The Assault on the Ψ

Martin Bier

Quantum mechanics is mysterious. Consciousness, homeopathy, cancer, and anesthesia are also mysterious. The thought that there may be a connection is tempting. This idea, however, has led to to a whole lot of quantum-biological nonsense and a vast gray area between science and pseudo-science.

"Shut up and calculate"

About a hundred years have passed since quantum mechanics was first developed. The first few decades of the 20th century were a turbulent time in physics. Quantum mechanics proved very successful in describing what was happening on the atomic level. The emission of light by objects when they are heated up (i.e. the light bulb), spectral lines and later things like superconductivity, superfluidity, and the laser could be well understood and described with quantum mechanics.

Quantum mechanics is not an approximation or an ad hoc trick to make the equations agree with reality and with each other. It is a fundamental theory that is supposed to describe what is really happening on the atomic level. A wave function, the Ψ, is at the basis of the theory. The Schrödinger equation rules the evolution in time of the wave function. The Schrödinger equation is not hard to make sense of. The equation is linear (i.e. sums of multiples of solutions are also solutions) and for many specific cases there is an exact solution or, at least, a good way to approximate the solution. A problem, however, arises when you want to leave the math for a moment for what it is and understand what is exactly happening when an observation is made on a system on the atomic level.

In quantum mechanics a particle, like for instance an electron, is represented with the aforementioned wave function. The electron is then no longer a point particle, but more something like a rippling of the water in a pond; a rippling that is simultaneously present at more than one spot. Suppose you have a device that takes the outcome of an atomic level event, amplifies it, and makes it visible on a macroscopic level. A Geiger counter is a good example. What is supposed to happen when the observation is made is that the wave function collapses onto one of its coordinate axes. Such coordinate axes are not to be thought of as tangible geometrical objects with real directions in three dimensional space. They are part of a mathematical model and there can be infinitely many of such axes. There is no equation that describes the collapse. The numerical outcome of the observation depends on which of the coordinate axes the wave function collapses on. It is only probabilities that are associated with the different coordinate axes that can be derived from Schrödinger's equation.

"Observation" is a somewhat vague notion and many physicists have a problem with its central role in quantum mechanics. Also the fundamental stochasticity of the theory and the peculiar collapse of the wave function are troublesome for many. Einstein's "God does not play dice" is famous. Feynman's attitude was as cynical as it was pragmatic. In *The Character of Physical Law* he writes: "On the other hand, I think I can safely say that nobody understands quantum mechanics" (Feynman, 1965). "Shut up and calculate" is another statement that is sometimes attributed to him.

FIG. 1: Erwin Schrödinger's portrait on an Austrian banknote

Many textbooks and devices bear witness to the success of the "shut up and calculate"-mentality. But below it is the derailments that will be discussed, i.e. the cases of little calculation and lots of hot air. There are theories that explain or predict very little and try to look respectable through the use of wave functions.

A human body as a laser cavity

Herbert Fröhlich was a very prominent solid state physicist in the middle of the 20th century when solid state physics was still a very hot area. It was in the latter days of his career, at the end of the 1960s, that he started focusing on the physical origins of biological function. His work on this subject appeared in regular scientific journals (Fröhlich, 1968) and even in the very prestigious journal *Nature* (Fröhlich, 1970). Also contemporary research that builds on Frölich's ideas is commonly published in bona fide scientific periodicals. But the involved ideas should, at best, be considered speculative and dubious.

The inspiration for Fröhlich's theory was the laser. The fundamental principle behind the laser was formulated by Einstein in 1917 (Einstein, 1917). But working lasers were first constructed in the 1960s. A thorough understanding of how a laser operates indeed requires quantum

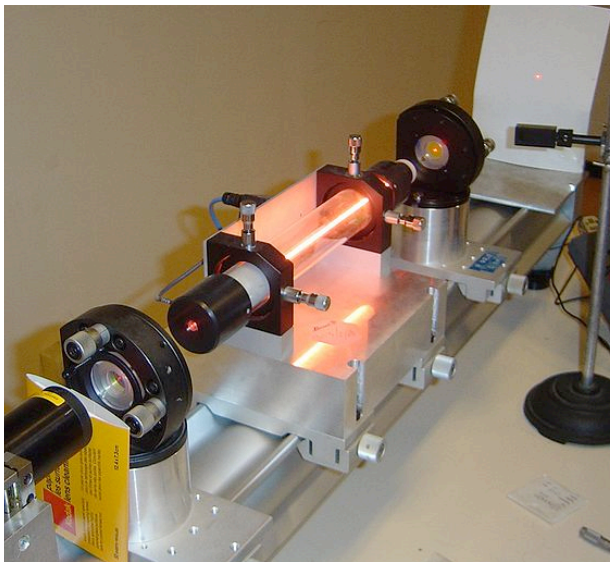

FIG. 2: A laser setup. The laser medium is in the tube in the middle. The laser beam leaves the tube through a partially transparent mirror at the right end of the tube.

mechanics. But the basic mechanism can be understood without recourse to wave functions.

Suppose that a molecule has a ground state with an energy E_0 and an excited state with a higher energy E_1. When that molecule falls back from the excited state to the ground state it can emit a "light particle," a so-called photon, with an energy $\Delta E = E_1 - E_0$. Now if such a molecule is hit in its excited state with a photon of energy ΔE, then the interaction between the photon and the molecule can lead to a stimulation of the molecule's falling back to E_0. After stimulated emission it is two photons that proceed. It is clear that a chain reaction will occur in a medium that is filled with molecules that are in the excited state. When stimulated emission takes place, a light wave will keep the same wavelength, but increase in amplitude. The resulting laser beam is coherent, i.e. all photons are in phase. For a laser to function continuously it is necessary that molecules in the laser cavity are continuously pumped back to the excited state. This can be done, for instance, with electric discharges.

According to Fröhlich proteins and other biomolecules in a living organism can interact with each other like the molecules in a laser medium. Proteins commonly have very strong dipoles. When such dipoles oscillate microwave radiation can be emitted. Such radiation can, in Fröhlich's picture, stimulate emission of radiation of the same wavelength in other proteins. It is because of this "communication" between proteins that an organism can operate as a unity. It is purported, for instance, that cells in the heart can coordinate and all take part in the same heartbeat through "Fröhlich coherence."

It is true that the chemical bonds in a protein can vibrate and emit electromagnetic radiation in that way. But you don't get a functioning laser just like that. There is a good reason that about 40 years passed between the concept of the laser and its actual construction.

A chain reaction requires a sufficient density and quantity of the chain reacting substance. If there is, for instance, not enough vaporized gasoline in the air-gasoline mixture in the cylinder, then the spark from the spark plug will not lead to the desired combustion. Uranium needs to be enriched before it can be utilized in a nuclear reactor, i.e. the concentration and the quantity of the active ingredient ^{235}U need to be brought above a certain threshold before a self-sustaining chain reaction can occur. Just like for the combustion engine or a nuclear reactor it is "all or nothing" for the laser. In the laser cavity a laser beam requires a high density of photons and a large power transfer through a small space. Below a certain threshold, the stimulated emission will simply never get started. A laser beam carries a minimum of a about a kilowatt per square centimeter. Densities that high simply don't happen in a human body. For comparison: a kilowatt is what a professional cyclist may generate with his entire body for about 10 seconds in a sprint. In a *Nature* column Fröhlich urges on his colleagues to search for coherent radiation at the surface of a living organism (Fröhlich, 1970). Of course, nothing like that has ever been observed in the four decades since.

Proteins occupy about 15 to 35% of the cell volume. But there are many kinds of proteins and for any individual type protein the concentration is at most a few grams per liter. Proteins, furthermore, are very complicated molecules. When a solution of proteins is subjected to a beam of microwaves, we see that microwaves of many different wavelengths are scattered in all directions. This is because the energy of an absorbed photon does not stay fixed in one spot and in one oscillation, but instead is rapidly dispersed across the irregular protein structure before it is re-emitted. An oscillating chemical bond in a protein is connected to many other chemical bonds that oscillate at other frequencies. In the periodic structure of many solids it can be easily understood how stimulated emission can occur. But how it can happen with proteins dissolved in a liquid is hard to imagine.

Communication and coordination within an organism are generally taken care of through hormones and through the nervous system. The involved signals are very concrete and very recordable. Much of modern medicine is based on tinkering with such signals. "Fröhlich-coherence" is commonly proposed as a kind of "hand of God"-explanation when some data appear hard to interpret or when some regulation is not fully understood. It has, for instance, been suggested that the health effects of nearby power lines come about because the emitted radiation disturbs the Fröhlich mechanism.

It is not surprising that Fröhlich's jargon is used frequently and with great effect when the health industry is marketing vague gadgets. In many instances alternative medicine has also gratefully embraced Fröhlich's theories. Especially the acupuncturists like to refer to Fröhlich for a scientific foundation and a legitimization of their activ-

ities. On http://www.drchauallergyclinic.com/cold.htm we find an advertisement for a little laser lamp. Cells with electromagnetic problems can allegedly be forced back to the correct and healthy frequencies by shining light from this little lamp onto the problematic tissue.

From cytoskeleton to checkmating

Among physicists the Nobel Prize winner Eugene Wigner stood somewhat alone in his conviction that consciousness is required to make the wave function collapse. Wigner died in 1995. That was one year after the Queen of England knighted Roger Penrose. Penrose basically inverted Wigner's idea. According to Penrose consciousness is a consequence of the collapse of quantum mechanical wave functions.

Just like Herbert Fröhlich, Roger Penrose had built up an impressive record in a non-biological branch of physics before he devoted himself, at a later age, to the quantum origins of life and consciousness. *The large, the small, and the human mind* (Penrose, 1997) contains a concise and very readable explanation of Penrose's quantumbiological theories. The theories of Roger Penrose and his coworker Stuart Hameroff are much more imaginative and all-encompassing then those of Fröhlich. With a great many examples Penrose argues that the human mind does not operate algorithmically. The way in which we, for instance, analyze a position in a chess game is, according to Penrose, more than just a sequence of procedures. Together with the anesthesiologist Stuart Hameroff, Penrose developed the idea that the cytoskeleton harbors a quantum computer. The operations that are carried out by this quantum computer are what would lead to consciousness.

The cytoskeleton is kind of a network of support beams that gives the living cell structural reinforcement. Every cell that is larger than a bacteria has a cytoskeleton. Microtubule (Figure 3) is the main constituent of the cytoskeleton. The monomers in the a microtubule spiral are proteins that consist of about 800 amino acids. Two conformational states are possible for each individual monomer. By associating these states with the 0 and the 1 of the digital code we have formulated the basis for a computer. It's a quantum computer in this case, because for each monomer the wave function is suspended between the two states. The two different conformational states have different electric dipoles. The dipoles of neighboring monomers can "feel" and affect each other and, in this way, the monomers interact with each other. This would entangle the involved wave functions. The time evolution of this system of entangled wave functions would, in principle, be like a working quantum computer.

The cytoskeleton differs from a customary network of support beams in that it is in continuous motion. Cells grow, shrink, and change shape all the time. For nerve cells the dimensions of the synapses can be changed through the growing or the shrinking of the microtubules. It is at these synapses that signals are being transferred from one cell to the next. At the synapses, according to Penrose and Hameroff, the regular nervous system is connected to the microtubule network and it is there they interact.

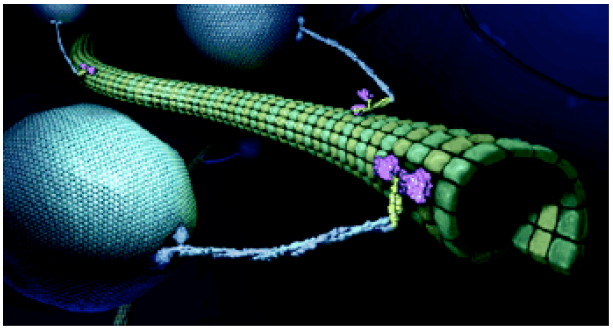

FIG. 3: Cover image of *Journal of Cell Biology*, Vol. 151 (2000). An artist's impression of microtubule. Microtubule is a very stiff polymer and it is the major part of the cytoskeleton. Every little green block is a monomer. Such a monomer is an individual protein of about 800 amino acids. The eventual polymer is a spiral that counts 13 monomers per winding and has a diameter of 23 nanometers.

Penrose has worked in quantum theory and in general relativity since the 1960s and has earned a great reputation. However, his theory about the collapse of the quantum mechanical wave function is very unusual and very far from being widely accepted. Suppose an electron can exist in two states. This could be "spin up" and "spin down." The wave function would then be suspended between these two states. According to Penrose both states will really evolve. However, there is a gravitational attraction between these two states. Penrose's idea is that the wave function collapses onto one of these states when the energy that is associated with the gravitational attraction becomes too large. For the microtubule this is supposed to work as follows. Every monomer consists of two clusters and the distance between these two clusters is different in the 0 and the 1 state. It is a small difference; it is only tenths of nanometers. Gravity leads to an attractive force between these two clusters. In the electrochemical reality this gravity is completely overwhelmed by electrostatic interactions and the thermal motion of the molecules. But, according to Penrose, gravity is essential for the collapse of the wave function. Two states with an gravitational energy difference ΔE can coexist in a wave function for a time Δt as long as ΔE and Δt are within the limits that are set by Heisenberg's uncertainty relation, i.e. $\Delta E \times \Delta t \approx h/2\pi$. The symbol h represents Planck's constant, which is a very small number (6.6×10^{-34} Js).

It is not hard to compute that the combined wave function of about a billion monomers lasts around a second. For a heavier object like a human being the wave function collapses within 10^{-30} seconds according to the quantum gravitational model of Penrose. For lighter objects like an electron or a proton the wave function can persist

for many millions of years. But for a polymer like microtubule the survival timescale of the wave function is one that could be relevant for the operation of the nervous system. The basic idea of Penrose and Hameroff is that the microtubule quantum computer starts starts calculating, but that after about a second the calculation is terminated by the quantum gravitational collapse of the wave function. The cytoskeleton would at that moment effectively transfer the state of the calculation to the nervous system. Because the precise moment of termination is not algorithmically determined, this hypercomputer transcends algorithmicity. It is in this way that, according to Penrose and Hameroff, we experience a "moment of consciousness" about every second.

The anesthesiologist Hameroff feels that, with these insights, he is on to solving one of the greatest fundamental problems of anesthesiology. It is still not fully understood why certain chemicals lead to anesthesia and others do not. The key here, according to Hameroff, is not to be found in the interaction between the anesthetics and the nerve cells, but, instead, in the interaction between the anesthetics and the microtubule.

The theories of Penrose and Hameroff are very ingenious. However, there are a great many very reasonable objections that have been formulated. Penrose is somewhat alone in his idea that human thinking does not proceed algorithmically. At the end of *The large, the small, and the human mind* there are three critical essays by prominent colleagues of Penrose about the theory. One of these criticisms is actually about this algorithmicity. The shortest of the three essays is from the hand of Stephen Hawking. Hawking points out that quantum gravitation as a criterion for the collapse of the wave function is questionable. There are other mechanisms that lead to a much quicker collapse.

In the original formulation of quantum mechanics it is "measurement" that causes the collapse of the wave function. Nowadays, however, there are not many physicists who believe that the consciousness of a measuring human being is the only way to effect such a collapse. Any disturbance of the wave function, it is now thought, leads to collapse. Such a disturbance can be a measurement, but it can also be the interaction with another particle. In this way it is legitimate to put two proteins and their interaction in one wave function. But as soon as a molecule from the surrounding solvent comes even near to one of the proteins, it is over and the wave function collapses.

In an article in 2000 in *Physical Review E* Max Tegmark worked out the numbers associated with this objection (Tegmark, 2000). His results showed that the collisions between the microtubule and the water and ions from the surrounding solution make the microtubule-wavefunction collapse within 10^{-13} seconds. That is much faster than the one second that quantum gravitation leads to. The 10^{-13} seconds is also much faster than the timescale at which the nervous system operates. The reception, processing and transfer of a signal through the nervous system takes about a millisecond. Wave functions that, during every millisecond, develop ten billion times and then collapse again can only be background noise for the nervous system.

Tegmark's paper led to a lot of comments and debate. A short comment in *Science* made it appear as if Tegmark's article was the almost definitive refutation of the quantum brain (Seife, 2000). But this appeared not to be true. According to Hameroff and his coworkers the microtubule is well insulated in a living cell and they claim that the interactions that Tegmark evaluates simply don't occur (Hagan et al, 2002).

Hameroff has meanwhile discovered that that the cause of cancer is also to be found in microtubule's entangled quantum coherent states (Hameroff, 2004). It was also in 2004 that Roger Penrose once more published a book of more than a thousand pages: *The Road to Reality: A Complete Guide to the Laws of the Universe*. But this book again features very solid and very widely accepted science.

The collection and processing of information by living creatures has, for many decades, been part of the field of biology. The theory of Penrose and Hameroff looks like a giant leap straight from quantum physics to the solution of the central enigma of neurobiology, i.e. consciousness. However, it was by actually leaving the vague notion of "consciousness" for what it is and by just focusing on the mere transmission of signals through the nervous system that neurobiology has been successful in the last half century and has yielded some tangible and applicable results.

Cold fusion and the memory of water

In 1988 an article appeared in *Physical Review Letters* by three prominent Italian physicists (Del Giudice et al., 1988). *Physical Review Letters* publishes papers of no more than four pages and addresses a broad audience of physicists. It is the most read, the most cited, and by far the most prestigious physics journal to publish in. The title of the article was "Water as a Free Electric Dipole Laser." In this paper the authors speculate on the possibility that liquid water can emit electromagnetic radiation through a mechanism that would be similar to that of the free electron laser.

The free electron laser is an invention of the 1970s. Nowadays there are worldwide about 50 free electron lasers. It is useful in this context to explain the operation of the free electron laser and of the allegedly analogous water laser of the 1988 article.

The construction of the free electron laser is a little more complicated than that of the traditional laser. With the free electron laser there is no medium in the laser cavity. Instead use is made of a beam of electrons that are accelerated to almost the speed of light. The laser cavity is a vacuum with magnets on both sides (Figure 4). Because of the Lorentz force the electrons are deflected in a direction that is perpendicular to both the direction of the speed of the electrons and the direction

of the magnetic field itself. When moving electrons are forced in a curved trajectory, they emit so-called synchrotron radiation. There is nothing mysterious about this. Electric charges that change velocity cause electromagnetic radiation. That is also the way in which a broadcasting antenna works. Synchrotron radiation has, in principle, a very wide frequency range - a range that includes microwaves, infrared light, visible light, ultraviolet light, and Röntgen radiation. However, with the setup in the figure a feedback mechanism occurs that makes the system converge to the emission of just one wavelength. Photons with the right wavelength can, one period (λ_u in the figure) onwards, bring about the stimulated emission of a photon of the same wavelength. In this way one eventually obtains a nice coherent laser beam.

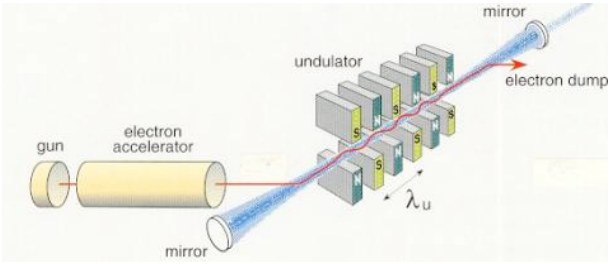

FIG. 4: The free electron laser. A beam of fast electrons is forced to deviate alternately to the left and to the right in the undulator. The curves in the trajectory cause the emission of electromagnetic radiation. Stimulated emission can occur for radiation with a wavelength that has the right ratio with the periodicity of the electron trajectory.

A good physical description of the free electron laser should involve quantum field theory. In quantum field theory the interactions between charged particles are described by combining quantum mechanics with Einstein's special theory of relativity. The authors of the 1988 *Physical Review Letters* article start their treatment with some very intimidating equations from quantum field theory. I fear that even a great many professional physicists will be put off by the lack of intuitive transparency here. The basic idea is that charges also move in curved orbits when water molecules, with their strong dipoles, start turning around. This would cause radiation and even stimulated emission.

In the penultimate paragraph of their article Del Giudice, Preparata and Vitiello express a small reservation: "Even though, it must be admitted, our analysis is in many ways at a preliminary, rather rudimentary stage, nevertheless, we believe that ..." The last sentence of the article reads: "Of course much more work is needed in this direction." Since its publication in 1988 the article has been cited about twenty times in other scientific articles. In spite of the expressed need one finds very little in these other scientific articles in terms of the further underpinning of the Free Electric Dipole Laser (FEDL). Instead, the 1988 FEDL article has actually been put forward as constituting a scientific underpinning for all sorts of very dubious stuff from the scientific margins.

Barely two months after the notorious "cold fusion" press conference of Fleischmann and Pons, the FEDL article is cited in a short speculative paper ("It is the purpose of this paper to provide a few hints that might lead to a theoretical understanding of the fascinating phenomena ...") in which a mechanism is proposed for the cold fusion (Bressani, Del Giudice & Preparata, 1989). Out of these three authors, two also had their names above the original FEDL paper.

In a book review in 1991 in the Italian newspaper "La Repubblica" cold fusion was characterized as a "scientific fraud." The scientific debate then got a little legal interlude when right away Fleischmann, Pons and the three authors of the above mentioned 1989-paper filed a civil lawsuit and demanded five million dollars in damages. The Italian court then launched a large scale investigation to determine whether the characterization was libelous or justified. The five plaintiffs lost the case. They eventually had to pay the court's costs.

Almost as an afterthought it is stated at the end of the FEDL paper that a permanent electrical polarization can form around an "impurity that carries a sizable electric dipole." The possibility of such a polarization rolls out of the long and complicated formulae and it is presented on the last page of the paper. But it remains vague. For many decades experimentalists and theoreticians have been familiar with, for instance, the immobile shell of water molecules that forms around an ion. The shell forms because water molecules have a strong dipole. So within a distance of about a tenth of a nanometer from the ion, the dipoles align with the electric field of the ion. They thus form a sturdy sphere around the ion. The formation of the hydration shell can be modeled and the size and energy of the shell can be predicted from the models. The hydration shell has measurable consequences for chemical interactions and the outcomes of the measurements can be compared with the theoretical predictions. But in the FEDL paper there is no estimate of the involved energy or entropy. It mentions "ordered structures in macroscopic domains" and then states that this could involve tenths of millimeters. Also elsewhere in the literature I have not found any estimate or approximation of the involved energy. This is particularly painful as traditional quantum mechanics has always been very successful in coming up with very accurate quantitative predictions of energy levels.

In much of the pseudo-scientific work that cites the FEDL paper it is suggested that traditional physics should be left for what it is and that the FEDL paper reveals a deeper and more correct truth. However, the FEDL paper is a frustrating read to an open minded physicist: it is vague and it lacks intuitiveness. The free electron laser is about a beam of electrons that moves with almost the speed of light in a vacuum. Just like with the traditional laser, the free electron laser involves energy densities that do not occur in a living organism. What we do find in a living organism is an intense ther-

mal motion of the water molecules that ordinarily make up the organism for the most part: at room temperature water molecules move with a speed of about 500 meter per second. These molecules, furthermore, interact every second with several tens of trillions of other water molecules. More than a century of condensed matter physics has yielded, among other things, the insight that it takes more than a single ion, oscillating or not, to force order at a macroscopic level in a water bath. Creating a macroscopic order in liquid water requires a macroscopic amount of energy. That energy cannot be extracted from the thermal motion of the water molecules themselves. That would be in violation of the second law of thermodynamics. One could, for instance, freeze the water in order to obtain a macroscopic order. But that would require a refrigerator that consumes macroscopic amounts of energy. That a single ion or a molecule with or without a vibrating dipole would force the water into a large scale macroscopic order goes against physical laws, physical insights, and physical intuition.

It is especially the "permanent electric polarization around an impurity"-suggestion in the FEDL paper that has been cited more and more in the last couple of years in order to support claims that liquid water could keep and carry a "memory." Structures in liquid water, it is purported, would be able to retain a "memory" of an originally dissolved compound even if the dilutions are such that no molecule of the original compound is left in the water.

The existence of a "water memory" was first suggested in a controversial publication in *Nature* of the group of Jacques Benveniste (Davenas et al., 1988). That was in the same year that the FEDL paper appeared. Benveniste and his co-workers reported how a biochemical substance had an effect even after the original molecules had disappeared completely in the course of the many subsequent dilutions. Never before had a validation of homeopathy reached such a prestigious scientific journal. In an attempt to make their results credible to the scientific mainstream Benveniste and his co-authors speculate at the end of the paper, that the water may contain a memory. A dissolved molecule would make a permanent imprint on the water and this imprint would persist even after the imprinting molecules have been diluted away. In support of this statement there is a reference to a publication by the aforementioned Herbert Fröhlich.

Browsing through the Science Citation Index one notices that about half of all the citations of the FEDL paper occurred in the last decade and for the most part in *The Journal of Alternative and Complementary Medicine*. Almost all of these citations are supposed to support the claim that modern quantum field theory corroborates the basic principles of homeopathy. The first such citation is in a review article of 30 pages (4 pages of which are references) about homeopathy (Vallance, 1998). The second article in *The Journal of Alternative and Complementary Medicine* that cites the FEDL article is a bit of the exception that confirms the rule. It is not about homeopathy. It is a 2002 article by Beverly Rubik that, in essence, is nothing but a poorly camouflaged advertisement for a device that is purported to protect people against the harmful effects of stress through "homeodynamic stabilization." It involves a patented company secret and we thus read: "Presently, the precise engineering details of Sympathetic Resonance Technology are proprietary, a trade secret. Only a general description of Sympathetic Resonance Technology can, therefore, be provided here." In the subsequent paragraph the absurdities abound: "The output is the proprietary non-Hertzian fields generated by the proprietary frequencies." So apparently one can also patent a frequency. A vague device requires a vague theory, though Rubik prefers to use the word "subtle": "Sympathetic Resonance Technology involves subtle energy, an energy that has certain properties of electromagnetic fields but is subtle so that its key frequencies cannot be detected by using conventional electromagnetic detectors." A few lines down we are told that matter can store and transfer information and that the FEDL paper constitutes the relevant scientific support for this claim.

After his 1988 *Nature* article Benveniste expanded his "water memory" hypothesis to an extensive and eccentric theory about how water can copy and send signals. He did find his way to the FEDL paper. Benveniste died in 2004, but his webpage (http://www.digibio.com) is still maintained and the FEDL paper is there the only reference on the "What is Digital Biology?"-page.

LCH, MARH, RHom, PhD, CChem, FRSC

The Free Electric Dipole Laser paper of 1988 has become a standard citation in the publications of the very prolific Lionel R. Milgrom. Lionel R. Milgrom is the former director of the British "Society of Homeopaths." Behind his name Lionel carries a enormous amount of titles; titles that he faithfully hauls from one article to the next. Steady is the flow of publications from his hand and he very regularly contributes to the *The Journal of Alternative and Complementary Medicine*.

Quantum mechanics as we know it applies on the atomic level. There are elegant derivations that show how quantum mechanics turns back into classical Newtonian mechanics when the scale is enlarged to a level at which the aforementioned Planck's constant becomes negligibly small. But this does not bother Lionel at all. There is, he tells us, "... a more general version of quantum theory (called weak quantum theory; WQT), which relaxes several of its nanoscopically limiting axioms, including Planck's constant" (Milgrom, 2008). The article in which we find this statement carries an imposing title: "A new Geometrical Description of Entanglement and the Curative Homeopathic Process."

In this article the patient, the practitioner, and the remedy are ruthlessly represented as wave functions: "The idea of PPR entanglement on the other hand, en-

visages the patient (Px), practitioner (Pr), and remedy (Rx) achieving a potentially therapeutic macro-entangled state. This is described by a state function $|\mathbf{\Psi_{PPR}}>$ (as are each of the patient, $|\Psi_{Px}>$; the practitioner, $|\Psi_{Pr}>$; and the remedy, $|\Psi_{Rx}>$) in a 'therapeutic state space.' However, these state functions are not related to quantifiable physical observables (e.g., position and momentum) as in orthodox quantum theory. They are related to more qualitative observables, such as the signs and symptoms of a dis-ease, as expressed by the patient and observed by the practitioner." Next the wave functions are placed on the corners of polyhedrons that are subsequently reflected and rotated. The eventual conclusion is an artful piece of New Age idiom: "... the practitioner may notionally facilitate formation of the tetrahedral entangled PPR and curative stella octangula states but not, in semiotic terms, be at their epicenters. These 'places' are reserved exclusively for the patient through the journey to cure."

Nowhere on the pages of the *The Journal of Alternative and Complementary Medicine* do we ever even find a critical note regarding Milgrom's grotesque theories. However, several bloggers had some very harsh things to say. Lionel got a lot of flak in the blogosphere. Bloggers, apparently, are not really intimidated by academic titles, by wave functions, and by verbal ectoplasm. On December 19, 2008 blogger "Orac" from http://scienceblog.com/insolence discusses Milgrom's aforementioned article very extensively. His tone is scathing, but even Orac cannot deny the Lionel's work is very imaginative. Orac compares Milgrom with Tolkien as also Milgrom appears to create a whole new universe of his own. Indeed, Milgrom's universe feels like a unique mixture of medieval mystique and modern science.

Part of Milgrom's citations are very serious and legitimate physics articles. But very frequently he also talks about completely unphysical entities like the "vital force." He, very professionally, abbreviates this to "Vf." Mixing it all leads to beautiful rhetoric like "Given the already-mentioned multidimensional nature of Vf ..." Milgrom is a gifted wordsmith. He is almost a poet. His choice of words, his construction of sentences, and his line of argument are perfect. His figures are impressive. Almost unwittingly the reader is carried along to a magical, kabbalistic world. It arouses a bit of suspicion that the date of publication of the article is April 1, but then it turns out that this is actually part 11 in a series of articles about Patient-Practitioner-Remedy Entanglement.

On July 5, 2008 Andy Lewis of http://www.quackometer.net/ devotes a notable blog to Milgrom's quantum-theoretical ruminations. According to Lewis, Milgrom should have published in a physics journal if his "quantum theory of homeopathy" is intended as serious physical modeling. If, on the other hand, the formalism of quantum mechanical wave functions is just meant to be metaphor, then, Lewis argues, it fails because a metaphor is supposed to clear up a difficult idea through comparison with something that the audience is more familiar with. And quantum physics is not really familiar territory, neither to the general audience, nor to practitioners of alternative medicine.

Lewis appears too levelheaded to see how quantum physics is actually Milgrom's ultimate rhetorical coup de grâce. Milgrom needs the scientific authority of quantum physics to stun the reader and then lead him to the moral of the treatise. Already in the second paragraph of Milgrom's article we read: "Evidence-based medicine and the double-blind randomized-controlled trial, like much of biomedical science, are rooted in the reductionist philosophy of logical positivism combined with local realism." And a little further we find "... quantum theory transcends local realism and the reductionism of biomedicine" and "PPR analysis affords a *post hoc* explanation of the observed 'leakage' between verum and placebo groups during recent double-blind provings of homeopathic remedies ..." All in all, Milgrom's quantum theory is telling us that reality is infinitely more complicated than clinical tests, double blind trials, and statistical analysis. At the end of the paper we read: "... it is clear that the nature of the therapeutic process requires its initial separation and 'isolation' from the usual external environment as a necessary prerequisite for the coherence of entanglement to occur and cure to begin." And this basically means that it is essential for the effectiveness of homeopathy that there is no interference from the Department of Health, the Food and Drug Administration, curious biostatisticians, the James Randi Educational Foundation, etc. etc.

Milgrom's obscure brew of semiotic signs and entangled wave functions is eventually nothing but a camouflaged attempt to immunize homeopathy against the verdict of Evidence-Based Medicine and its Double-Blind Randomized-Controlled Trial. The Double-Blind Randomized-Controlled Trial is the only credible way to quantitatively express the effectiveness of a treatment as compared with the effectiveness of another treatment. Progress of medical science comes about through carefully performed Double-Blind Randomized-Controlled Trials. Without the Double-Blind Randomized-Controlled Trials medical science would not be a science anymore.

If, for some fundamental reason, the Double-Blind Randomized-Controlled Trial does not apply to homeopathy, then homeopathy is bound to remain what it, in essence, already always was: a belief. I have always been very much impressed with the amazing things one can do in physics with quantum mechanical wave functions. But I had never suspected that these wave functions, in the hands of Lionel Milgrom, would turn out to be able to reveal the true nature of homeopathy.

Biotheology

It has only been in the course of the last few centuries that the conclusion has been reached that no special "vi-

tal" principle is needed for a living organism to be alive. The number of biophysicists and biochemists has been growing fast and ever more convincingly it appears that biological functioning is based on laws of physics and chemistry. The above described quantum biological theories look like a return to the idea that the driving force behind life is something magical and unmeasurable. The quantum biologists have never really gotten any further than some vague pseudo-explanation.

But pseudo-explanation turns into tragedy when one considers the medical spin-off that quantum biology has inspired. Googling on "quantum healing" leads to many thousands of results. "Quantum touch" therapy seems to have quite a following. With a quick visit at http://www.quantumtouch.com it can be ascertained that "quantum touch" is nothing but an old-fashioned laying on of hands. But now the Holy Ghost is no longer part of the ritual. An entirely new jargon has been manufactured: "When the practitioner holds a high vibrational field of life-force energy around an affected area, she or he facilitates healing through the process of resonance and entrainment." And a little further we read: "We believe that what we're doing is affecting matter on that quantum, subatomic level and it works its way up through the atoms, the molecules, the cells, the tissue ... and then we see bones move." We are next informed that this is all very bona fide and scientific, because quantum biologist Glen Rein "has found that healers were capable of affecting the very winding of DNA. In order to accomplish this, healing must first begin on a quantum or subatomic level and work its way though the rest of the body." Elsewhere (http://www.soundenergy.net/dnamod.htm) it appears that Glen Rein has also figured out that rock music can not loosen the windings of DNA, but that Gregorian chants and religious incantations in general are actually able to do just that. Glen Rein runs the Quantum Biology Research Lab in Northport, NY. He is a faculty advisor at the somewhat obscure Holos University. And yes! he is also an editor with the same *Journal of Alternative and Complementary Medicine* that we encountered before. Last but not least he is involved in the marketing of "Aulterra." Aulterra is "an organic, paramagnetic and diamagnetic material prepared with a unique blend of scientific and homeopathic processes." You can buy an "Aulterra Neutralizer" and attach it to your cell phone. This is purported to reduce the harmful effects of electromagnetic radiation and to even reverse damage that has already been done.

Quantum biology is really nothing but New Age biotheology and an excuse for quackery.

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