thin filaments changed. In papers published in 1957 and 1959, Hugh Huxley proposed a Sliding Filament Model, in which contraction results as the cross-bridges linking the actin and myosin molecules tilt and pull the filaments past one another.[3, 4] This is the currently accepted model of muscle contraction.

In 1950 the noted British physiologist, A.V. Hill challenged biochemists to prove that ATP really is the source of energy for muscle contraction.[5] In 1962, Davies and colleagues responded with studies showing that ATP actually does break down during the contraction of muscle.[6, 7] Eventually it was established that the myosin cross bridges have the enzyme ATPase that releases the energy stored in the terminal phosphate bond of ATP and converts that bond energy into the tilt of the myosin head to power movements. The contraction of a muscle, then, arises from the sum of the movements of myosin cross bridges driven by the breakdown of ATP. Further research led to the view that all vital

processes are driven by ATP produced by the mitochondria, which came to be referred to as the "dynamos" of the cell, the primary power source for living systems.

ELECTRONS AND ENERGY

The above quote from Albert Szent-Györgyi introduces the idea that *all levels of organization are equally important and we have to know something about all of them if we want to approach life.* He hinted at a deeper level from which we can view biological energetics. This is the level of electrons, and leads us to the study of quantum mechanics. Quantum considerations led to a definition of the flow of energy from the sun:

> *If a photon, ejected by the sun, interacts with an electron of a molecule on our globe, then the electron is raised to a higher energy level, to drop back, as a rule within 0.00000001 to 0.000000001 sec., to its ground state. Life has shoved itself between the two processes, catches the electron in its high-energy state, and lets it drop back to the ground level within its machinery, using the energy thus released for its maintenance.*[8]

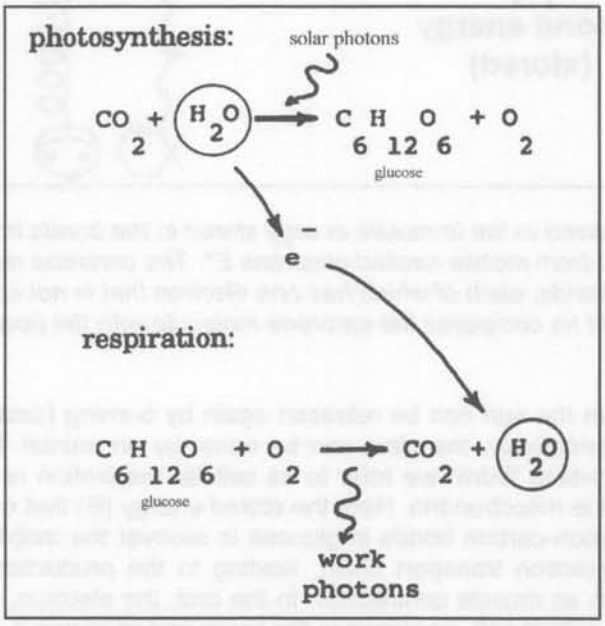

Figure 2. Overall scheme for the flow of energy from the sun to the chloroplasts of green plants and thence to animal cells where respiration or oxidative metabolism takes place.

Hence the energy that powers our muscles and brains and glands and organs and everything we do actually comes from the sun, as summarized in Figure 2. An energetic photon travels 93 million miles from the sun to the earth where the photon interacts with an electron in a chlorophyll molecule in the leaf of a green plant. The electron becomes excited when it acquires the energy from the photon. Szent-Györgyi distinguished these excited mobile electrons as E* (Figure 3). These excited or "hot" electrons are passed like hot potatoes from one chlorophyll "antenna" to another until they reach a special chlorophyll molecule called the reaction center. Here the excited electrons are passed along an electron transport chain which extracts the excitation energy E* from the electron and uses that energy to form the high energy phosphate bonds of ATP. This molecule, in turn, energizes the reaction of glucose with oxygen to form from carbon dioxide and water. Szent-Györgyi referred to the immobile energy stored in the bonds in the glucose molecule as (E). In essence the energy from the sun becomes trapped or stored in the chemical bonds of sugar molecules. These molecules can be joined together to form starch or cellulose – the energy storage materials of the green plant. The electron from the chlorophyll molecule that has been incorporated into starch must be replaced. The

replacement electron comes from water, as shown in Figure 2, and oxygen is released by the reaction.

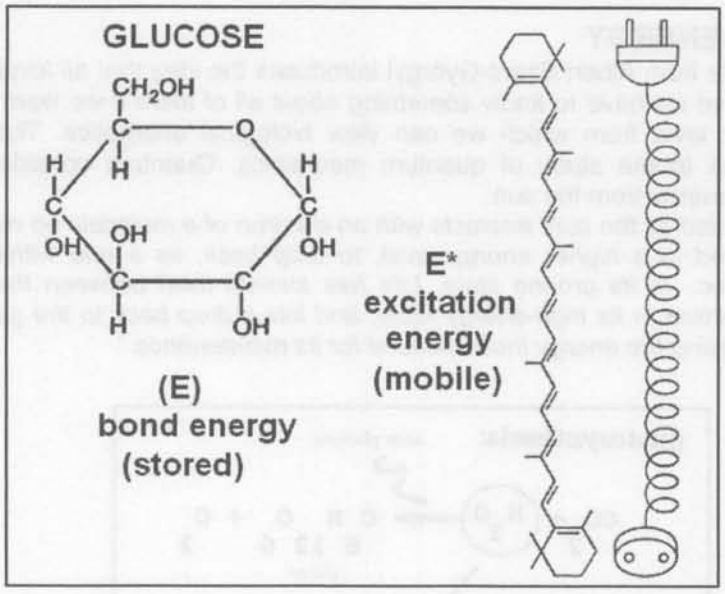

Figure 3. Szent-Györgyi referred to the immobile energy stored in the bonds in the glucose molecule as (E) to distinguish them from mobile excited electrons E. The carotene molecule on the right contains a series of double bonds, each of which has one electron that is not confined to the bond but is free to move. On the right he compares the carotene molecule with the power cord for a toaster.*

The light energy from the sun can be released again by burning (oxidizing) the plant, which produces light and heat. Alternatively, the plant can be eaten by an animal. In this case, energy is released by the slow step-by-step "burn" we refer to as cellular respiration or oxidative metabolism. This process takes place in the mitochondria. Here the stored energy (E) that originally came from the sun is released from the carbon-carbon bonds in glucose to recover the mobile excited electrons E* that are passed along an electron transport chain, leading to the production of ATP that powers physiological processes such as muscle contraction. In the end, the electron, depleted of its energy, is given back to water in the animal cell, as shown in the lower part of Figure 2.

We can see that the plant chloroplast and the animal mitochondrion are sort of mirror images of each other. In the chloroplast, light energy from the sun is captured when it excites electrons E* that are passed along an electron transport chain to generate ATP that is used to power the cellular activities in the plant, including the combining of CO_2 and H_2O to form glucose molecules. The excitation energy E* is converted to energy (E) that is stored in the chemical bonds of glucose. In the animal mitochondrion the chemical bonds of glucose are broken, the stored energy (E) is released, and the resulting mobile excited electrons E* are passed along another electron transport chain that generates a proton gradient across the inner mitochondrial membrane. An ATP synthase molecule embedded in the inner membrane uses the energy of the proton gradient to generate the ATP that is used to operate our physiological processes.

While the picture just described is satisfying in many ways, there are some unsolved aspects that were summarized at a symposium held at the New York Academy of Sciences.[9] One of the key issues was identifying the mechanism by which energy is conveyed from the places where it is produced (mitochondria) to the places where it is consumed (such as the myosin cross bridges in muscle). One of the issues discussed at the symposium was whether the present conceptual framework of bioenergetics was adequate to resolve the outstanding issues, given sufficient time and effort, or whether new perspectives and techniques would be required. These are obviously important

issues in relation to the energetics of vital processes such as the immune functions that have key significance for longevity.

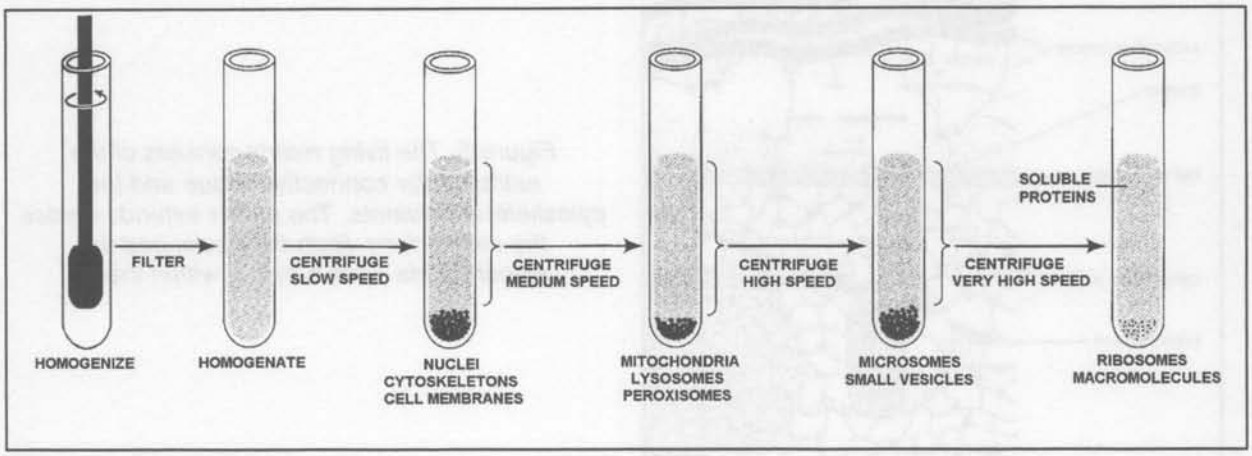

Figure 4. Cellular components can be separated and isolated by homogenizing the tissue and passing the homogenate through a series of centrifugations at different speeds. Individual organelles such as mitochondria can be separated and purified, and other techniques can fracture the organelles and separate out their molecular constituents, such as the enzymes involved in electron transport.

In retrospect, we can see a likely reason for the unresolved issues. The study of the electron transport chain in chloroplasts and mitochondria, as well as the study of how ATP powers cellular activities, benefited from the technology that led to the Nobel Prize in 1974, awarded to Albert Claude from Belgium, Christian DeDuve from Rockefeller University, and George Palade of Yale University School of Medicine. Their accomplishment was a set of techniques that made it possible to isolate and study the molecular components of organelles such as chloroplasts and mitochondria (Figure 4). With differential centrifugation it was possible to isolate mitochondria from cells. Additional techniques could then be used to break open the mitochondria and separate the membrane layers, molecular complexes and individual molecules such as those involved in intermediary metabolism and the electron transport chain. The study of these molecules in isolation has led to great advances in our understanding of the dynamics of energy transfer. However, it is helpful to remember what Szent-Györgyi said about this molecular approach, which he had pioneered in his early research: "*I know, now, that all levels of organization are equally important and we have to know something about all of them if we want to approach life.*"

The problems of energy transfer discussed at the New York Academy of Sciences symposium arose, in part, because the huge successes of the molecular approach left out other levels of organization of the cell, such as the cytoskeleton and the cell surroundings, the connective tissue matrix, as well as the lower levels of organization, such as electrons and protons. The cell and tissue frameworks – the cytoskeletons and extracellular proteins – are usually discarded in biochemical studies because the primary focus is on the molecular level. Most biochemists were satisfied with the concepts that energy metabolism involves two electron transport chains, one in the chloroplast and the other in the mitochondria, and the investigation of electron transport chains more or less ended there. Szent-Györgyi was one of the few who looked to the properties of the cell and tissue frameworks as possible conductors of energy and information.

There are good reasons to look beyond the electron transport chains as they are usually described, to see if the excited electrons E^* as well as protons (H^+) might be passed on, transported, to other parts of the cell and to neighboring cells and tissues. Szent-Györgyi began such a study as he believed strongly that it would lead to an understanding of some of the missing links in our concepts of disease and clinical medicine. Few biologists and biomedical researchers followed Szent-Györgyi into the realm of quantum physics, so the concepts that emerged are not well known. The following summarizes some of the story and points toward clinical applications related to anti-aging medicine.

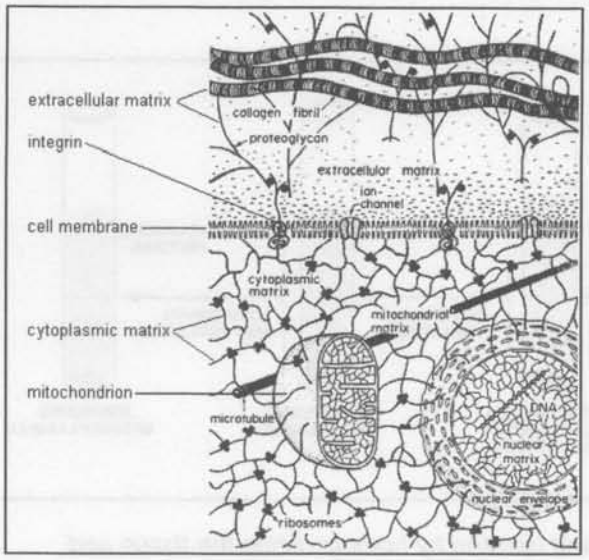

Figure 5. The living matrix consists of the extracellular connective tissue and the cytoskeletal elements. The matrix extends across the cell surface. Both the nuclei and the mitochondria have a matrix within them.

A key discovery was that the proteins forming the cell and tissue frameworks are electronic semiconductors and that the layers of water adhering to these proteins conduct protons. And the two charge transfer processes, for electrons and protons, interact with each other.[10] Hence there are good reasons to suspect that the two energetic entities produced by chloroplasts and mitochondria, the mobile excited electrons E* and the protons (H^+), can move beyond those organelles and can deliver their energy to more distant places. While ATP can diffuse from mitochondria to the sites where it is needed, such as the myosin cross bridges, diffusion is a relatively slow and random process. Electrons and protons may augment the role of ATP by transferring energy at a much higher velocity, and the cell and tissue frameworks can provide channels for directed flows.

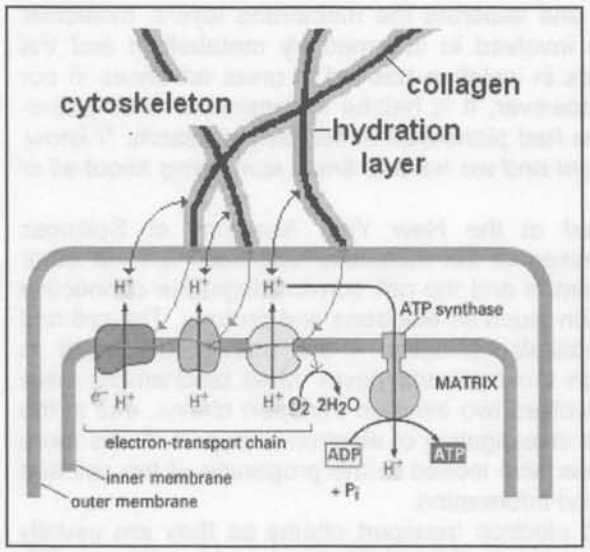

Figure 6. Detail of the mitochondrial membranes and electron transport chain on the inner membrane. Electron transport is thought to create a gradient in hydrogen ions. It is proposed that some of these hydrogen ions can transfer to the hydration layers around the proteins of the cytoskeleton (black arrows), and that excited electrons (red arrows) can be semiconducted away from the mitochondrion via the cytoskeleton proteins.

Figures 5 and 6 summarize the concept being presented here. First, a number of studies[11-14] have described structural and functional links between the cytoskeleton and mitochondria (see Figure 5). We know from considerable research on the mitochondrion that it consists of an outer and an inner membrane, and that these membranes have different properties. Embedded in the inner membrane are the enzymes responsible for electron transport (Figure 6). The outer membrane of the

mitochondrion is relatively porous. This means that there is no reason in principle that the protons (H^+) transported into the outer compartment of the mitochondrion during electron transport should be confined there. The hydration layer around the cytoskeletal filaments provides an ideal conduit for the movement of protons throughout the cell, across the cell surface, and to the surrounding tissues. Likewise it is reasonable that the mobile excited electrons E* can be taken up by the semiconducting cytoskeletal proteins and conducted to sites a distance away. It has also been proposed that energy can be transported through the cytoskeleton by solitons and other means.[15-17] Finally, it is important to recognize that these pathways may operate in both directions: they can probably conduct excited electrons away from mitochondria, and deliver externally supplied electrons to mitochondria. It is this possibility that raises interesting applications for anti-aging medicine, as we shall see next.

RELEVANCE TO ANTI-AGING MEDICINE

In terms of anti-aging medicine, we are interested in the factors that can restore and maintain adequate energy supplies and the distribution of energy throughout our bodies so that vital processes can continue to function optimally throughout our lives. We have summarized biochemical and biophysical aspects of energy production and utilization in the human body. Evidence has been summarized suggesting that movements of protons and electrons may be involved in rapid and systemic distributions of energy. The ability of charge to migrate through the living matrix is relevant to anti-aging medicine because of the potential antioxidant nature of mobile electrons. The inflammatory theory of disease has recently become one of the dominant areas of biomedical research. It is becoming widely appreciated that chronic inflammation and chronic diseases, including the so-called diseases of aging, are intimately related. While a great deal of research is being done to correlate inflammation with disease states, there are few theories on the mechanisms involved. The following provides a logical and testable theory based on a variety of kinds of evidence.

Electrons as Antioxidants

It has been suggested that free or mobile electrons are the ultimate antioxidants.[18, 19] These are the excited electrons E* described by Albert Szent-Györgyi, as discussed above. Some of the most significant evidence comes from a new and somewhat surprising line of investigation. The research concerns the nature of the changes that take place when a person walks barefoot on the earth, and when they are connected to the earth during sleep. Initial research showed that connecting the body to the earth during sleep normalizes the daily cortisol rhythm and improves sleep.[20] A variety of other effects have been documented, including reduction in pain and inflammation. Moreover, a variety of beneficial physiological changes take place virtually immediately when the body is connected to the earth.[21, 22] Dr. Gaétan Chevalier and his colleagues have begun a series of studies that use a conductive patch placed on the ball of the foot, as shown in Figure 7. This arrangement makes it possible to establish a precisely timed earth connection, and to record changes in various physiological parameters before and after the connection is made. The anti-inflammatory effects of connecting to the earth arise because the earth's surface is an abundant source of excited and mobile electrons, E*. Evidence for anti-inflammatory effects comes from studies employing medical infrared imaging,[23] from a study of the transfer of electrons from the earth to the body,[24] from a study examining improvements in sleep,[20] and from studies of rapid healing of injuries to elite athletes.[18, 19]

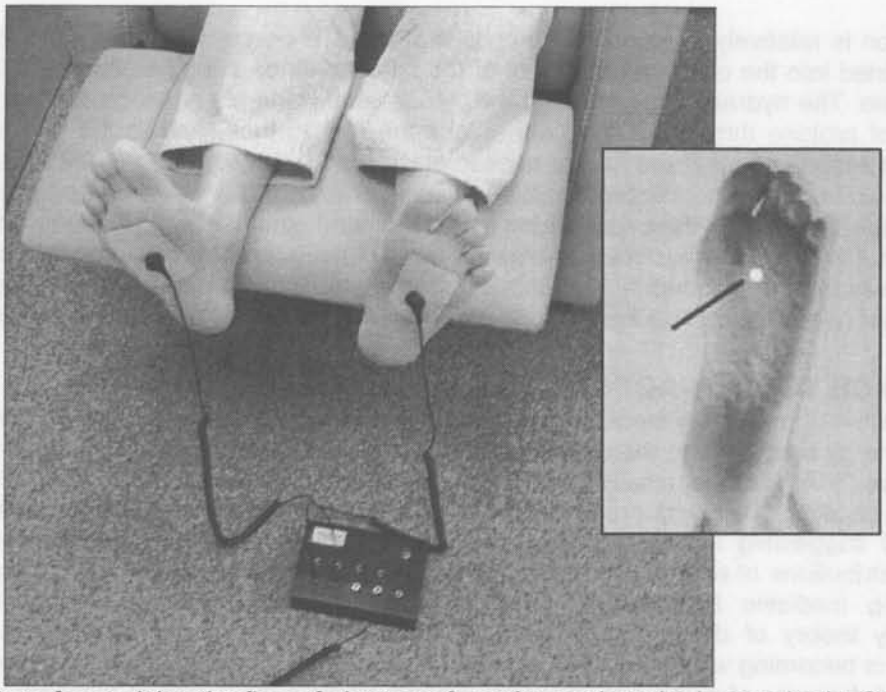

Figure 7. Technique for studying the flow of electrons from the earth to the human body. Conductive patches are placed on the ball of the foot. Wires connect these patches to an earthing rod inserted into the soil near a healthy plant to assure a good connection with the supply of free electrons on the earth's surface. Inset shows the proximity of the conductive patch to acupuncture meridian point known as Kidney 1. From Chevalier and Mori, 2008. reference [22].
I thank Drs. Chevalier and Mori for permission to reproduce this illustration.

Note that the position of the conductive patch shown in Figure 7 corresponds to an acupuncture point known as Kidney 1. This is the primary acupuncture point on the foot. While there is skepticism about whether or not acupuncture meridians are real, the evidence from study of connecting the foot with the earth is consistent with one idea about the evolutionary origin and physiological significance of the meridian system. Stated simply, it appears that Kidney 1 enables the bare foot to absorb energetic electrons E* from the surface of the earth and distribute those electrons throughout the body.[18, 19]

The concepts presented here have led to a concept of "inflammatory preparedness" in which the continuous connective tissue and cellular and nuclear matrices, referred to as the living matrix, can act as a distribution system for anti-inflammatory electrons. These electrons can be stored in a body-wide reservoir made up of the ground substance polyelectrolytes or glycosaminoglycans that reach into all parts of the body.[25, 26]

It is well known that the body tends to wall-off sites of injury and that the immune system delivers highly reactive oxygen and nitrogen species to sites of injury to destroy pathogens and to break down injured cells and tissues. It has been suggested that chronic inflammation arises when some of the free radicals leak from an injury site and begin to damage nearby healthy tissues and cells.[26] The extracellular, cellular and nuclear biopolymers or ground substances constitute a body-wide reservoir of charge that can maintain electrical homeostasis and "inflammatory preparedness" throughout the organism. The pervasive anatomical distribution of the ground substance is such that free mobile electrons E* are readily available to protect any site on or in the body that is injured. When the ground substance reservoirs are depleted, as by prolonged disconnection from the earth, free radicals leaking from injury sites can damage otherwise healthy tissues, cells, and DNA. Inflammatory preparedness is thereby compromised, as is the normal functioning of the immune system.

Electromagnetic Therapies

A second and very different line of investigation of the role of electrons in reducing inflammation concerns various devices that cause charges to move about in tissues. This research has been going on for a very long time. One of the key areas of investigation is the effort to solve a serious medical issue known as non-union of fracture. In 1812, a surgeon at St. Thomas's Hospital in London passed "electric fluids" through needles inserted into the fracture gap. By the mid 1800's, electrical stimulation was the accepted method for treating slow-healing fractures. By the late 1800's, electrical and magnetic healing devices had become extremely popular for treating virtually any ailment, from cancer to colds. This situation eventually created a backlash. The Pure Food and Drug Act was passed in 1906, and the Flexner Report was published in 1910, the latter established science as the basis for medicine and clinical education. Soon all electrotherapies, including electrical bone stimulation, were declared scientifically unsupportable and legally excluded from clinical practice.[27] This was not because they were ineffective, but because they had not been exposed to scientific investigation. The randomized clinical trial had not yet been invented. Such trials began in the 1980's and led to regulatory approval of implantable devices that passed currents through fracture sites beginning in 1987. Subsequently it was realized that currents could be induced to flow through a fracture site by using pulsing magnetic fields applied from coils positioned outside of the body.[28] The coils induce current flows in the tissues. This non-invasive approach avoided the need for surgery, and was documented to be safe and effective in multi-center clinical trials. Today two methods, implanted electrical stimulators and external magnetic coils are widely used for the treatment of non-union and delayed healing of bone fractures. And Pulsed Electromagnetic Field Therapy (PEMF) has also been applied to the healing of other tissues.[29]

Magnetic fields can introduce energy (microcurrents) within the body, either for diagnostic or treatment purposes. The usual textbook explanation involves one of the fundamental laws of electromagnetism known as Faraday's Law of Induction: a time-varying magnetic field will cause charges in surrounding regions to move. In living systems the primary charge carriers for low frequency electric currents are thought to be electrolytes: charged ions such as sodium, potassium and chloride, which are abundant in blood and other body fluids. Another mechanism that becomes more important at higher frequencies involves much smaller charged particles such as electrons and protons (H^+) that can be semiconducted through the living matrix and the water system, as described above and in Figure 6.

Biophysical studies have shown that cells and tissues can respond to electrical signals that are far weaker than those needed to depolarize neurons, produce heating or cause ionization.[30] Moreover, magnetic fields can cause dipolar molecules (molecules that do not have a net electrical charge but that have an uneven distribution of charges) to bend or rotate or change their configuration. In other words, enzymatic processes and cell behavior are both expected to be influenced by magnetic fields.[31]

There is evidence that microcurrents stimulate ATP production, protein synthesis, and amino acid transport across cell membranes in skin cells of the rat. A simple explanation for this finding is that the movement of electrons through the matrix saturates the electron transport chains involved in ATP synthesis, and that this increases the output of ATP.[32]

Finally, an important aspect of the use of PEMF for the healing of bones and other tissues is that the process is frequency specific. Moreover, there is evidence that the frequency used must be individualized to the patient – a frequency that works for most patients will not work for all.[33, 34] The following describes a system that tailors the frequency to the individual, and that incorporates the other principles described above.

The ONDAMED® System

The information presented so far helps explain some of the results being obtained with modern therapeutic devices. For example, the ONDAMED® system introduces a paradigm that does not require a patient to be given a diagnostic name or label for their disorder or disease. Instead, their condition is described in terms of an energetic imbalance that can be corrected by the application of low level pulsing electromagnetic fields of the appropriate frequencies. This is a vital distinction because of the growing concern about "diagnosis shock." This is the emotional reaction that takes place when a patient has been informed that they have a serious disease. Diagnosis shock can

compromise the healing process by bringing about depression and other emotional conditions that suppress the immune system at a time when it is most needed.

The operation of the ONDAMED® system has been described elsewhere[35] and has been the subject of previous articles in *Anti-Aging Therapeutics* and *Anti-Aging Medical News*.[36, 37] The device incorporates emerging understandings of the nature of the electrical and electronic aspects of the human body as worked out by distinguished German researchers and clinicians over the past half century. The process begins with exposing the body to very low level electromagnetic fields of various frequencies and determining which frequencies the individual responds to using a technique known as the Vascular Autonomic Signal or VAS. In essence, the VAS is a very sensitive reflex; a way of "listening" to the body. A wide variety of therapeutic schools around the world train practitioners to read the VAS and use it to define areas of the body under stress, the causes of the stress, chemical intolerances and the most beneficial interventions. In 1966, Dr. Paul Nogier of the Medical School in Lyon, France discovered that the Vascular Autonomic Signal is evoked in the radial pulse (termed the RAC in French, for Réflexe Auriculo-Cardiaque or Autonomic Circulatory Reaction) when one touches certain points on the ear of a patient. Subsequently, Nojier discovered that the arterial system responds in a reproducible manner to a variety of changes to key physiological systems in the body. To be specific, the VAS is a rapid change in the tone of the smooth muscles in the walls of the arterial system throughout the body, mediated by sympathetic and parasympathetic neurons.[38, 39] The VAS can also provide early warnings of subclinical issues and therefore provide the practitioner with the ability to reverse developing issues, sometimes before they have become clinically evident. The implications for longevity are obvious.

Figure 8. The ONDAMED® system introduces a paradigm that does not require a patient to be given a diagnostic name or label for their disorder or disease. Instead, their condition is described in terms of an energetic imbalance that can be corrected by the application of appropriate frequencies of low level pulsing electromagnetic fields. The use of the hand-held applicator (Figure 9) enables the practitioner to locate parts of the body that require attention.

The ONDAMED® device is shown in Figure 8 and the hand-held applicator is shown in Figure 9. The applicator enables the practitioner to locate areas of the body where there are energetic blockages or deficiencies or imbalances, and to determine the level of stimulation needed to restore balance. An increasing number of physicians and other health care professionals are utilizing this system to augment their conventional practices. The ONDAMED® is intended for prescription use by a licensed health care professional, and is therefore not intended as a substitute for regular medical diagnosis or treatment. Instead, its greatest value appears to be for conditions that are difficult to treat with usual medical procedures. ONDAMED® is proving invaluable for the patient who has exhausted all other treatment options and is not improving. In the past, such patients have been frustrating for the physician who is not seeing progress in spite of his or her best efforts. It is very satisfying for all concerned when these intractable conditions are resolved.

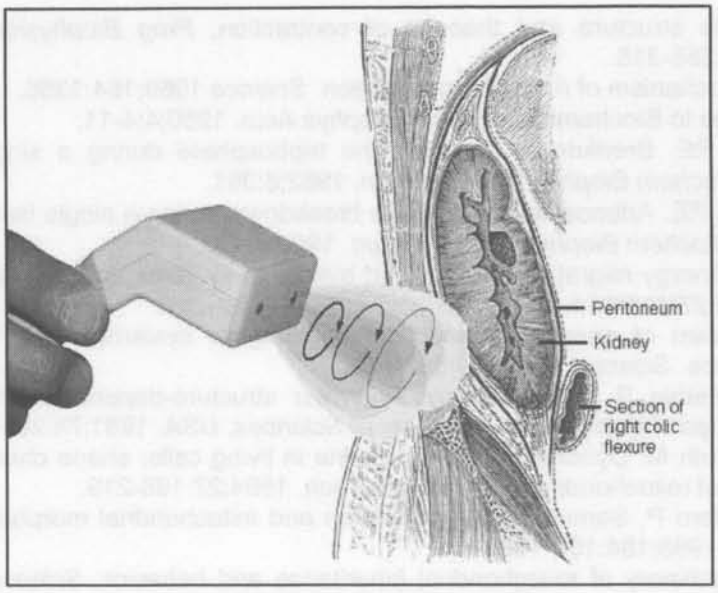

Figure 9. The hand-held applicator used with the ONDAMED® system enables the practitioner to locate areas of the body where there are energetic blockages or deficiencies or imbalances, and to determine the level of stimulation needed to restore balance.

The information discussed in this article begins to provide an explanation of the effects of the low level pulsing fields in "stirring" the charges within tissues and facilitating their entry into focal areas of chronic inflammation. At the same time, it is thought that the device stimulates the entry of mobile electrons into cells and their mitochondria, essentially saturating the electron transport chains so that levels of ATP increase. A successful immune response requires energy for the cells that must migrate to sites of injury, secrete various proteins, and engulf and digest debris. Likewise, the cell division needed to replace injured cells requires energy. These are processes that are compromised when ATP production is reduced, and appear to be quickly reversed with appropriate treatments that increase the availability of electrons to resolve chronic inflammation and stimulate ATP production.

CONCLUDING REMARKS

Optimum health, vitality, and longevity depend on maintaining the structural and functional integrity of our internal energetic systems. Of particular interest are the systems that energize the diverse activities of the immune system. This article discusses various perspectives on those energetic systems, including the role of the living matrix as both a reservoir of electrical charge and a medium for rapidly conducting antioxidant electrons to sites of injury anywhere on or in the organism. The surface of the earth can be viewed as a source of mobile electrons that can benefit the barefoot person. Studies of the physiological changes taking place when a person is connected to the earth are revealing details of how excited electrons from the earth can be conducted throughout the body via the acupuncture meridian system. Electromagnetic healing technologies such as the ONDAMED® appear to create movements of electrons in and around sites of inflammation. The inflammation hypothesis provides an explanation for the very broad range of conditions addressed with pulsing electromagnetic field therapy, particularly when the frequency of the field is tailored to the individual patient and focused on the appropriate part of the body.

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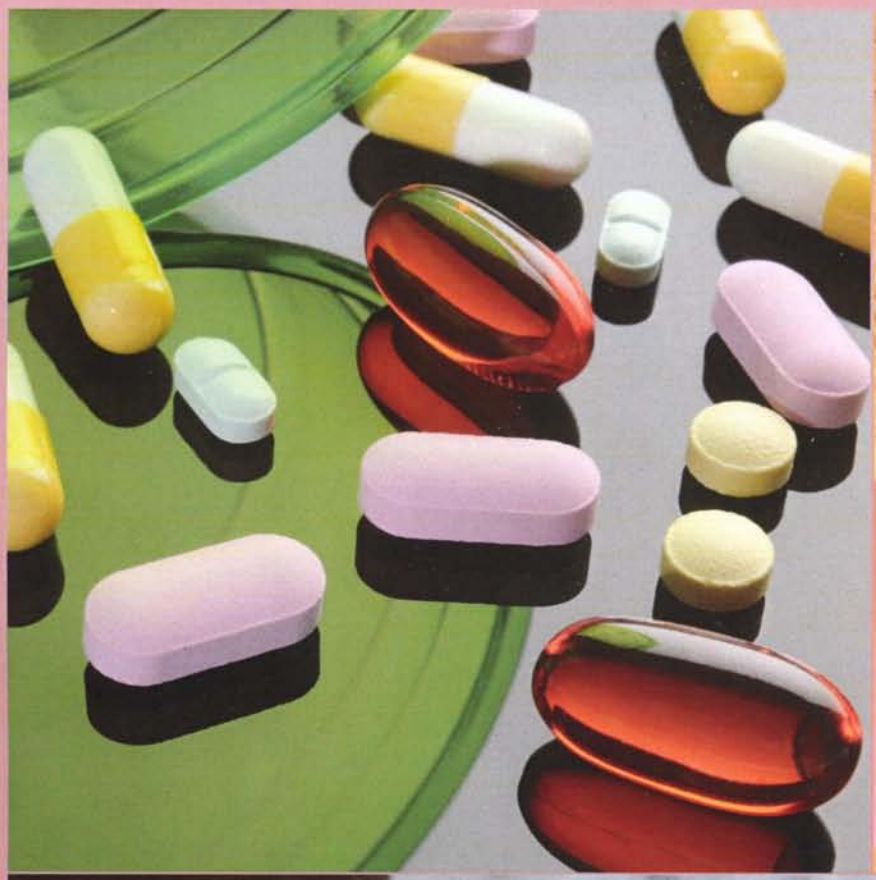

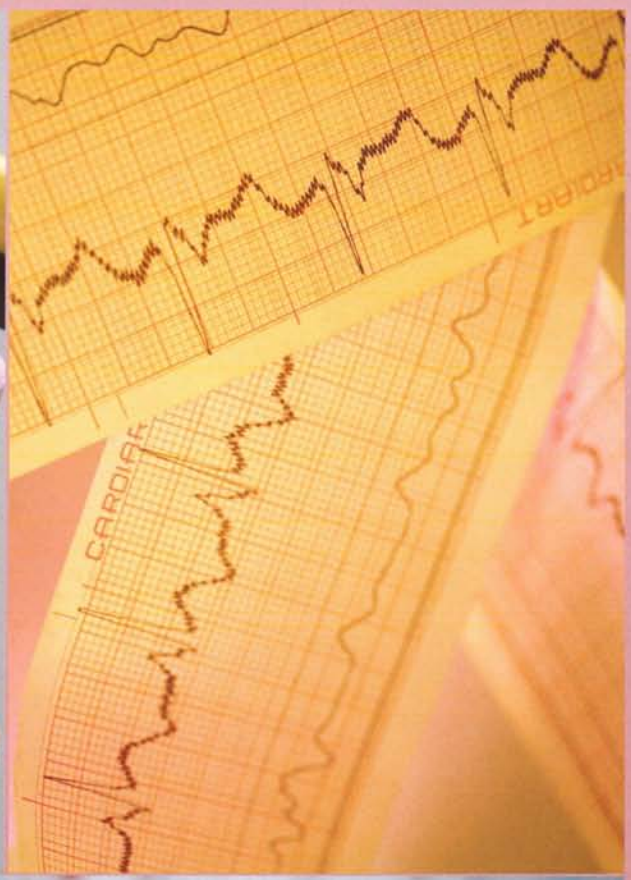

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