Low Level (Cold) Laser Therapy: Medical Breakthrough or Pseudoscience Scam?

An Opinion Paper

Practitioners and instrument manufacturers make several claims about LLLT. Copious technical specifications are provided (wavelength, frequency, pulsed/continuous, energy density, Watts/cm2). Their bottom line is – does it deliver photons to the injured tissue? I believe there is a much more important question – what could the photons possibly be doing when they get there?

LLLT enthusiasts claim

- Reduced pain – by rebalancing Na+/K+ pumps
- Reduced inflammation and increased sense of wellness – by affecting chemical signals within the blood stream, including endorphins and serotonin
- Quicker healing – accelerates cell regeneration and stimulates collagen formation
- Increased breakdown of scar tissue – which can be the source of muscle tightness, pain and inflammation
- It stimulates angiogenesis and repair of lymph vessels – this improves circulation to the tissue

None of these things are possible without a basic, underlying assumption – incident photons stimulate production of ATP. Photons (packages of light energy) are 'captured' and used by our cells. More energy is available for healing our tissues. The photons are transformed into biochemical energy (ATP) in the mitochondria – the cell's powerhouse. It is a fact that all cell processes require energy in the form of ATP. It is used to fuel the transport mechanisms in the cell membranes (for example, the Na+/K+ pumps), it activates enzymes so they can do synthetic work, it allows cross-bridge formation so that muscle cells can contract and you can do work! But where does the energy come from? Ultimately, it comes from just one place – the sun.

Does this mean that bathing a case of lateral epicondylitis in the light of a specific wavelength will work to add useful 'energy' to our cells and tissues? The answer is no. Why do some practitioners believe it works? I believe it is because they have forgotten some of the basics of the chemistry of life.

LLLT fans propose that photons are captured by Cytochrome C – a pigment within the mitochondria, thus entering the Electron Transport Chain and driving the synthesis of ATP. This is, plain and simple, **not possible** and the balance of this discussion will focus on why it isn't possible.

It is my position that our mitochondria have **zero** capacity to capture energy from incident light. They do have a magnificent ability to extract energy from our food – food that contains the energy of the sun, captured and converted and held for us by plants. Photosynthesis is complicated. It isn't easy to save a photon of light and turn it into a package of chemical energy that our cells can use now or tomorrow or the next day.

Plant and animal cells share many common features.

- They both have membrane bound organelles to compartmentalize specific biochemical functions. Selective separation of components results in the creation of electrochemical gradients (keeping electron donors apart from electron receptors). These gradients represent potential, stored energy – which can then be taken from one form and transduced into another (more useful) package.
- They both utilize pigments. These are special metalo-protein complexes which selectively absorb/transmit particular wavelengths of light because they are composed of highly conjugated ring systems with very mobile (delocalized) electrons above and below the plane of the molecule.

Chlorophyll and Cytochrome C are two examples of 'pigments'. Cytochrome C is found within the Electron Transport Chain of the mitochondria and is an essential element of the process of cell respiration. Both plant and animal cells have mitochondria. Chlorophyll is located within chloroplasts, an organelle found only in plants and is the key to the process of photosynthesis.

These two processes – photosynthesis and cell respiration – are the basis of life on the planet.

$CO_2 + H_2O \rightarrow$ carbohydrates $+ O_2$

This is **photosynthesis**. In the presence of light and chlorophyll, photolysis of water occurs. This is a reduction reaction which traps energy within the chemical bonds of carbohydrates, which allows for storage of the sunlight's energy until it is needed.

Carbohydrates $+ O_2 \rightarrow CO_2 + H_2O +$ ATP

This is **cell respiration**. It is an oxidation reaction, releasing the energy trapped within the carbohydrate and transferring it to the bonds of ATP, the package of energy which can be used to run various processes of cell life. (Compare this to the phenomenon of fire – the equation is the same but the energy is released in the form of heat.)

It is the special structure of pigment molecules which allows both of these processes to occur, but one pigment cannot be substituted for the other. Chlorophyll and Cytochrome C, while they have many similarities, are not the same.

When light strikes a pigment, photons of a particular wavelength will be absorbed, thus giving the molecule a particular colour. There are four possible fates for the photons which are absorbed by a pigment.

- Lost as heat energy – the light is redistributed as atomic vibrations, which produces heat
- Lost as light – the pigment molecule is energized, then light is released (think fluorescence)
- Resonated to its neighbors – via a complex array of ring structures (this is exactly how chlorophyll is built)
- Transduced to chemical energy via reduction reaction – this occurs at the reactive core of chlorophyll

Cytochrome C within the mitochondria (like all of the components of the Electron Transport Chain) is specialized to transfer electrons. This is its only task. The electrons have to come from somewhere. They were donated by water, within the cells of a plant, during the process of photosynthesis. Cytochrome C does not have the capacity to capture and transform the energy of incident photons. Only chlorophyll can do that.

It is my assertion that the only possible fate of photons which interact with the mitochondrial (cell respiration) pigments is the first one – they are lost as heat energy. The warming of the tissues will result in vasodilation, which could certainly be helpful for the healing process. A hot pack might be easier (and infinitely cheaper).

So when LLLT proponents claim that “Just as plants absorb light to grow and repair, so do humans”, they reveal a lack of understanding of the basics of the chemistry of life.