Call for a New Syntonic Principle

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> *Your Majesties, your royal highnesses, ladies and gentlemen, we live in a world of light.*
> Physics Nobel Prize Presentation Speech, 2005

Spitler's book, *The Syntonic Principle*, was published in 1941. His syntonic principle was based on scientific findings and beliefs from before 1940. In the 75 years prior to 1940, the theoretical foundations in all of science took a quantum leap. This led to the modern conception of the atom with a positive nucleus and orbiting negative electrons. Light phenomena played and still commands a central role in the advancement of science. In the last decades of the 19th century, the wave nature of light totally dominated scientific thought. In the first decade of the 20th century, Einstein and others recognized that when light impacts matter, it acts like a particle of energy (later called a photon) and that photons of different wavelengths impact matter with different quantities of force. Blue light photons carry greater force than green, yellow, and orange photons, and red photons carry the least force. This discovery was vital in the development of the quantum theory of matter. Light—it's color—measures the energy and dynamics of chemical and physical reactions. The color of the light absorbed and emitted by matter has been an important key to understanding nature.

> *Molecules send us messages through photons, be it through photons they absorb, be it through photons they emit.*
> Albert Szent-Györgyi

Now it is 75 years since Spitler published his thesis and we've learned a great deal about nature since then. It seems to me that Syntonics needs an updated Syntonic Principle and that we need a deeper understanding and an up-to-date science-based model that describes how syntonics and other forms of light therapy work. The physical, chemical, physiological, and medical sciences are experiencing huge paradigm shifts where long-held and unexamined assumptions are about to be revised. I hope that this article will be a catalyst for a Principle update.

This article attempts to:

- Describe what happens when a photon hits an atom or molecule.
- Show how this light works to energize the protein and water molecules in living cells, and the ways light works to help cells communicate, coordinate, and produce energy and balance.
- Describe a model of how syntonics phototherapy can possibly work the feats of healing we see with our patients.

Note that the findings and ideas here are greatly simplified and leave out quantum mechanics and modern physics. With every increase in the magnification, speed, and sophistication of the scientific technology that measures the spectrum of color, scientists can peer deeper into the nature of physical reality. The scientific and technological revolution happening right now has already impacted our lives more than the industrial revolution. And we ain't seen nothin' yet. Now is an exciting time to be a syntonist!

THE CHANGING OF BODIES INTO LIGHT AND LIGHT INTO BODIES

> *Are not gross Bodies and Light convertible into one another, and may not Bodies receive much of their activity from the Particles of Light which enter their Composition?*
>
> Isaac Newton, *Optics*, 1721

Photons are force carriers. They carry the energy or the force of light. Photons have no mass, no charge, and they pulse or vibrate through a vacuum at the speed of light. Photons are not matter, but can interact with matter to alter its chemistry, structure, and energy. Under certain conditions, matter will emit and absorb light energy. Matter heated to above a certain temperature emits photons—think light bulbs, fire, and our sun. Increase the temperature and the emitted light gets bluer. Matter can also absorb photons. An absorbed photon striking an atom or molecule passes its energy into an electron. The excited electron is forced out of its ground state into an orbit of greater energy. It is the energy of electrons that drives the machinery of life. The energy of light—its color—is directly related to the strength (ionization potential) of the donor molecule to release an electron and the willingness of the acceptor molecule to receive it (more about this later).Electrons, Atoms, Molecules, and Light

Solid matter is not solid when you get right down to it. Matter is active, energetic, and extremely fast-moving. An atom is mostly "empty" space. The mass of an electron is about $1/1500^{th}$ the mass of a proton. The diameter of an atom (of its largest orbit) is about 10,000 times the diameter of its nucleus. Electrons are distributed in orbitals or shells described as probability clouds or allowed levels of energy. Between each orbit is a "forbidden zone" where electrons are not found.

The total number of electrons in an atom is equal to the number of protons in its nucleus. So since the total negative charge of the electrons equals the total positive charge of the protons, atoms have no charge.

Electrons in the orbital closest to the nucleus have the least energy and each successively larger orbit is more energetic. The highest occupied orbit, is the orbit that contains at least one electron. The lower orbits are fully occupied (have the maximum allowed number of electrons). The highest occupied orbit can be fully occupied, partially occupied, or almost empty. Beyond the highest occupied orbit is a series of "virtual orbits," generally empty but ready to accept excited electrons that have been "photoexcited" by colliding with a photon. Electrons in the outermost occupied orbital are the most loosely bound to the nucleus and it is these outer electrons that are shared between atoms or molecules to create new molecules with unique chemical and energetic properties.

An atom's behavior depends on whether its outer occupied orbit is full (not in need of any more electrons), almost full (wants another electron to fill the orbit), almost empty (wants to give away an electron), or half empty (wants to gain or lose electrons in order for its outer orbit to become fully occupied). That's chemistry. It is the outer electrons on the highest occupied orbits that are involved in chemical reactions. And it is these same outer electrons that absorb the energy of visible photons to bring about photochemical actions.

Spitler had it right when he wrote:

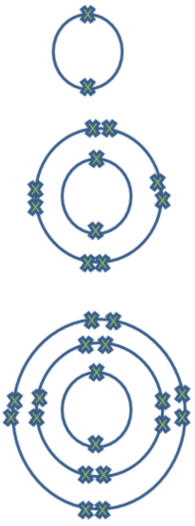
> Light carries chemical potentialities...It probably would seem strange to walk into a chemist's shop and request a quantity of light by the gram or pound as one might purchase other chemicals,

yet the fact remains that light carries chemical potentialities just as do other chemicals that are purchased by weight. [1]

Chemical reactions between atoms and molecules can cause them to combine, split apart, or rearrange in a number of ways. Visible light (photochemistry) can trigger these same chemical interactions. The force of a single photon can cause molecules to:

- Bond with an atom or other molecule
- Split molecules apart
- Change the shape of molecules
- Transfer charge to other molecules
- Sustain excited electron configurations (triplets)
- Luminesce (like fireflies)
- Convert energy to heat and vibration
- Ionize atoms or molecules (become charged by gaining or losing an electron)

It is important to realize that even the slightest alteration in the outer electron configurations of atoms and molecules fundamentally alters their chemical characteristics**.** Identical atoms of an element, when they each bond with a different type of molecule, will exhibit totally unique behaviors that are quite different from those of the original atom and from each other. The addition of just a single proton (hydrogen ion - H^+) or an electron (e^-) to a molecule will change its nature and function. Molecules and atoms bond according to their outer occupied orbits and they conduct electricity and information by electron transfer chains. During this transfer process, excited electrons pass through a series of donor molecules that transfer electrons to acceptor molecules, which then become donor molecules for another acceptor and so on, each step draining a bit of charge away from the excited electron. All of this activity can be read directly by measuring the spectrum of the light absorbed or emitted in these transactions. That is chemistry.

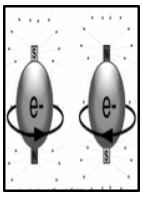


The smallest of all the atoms are Hydrogen and Helium. These have just one occupied orbit. The first or lowest orbit of all atoms can hold just two electrons, maximum. A Hydrogen atom has a single proton in its nucleus and one electron in its orbit. Its orbit is half empty or half full. A Helium atom has two protons and therefore two electrons (one pair) in its orbit. Its orbit is fully occupied. Hydrogen atoms readily give away an electron, thus becoming a hydrogen ion ($H^{+)}$ (a proton stripped of its electron leaves it with a positive charge). Hydrogen atoms can also gain a second electron to fill an orbit. This creates a negatively charged hydrogen ion (H^-). That is why hydrogen is such a versatile and active element. Hydrogen is the most abundant atom in the universe and arguably one of the most important elements in life. Helium with its fully occupied orbit is a "noble element" (like Neon and Xenon), is not driven to share its electrons and thus does not readily participate in chemical interactions.

For an electron to absorb a photon, the photon's energy (wavelength) must deliver just the right energy to force the electron out of its ground state orbit and into one of the empty and more highly charged orbits further out. Otherwise, the photon won't be absorbed and will pass

unchanged through the atom or molecule. Absorption takes just 10^{-15} seconds. Most molecules are excitable by light of one wavelength or another but usually they convert this energy to heat and vibration. This happens in just 10^{-12} of a second, too quickly to be involved in electro-biological energy transmissions.

However, in some molecules (florescent molecules), the photo-excited electrons remain in the excited orbit for longer (10^{-8} seconds) before falling back to the lower ground orbital. As such an electron falls, it shoots out a photon of fluorescent light. Many of the most important molecules in life are florescent. And because some energy is used up in this process, the wavelength of a fluorescent photon is "red-shifted" to a less blue wavelength than the originally absorbed photon. This fluorescent photon can trigger further photochemical actions by being absorbed into another molecule to set off another chain of electron transfer events. Remember that we are actually talking about millions of molecules, millions of photons, and millions of electron transfer chains.



According to quantum theory, electrons are arranged in pairs. Most atoms have a maximum of just two (one pair) in their closest orbit and a maximum of eight electrons (four pairs) in the next orbit levels. Larger atoms have more electrons, more orbits, and can hold as many as 16 or 32 electrons in their outer orbits. Orbits are subdivided into sub-orbitals or shell layers with each housing a maximum of two electrons (one pair). Electrons can pair only if they have opposite "spins". Electrons with parallel spins are "forbidden" to hook up.

In certain molecules, some local circumstance causes the excited electron to flip its spin as it jumps to the higher orbit. Its spin, now parallel rather than opposite to the spin of its initial partner, prevents it from dropping back to pair with its former partner. Thus the charged electron is locked into an excited orbit in what's called a triplet state. Triplets last from a few milliseconds to several seconds—enough time to be passed along a string of donor to acceptor molecules, from protein to protein or enzyme, which ultimately triggers a targeted cellular response or until a thermic collision switches its spin back to its original direction, allowing it to fall back into its ground state orbit and to shoot out a red-shifted photon as it falls.

The emitted light from a triplet state is called *phosphorescence.* Triplets are considered to be the main instrument of energy transmission in biology. The more electrons there are in the triplet state, the greater the chances that some of them will drop back to the ground level, each emitting a phosphorescent photon as it drops. Thus, a flood of photons and an avalanche of electron transfer actions can occur and at the final step, emit a red or infrared photon. This light can then be absorbed by a crucial enzyme or co-factor. DNA and RNA emit very long phosphorescence. Triplet excitation is made possible and stable by the surrounding water structures (but that's a story too long to write about in this article).

Red and infrared triplet phosphorescence might explain how blue and ultraviolet light therapy applied over the skin surface can affect physiological systems at tissue depths much beyond the shallow penetration of blue light. Phosphorescent red and infrared photons released in triplet reactions are able to penetrate much deeper into our tissues than blue and ultraviolet photons.

CELLS

The average human body consists of a hundred trillion cells with an average size of a millionth of a meter. It is difficult to conceive a number that large and a volume that small. Within that

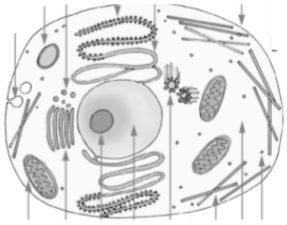
tiny space, an enormous amount of activity occurs all the time at speeds and complexity we can barely imagine. The parts of the cell are in constant intracellular communication and cooperation between all of these cells runs so smoothly in every possible situation that we seldom have cause to reflect on what a tremendously sophisticated and redundant communication system is required.

> *An organism is a whirlwind of cells made up of whirlwinds of atoms*
> G. Albrecht-Buehler

Guenter Albrecht-Buehler said the following about the body's cells:

> Doctors don't heal patients. Only the cells of the patient that can heal the patient. Only cells know how to close wounds, understand what to do with insulin and how to destroy pathogens. The best a healer can do is to: remove obstacles (e.g. surgery); advise patients about diet and lifestyle; supplement with vital energy (e.g. oxygen, nutrition, light); and supply drugs (weapons) to aid the cells. But always, they must leave the fight against disease to the cells.[2]

Living cells are not like tiny sausages filled with a watery solution of organic molecules, a nucleus and organelles (as in the familiar textbook rendition of the living cell). There is almost nothing that's passive or random that happens inside the cell and organism. Cells are constantly adjusting to changes in the outside environment by turning on and off the right mechanisms, the right genes, creating new genes if required to resolve present needs and prepare for future needs. In fact, there is nothing like free diffusion possible in the living cell. It is jam-packed with molecules, membranes and organelles. Ultimately, syntonics and other low-intensity light therapies must influence molecular systems at the cellular level. If a cell is vital and working normally, light has little impact, but if a cell is under stress and out of balance, photons of the appropriate color can optimize a broad range of local and systemic systems.



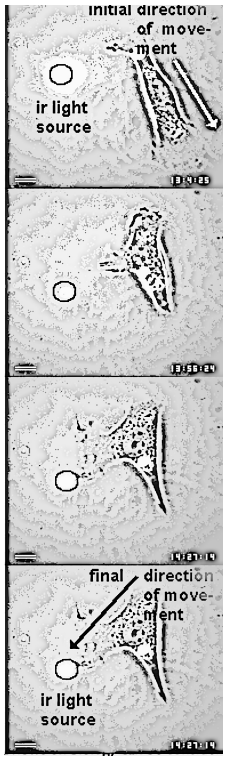
In the Mind of the Cell

Exactly 100 years ago, Nels Quevli wrote about the intelligence of cells:

> The cell is a conscious, intelligent being, and, by reason thereof, plans and builds plants and animals just as man constructs houses, railroads and other structures. Notice in this how precisely similar the actions of cells are to those of animals and human beings. They lie around and do nothing towards finding food as long as they have enough to eat, but lack of food and hunger stirs them to activity. … It never can be shown to be simply a chemical or mechanical act. There must be in the mind of the cell, a feeling or idea of a need of food to spur him to action. Matter can only act and change its place and form according to fixed chemical and natural laws without a sense of need or desire. Living beings act according to their wants and needs. They are masters and are able to direct the blind forces of nature and simple matter to their own purpose and use. It seems clear that the cells have invented, constructed and possess self-made devices with which they can gather and direct the heat or energy of the sun and thereby mold matter and direct the actions of the atoms of matter as they wish.[3]

Seventy years later in 1985, these ideas were echoed by Albrecht-Buehler in an article titled *Is cytoplasm intelligent too?*[4] Supporting the notion of cell intelligence, perhaps the most astonishing quality is the cell's ability to "see." Search online for this article to see a video showing a cell as it senses, locates, and moves while attempting to devour pulsating near-infrared lights placed near the cells. The figure to the right shows a series of still frames from the video.

The natural emitters of such signals are not yet known, he says, but the vision of an organism requires sophisticated signal processing to detect objects. Additionally, to discriminate the intensity, color, location, and dynamics of the object is a sure sign of intelligence. The ability of mammalian cells to emit and detect signals may belong not so much to the realm of optics but to the realm of long-distance communication. In other words, he says, "…it appears that continued research along these lines may demonstrate that mammalian cells exchange near infrared signals that influence their behavior."[5] "The study of cellular "vision" may be the door to our next quantum leap in the development of medicine," he predicts. As mentioned above, all diseases are ultimately healed by cells. Doctors "merely" aid the cells of their patients to do their job. He goes on to state: "Just imagine the powerful medicine doctors might practice in the future if they can literally "tell" cells in their own language (light) what they want them to do! For example, cancer cells might be "told" to stop growing or at least may be "summoned" to a certain place on the skin to be easily removed. Cells at the wound of a lost limb or eye may be "told" to grow it again. They did it once. If we learn the right "commands, maybe we can persuade the cells to do it again. Obviously, we need to learn to speak the language of cells if we want to carry medicine to this advanced level. Initially, we would record the light signals of cells in different parts and stages of an embryo. Subsequently, we could reproduce these light signals using microchips and laser diodes, and "play" them back to the cells of an adult patient, to cause it to perform one of its embryonic functions. Later, we may learn to compose our own messages in the language of cells, in order to compel cells to carry out specialized tasks, which they have never performed, even in the embryo."[6]



For more information on Albrecht-Buehler's ideas on cellular intelligence, refer to *Cell and Muscle Motility*. J. W. Shay, editor, Vol 6:1-21. You might also enjoy exploring Albrecht-Buehler's web site: http://www.basic.northwestern.edu/g-buehler/txtcont.htm.

Life is More of a Process Than a Thing

Addy Pross, a biochemical researcher, describes the whirlwinds of life:

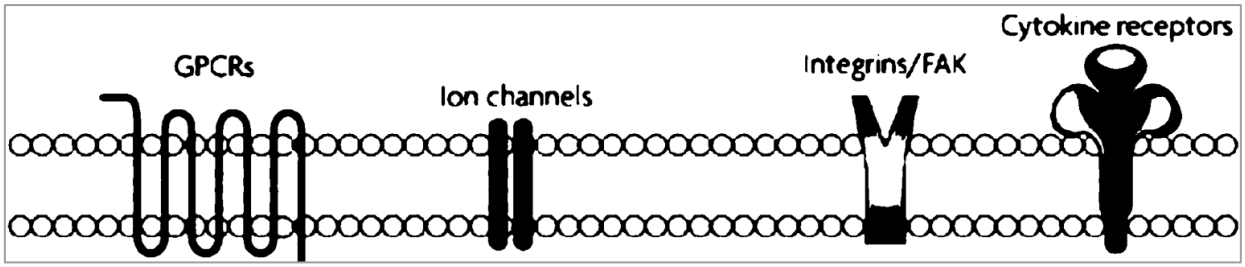
> Living organisms are an ongoing extremely complex network of chemical and sub-molecular reactions compared to the world of non-living entities. Life is a self-sustaining, constantly changing, and dynamically responding network that is organized to effectively utilize its capabilities in realizing its potential and its purpose. That purpose is to self-replicate to sustain itself in an unstable and ever-changing environment. To make this possible, the system must be reactive and therefore is also unstable. To maintain itself, it needs constantly to seek and consume energy that is constantly supplied by the environment. Even the smallest structural change in its organized complexity can bring dramatic consequences. For example, a single change in the human DNA sequence, one of the three billion units, can potentially lead to thousands of genetic diseases.[7]

The amazing feature of any living organism is its dynamic nature. Its parts are constantly changing. Each molecule in the body periodically is recycled and is replaced by a new molecule. A river can last

for millennia, though it might flood or trickle through the seasons, but the molecules of the water that makes up the river are always new. Just so does a population of animals or a forest of trees live over thousands of years but the individual animals that make up the population, or the trees that make up the forest come and go, as do the cells that make the organism and the molecules that form the cells.

Cell Signaling

Cell signaling is part of a complex system of communications that govern and coordinate basic cellular activities in response to the ever-changing predictable and unpredictable conditions within and outside of the cell. Errors in cellular information processing are responsible for diseases such as cancer, autoimmunity, and diabetes. A thin membrane divides the cell's inside from its surroundings. However, this membrane is more than a barrier; it also functions as an information filter and signal amplifier. Cells sense that something is happening via specialized membrane receptors that attach to or are embedded in the membrane. The figure below illustrates four types of membrane receptor complexes that allow various types of signals from the outside to enter the cell. Additional types of receptor complexes exist as well.



A signaling cascade comprises a series of enzymes or proteins that pass an energized electron across a series of donors and acceptors in what's known as a redox reaction. Here a donor protein that is ready to donate its charged electron passes it to an electron-hungry acceptor protein. This protein now becomes a donator and so donates to another willing acceptor, an action that continues down the series until electrons are passed to oxygen, the final acceptor in the chain. This is an energetic and not a chemical process. In fact, this involves quantum events and follows quantum laws as well as classical laws of physics, too complex and difficult to describe in this short article.

Signaling molecules such as hormones, growth factors, neurotransmitters, and other stimuli such as drugs, light, and odorants, reach to the outside of the membrane and not directly into the cell interior. Cell membranes are not the smooth and shiny surfaces we imagine them to be. Instead, specialized receptor proteins coat the surface. Membrane proteins are workhorses of the cellular machinery. It is estimated that 50% of all our body's proteins are membrane proteins for our cells. Each cell differs as to which of the body's thousands of signals it will recognize, how and for how long the signal will last, and which of the cell's own internal machines it will start (or stop from) working. It's an extremely complex process redundant with multiple error- and danger-detecting failsafe mechanisms.

Proteins

Picture a cell as a very tiny town, with active, ongoing systems that administrate, transport, generate energy, feed, recycle, communicate, construct, reconstruct, sense danger, etc. All these

systems must work together to protect, prevent, and perfect the town's vitality and survival. In a society, all this is handled by humans. In cells, proteins do all the work. They are directly responsible for the cells' movement, shape, and function. Proteins form the enzymes that accelerate and control the various chemical reactions necessary for life. The cells in our bodies contain about one hundred thousand different proteins. Just as we humans use specialized tools to perform specific functions and work in teams with other humans to accomplish necessary tasks, proteins interact with other proteins by recognizing their co-workers, influencing their actions, and coupling with groups of different types of proteins that together organize and work to regulate cell processes—interdependent, intentional, and exquisitely choreographed. Within the crowded intracellular environment, individual proteins are constantly coming into physical contact with other proteins and biological macromolecules. There is huge diversity in the frequency, specificity, and duration of these interactions. Even the tiny expression of a simple energy signal, like a school bell or factory whistle, can start and stop an avalanche of activities. Thus a seemingly tiny signal is amplified to result in a huge end effect. Very small alterations in proteins significantly change their actions, and the process is reversible—proteins can be regulated in both directions—speeding up or slowing down and starting and stopping a reaction path.

Cell Functions and Behavior Patterns

Hormones work at concentrations as low as one thousand billionths of a gram per milliliter of blood. And yet hormones from far away organs travel long distances to produce vital and powerful actions. How does a tiny bit of hormone cause huge changes inside?

Hormones don't couple with their target's receptors on a 1:1 basis. The signal is like a catalyst that is not altered or used up in this effort and so remains active and able to attract another and another of the intracellular messaging machines. Thus the message delivered by a single hormone is amplified a million times until its job is finished. The same is true of other signaling molecules and biologically active energizers such as photons. This process is similar to the operation of brakes on a car, where a gentle touch of the brake pedal is amplified and can stop even the heaviest truck. *If such a tiny bit of hormone energy can cascade to such powerful effects, then so can photons of light.*

Most hormones can't initiate a cellular response until they are branded by a co-factor, enzyme, or coenzyme. Many of these remain dormant until energized by a photon. To add to this complexity, a cell might have several different receptor types that all recognize the same hormone but activate different signal pathways. Other cell membrane receptors can recognize a variety of different hormones that that all service the same function.

Nature's photoreceptors are typically composed of a chromophore (a light-sensitive molecule that is bonded to a receptor protein at the top of a signaling cascade). The light activation of enzymes is one of the fastest growing fields of photobiology. Enzymes are important because they are catalysts that cause inactive enzyme and protein molecules to wake up. One photon can activate one enzyme molecule, and this activated enzyme can in turn process many thousands or millions of substrate molecules, thus providing a huge amplification for initiating a biological response with light. This remarkable amplification factor may be the explanation for why low levels of light therapy are effective. If the effect of one photon can be amplified biologically, then one does not need a lot of photons to produce an effect. One just needs to find the proper

wavelength of light to stimulate the proper enzyme, which in turn will stimulate the beneficial therapeutic effect.[8]

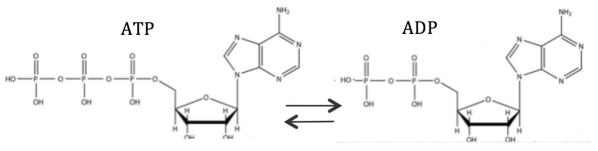
Mitochondria and ATP

Mitochondria

In addition to the stew of proteins and signaling systems in the protoplasm of a cell are a nucleus and a variety of organelles. The nucleus contains the cellular DNA that directs the formation of proteins based not only on genetic information but also on adaptive signals related to cell survival needs (i.e., the cell learns from experience). Organelles are specialized intracellular structures that serve some of the same functions for the cell as our organs (liver, kidney, heart, etc.) serve for the whole organism. One of these organelles, the mitochondrion, is considered the most vital entity in our cells and body. This is because mitochondria control fundamental cellular processes such as metabolism, respiration, homeostasis, cell division, and apoptosis (cell suicide). Mitochondria in different cell types (e.g., liver versus adrenal cells) serve different functions. Depending on their need for energy, different cell types contain a greater or lesser number of mitochondria (e.g., lens versus cone cells in the eye). Mitochondrial dysfunction is now known to cause a diverse list of pathologies such as cancer, cardiovascular problems, neuro-degenerative diseases such as Alzheimer's and Parkinson's in the brain, and Age-Related Macular Degeneration (ARMD), glaucoma, and Retinitis Pigmentosa (RP) in the eye. The list continues to grow as new mitochondrial-caused pathologies are being identified all the time. The physical and functional losses related to normal aging might also be due to mitochondria dysfunction.

Mitochondria originally were single-celled organisms with DNA and nucleus that lived apart from, but in symbiotic relations with, other living cells. At some very ancient time they merged to live inside their neighboring single-cell organisms and these eventually evolved into higher life forms, including human beings. Mitochondria are passed to the next generation, not by means of sperm and egg, but maternally via the mitochondria of the female's egg cells. Mitochondria have their own DNA systems (mtDNA). One of the most important mitochondrial functions is the production of adenosine triphosphate (ATP), the universal energy transfer molecule.

ATP is produced in two very different ways. The first way is by the mitochondrial electron respiration chain. Here triplet electrons are transferred along a remarkable system of enzyme and protein complexes in a multi-step process that converts the energy of blood sugars and oxygen into ATP, water, and carbon dioxide. The "T" in ATP stands for "triple" because three phosphates are attached to the adenosine molecule (see three phosphates in the left side of the figure) as compared with ADP where "D" (double) indicates two phosphates. This process requires oxygen (i. e., it is aerobic).



The other way that ATP is produced is anaerobic—it doesn't require oxygen. This system employs a totally different mechanism called glycolysis. In glycolysis, sugar is broken down by a process of fermentation (as in beer, wine, and vinegar). Glycolysis serves a vital role as a backup to supplement ATP production when the supply of oxygen can't keep up with the demand for it. It supplies the needed ATP energy to muscles during periods of strenuous work and when

escaping from danger. These actions relate to the sympathetic nervous system. Glycolysis is also triggered by an oxygen deficiency, hypoxia, resulting from insufficient blood flow following, for example, a stroke or head injury. Prolonged stress or illness can increase the fermentation ATP and this can lead to an acidic or toxic environment that contributes to chronic distress and disease. Lactic acid is a byproduct of glycolysis and when lactic acid builds up in the cells, muscular pain and cramping result. Cancer cells proliferating faster than the blood supply often exhibit a glycolytic cycle up to 200 times higher than the rate of normal cells. A similar disturbance in glucose metabolism is seen in Alzheimer's disease. New categories of mitochondria-related drugs are being developed to reverse underperforming mitochondria.

It is well established that low-intensity red light and infrared light increase the rate of ATP synthesis in underperforming mitochondria. Thus, light can revitalize overstressed, starved, thirsty, oxygen-deprived, impotent, or toxic mitochondria, unless the mitochondria are too damaged and beyond help. The research shows that light is absorbed by a mitochondrial enzyme called *cytochrome c oxidase* (COX). COX enzymes play a critical role in the final stage of aerobic ATP production. But COX needs the energy of a photon to be able to function. Dysfunctioning mitochondria can be resuscitated by light and light exposure can prevent or reverse mitochondrial diseases. This is the basis of the success of low-intensity light treatment of difficult-to-heal wounds, soft tissue injuries, arthritis, skin traumas, toxicity, inflammation, and hypoxia.

In addition to the red and infrared influence on the COX enzyme at the final stage of mitochondrial ATP production, blue light can also increase ATP production. In this case blue light is absorbed by a flavin molecule (flavin means blue light-absorbing) at an early stage of mitochondrial respiration process. Thus, contrary to expectations, both blue and red light stimulation can increase mitochondrial ATP production.

ATP

The ATP molecules produced in the mitochondria quickly swarm into the rest of the mitochondria and out into the cellular protoplasm, cell membrane, and outside the cell to find specific targets to phosphorylate. Phosphorylation is when ATP's highly charged third phosphate is attached to a targeted protein. The ATP engages at one or multiple key places on the protein to supply the energy (in the form of a highly energized phosphate) that is needed to perform actions such as moving proteins from one place to another or causing the folding, unfolding or refolding of proteins. The ATP, now stripped of a phosphate, is thus converted back to ADP. The newly produced ADP must then quickly change itself back into a mitochondrion to be recycled to ATP.

The average cell contains about one billion ATP molecules. Human bodies contain about a sextillion (10^{23}) of them. The combined weight of ATP and ADP is about ⅛ pound. Each of the cell's billion ATP molecules recycles 3 times per minute. When working hard, a single muscle cell can consume and regenerate over 10,000,000 ATPs per second. The total mitochondria in the average human body reconvert 3 X 10^{23} ADP molecules into ATP each minute of the day and night. We convert the equivalent of our body weight of ATP each day. If ATP couldn't be cycled, we would have to consume nearly our body weight in ATP daily.

CELLULAR MECHANISMS OF LOW-LEVEL LIGHT THERAPY

In the late 1970s, Tiina Karu, a biophysicist in Moscow, began researching to discover the cellular mechanisms related to low-level light therapy (LLLT). This section describes some of her discoveries and conclusions. In a chapter entitled "Mechanisms of Light Therapy on Cellular Level," (2000)[9], and "Absorption of Monochromatic and Narrow Band Radiation in the Visible and Near IR by Both Mitochondrial and Non-Mitochondrial Photoacceptors Results In Photobiomodulation," (2014)[10], she described several aspects of how light works. Her findings and conclusions support syntonic practices and provide hints that may answer questions about how filters that seem very similar can produce different effects, how different filter combinations from different parts of the spectrum produce similar results, why the same filter can improve many different functions, why syntonics doesn't always work, how light in the eyes can affect tissues and systems far from the eye, how light knows just where to go, and whether light always has immediate effects or whether the effects can be delayed by hours or days following a treatment.

The following paragraphs summarize some of her findings regarding these issues:

- *How does syntonics modify systems located far from the eyes?* Light excites actions that signal metabolic actions in cells that occur later in the dark. Photons excite light-absorbing molecules on the cell membrane's outer surface (the primary photoreaction). This sets off a chain of physical and chemical actions inside the cell that can occur in the dark (secondary photoreaction). The signals travel via cascades of biochemical redox reactions that amplify the initial signal and target specific molecular complexes that influence cellular homeostasis parameters.
- *Must therapeutic light sources be coherent or can the incoherent light used in syntonizers also work?* Conventional light sources (incandescent) at the right wavelengths are just as effective as monochromatic, coherent (laser) sources.
- *Why does syntonics sometimes bring such great healing and other times little or negligible impact?* Light doesn't improve cell functions that are already working well. The impact of light on a cell depends on its redox state, whether it is in a normal pH range or more acidic than normal. If the pH is normal, the cell is already vital and light has little or no effect. If the pH is lower (acidosis and hypoxia), light stimulation can normalize the pH and vitality.
- *How can one filter combination produce so many diverse healing effects?* A single wavelength of light can improve multiple types of local and systemic functions. If the mitochondria are not recycling enough ADP to ATP, photons at appropriate wavelengths cause ATP production to increase. This can lead to various reactions in different types of cells that result in a diverse range of healing effects (e.g., wound healing, chronic inflammation, ischemia).
- *Can light therapy really help to balance the autonomic nervous system?* Cells communicate and coordinate with other cells throughout the body. Light's impact on one type of cell will influence the metabolism of other types of cells. Various types of cells (e.g. liver, muscle, hypothalamus, etc.) respond to photo-induced modulations of cellular pH in a variety of different ways.
- *Shouldn't light from the red and blue ends of the visible spectrum produce opposite effects?* Mitochondria are photosensitive. This is the major impact of light on cells. Mitochondrial respiration (the conversion of sugars and oxygen to recycle ADP to ATP and water) requires

the energy of light to function. Cytochromes and flavoproteins are the key enzymes of the mitochondrial respiration chain that leads to ATP. Cytochromes are orange-red-, red-, and infrared-sensitive and flavoproteins are blue-sensitive.

- *Can light from syntonic filters that only slightly change the spectrum (like by adding D or S or changing mu/delta to mu/theta) really make a difference?* Studies that measured the absorption spectrum of light that improved important mitochondrial processes found that they were driven not just by one specific wavelength of light, but were improved by wavelengths from across the spectrum. They also found that other nearby wavelengths improved other metabolic-related mitochondrial functions such as ATP production, oxygen consumption, membrane potential, and refractive index. For example, Tiina Karu's findings showed that:
  - ATP production was increased by low levels of violet at 415 nm, orange at 602 nm, orange-red at 632 nm, red at 650 nm and long-red at 725 nm. However, blue at 477 nm and green at 554 nm had no effect.[9]
  - Oxygen consumption increased using ultraviolet at 365 nm and violet at 436 nm, but not at ultraviolet at 313 nm, green at 546 nm and yellow at 577 nm. Mitochondrial membrane potential, refractive index, RNA and protein synthesis were affected by red-orange at 633 nm (alpha-delta).[9]
- *Does the time of day or the season during which we are doing syntonics really matter?* The response to light depends on the current conditions at the time of irradiation. Thus, light treatments during the spring or summer season when cells are growing at their maximal rate may bring little or no results, whereas in the autumn and winter when the cells are the most dormant, light therapy increases cell vitality. This may explain why delaying a second series of treatment by a couple of months (to another season) can improve the results. The same principle can apply to circadian patterns that change throughout the day.
- *Why doesn't increasing the dose of syntonics bring increased improvement?* The speed of cell healing has a natural limit so that increasing the light intensity or length of treatment does not necessarily improve the outcome, even when using the appropriate wavelength of light. This limit of change might be why we must sometimes wait for days or weeks to see maximum results.
- *Why isn't there more definitive research that proves that light therapy really works?* Doing dependable light therapy research is very complex because there are so many factors at play. Because the results depend not only on the patient population (e.g. the age, gender, medical history, test findings, diagnosis and etiology of the patient and control populations), but the light parameters (e.g. wavelength, intensity, length, frequency, pulse rate, number of treatments, time of day, time of year, etc.) must be tightly controlled and optimized. Additionally, the results don't always appear immediately, but might manifest hours or even days after treatment. With this many factors to consider, light therapy results can be negative. Light therapy critics can always use one failed result to debunk dozens of positive outcomes, and research methods can be disparaged.

FOUNDATIONS AND THE FUTURE

This article was originally conceived as a review and tribute to the work of Nobel Prize winner, Albert Szent-Györgyi, whom I greatly admire. Just after Spitler's book was published in 1941,

he began to publish his new ideas on the life sciences. He felt had they had reached a dead end because their investigations stopped at the level of chemistry and did not embrace the sub-molecular and quantum energetics of matter and life.

Szent-Györgyi wrote simply and elegantly about photos, electrons, and hydrogen atoms, triplets, photochemistry, electron transfer chains, liquid ice versus bulk water, proteins, free radicals, the similarity between photosynthesis (sunlight produces sugars in plants) and photobiology (light's effects on animal respiration). He demonstrated his theories by showing rapid color changes in the fluorescent and phosphorescent light emitted as he mixed well-known biological molecules such as riboflavin (vitamin B_1), serotonin, and LSD (yes, LSD). He plunged these mixtures into liquid nitrogen to create long-lasting triplet electron states and showed how the color changes caused by adding just a tiny amount of oxygen, thyroxin or adrenalin did not require one-to-one molecular contacts, as would be predicted by chemical concepts, but that the color changes operated throughout the mixture, energetically or electromagnetically like electric waves or how a magnet gives shape to a loose pile of iron filings, all at once.

> *. . . the chief property of muscle is that we do not understand it. The more we know about it, the less we understand and it looks as if we would soon know everything and understand nothing. The situation is similar in most other biological processes and pathological conditions, such as the degenerative diseases. This suggests that some very basic information is missing.*
>
> Albert Szent-Györgyi, 1937[11]

In this article, I've attempted to summarize some of the more recent research results connecting light, syntonic light therapy, and sub-molecular and quantum energetics. Szent-Györgyi's work, however, remains a vital foundation for the subsequent work in this field. I hope that we can continue in his tradition of visionary thinking and research to advance our understanding of the profound effects of light on living beings.

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