

Americans are reportedly spending about \$14 billion per year on health-related therapies that have not been scientifically validated and are collectively referred to as "alternative" or "complementary." These range from psychic healing and intercessory prayer to alternative cancer treatments, aromatherapy, homeopathy, and acupuncture. Although many of these therapies are said to be effective because they have been used since ancient times, attempts have been made to rationalize them using modern scientific language.

In a symposium titled "Alternative Medicine in a Scientific World" at the 1997 annual meeting of the American Association for the Advancement of Science in Seattle, a panel of scientists and researchers considered this topic. The session was organized by Ursula Goodenough of

the Department of Biology at Washington University, St. Louis, and Robert L. Park of the Department of Physics at the University of Maryland and the American Physical Society. Speakers evaluated and discussed the extent to which the claims of alternative therapies are consistent with the laws of physics, the nature of the evidence cited to support the efficacy of alternative treatments, the reasons why bogus therapies seem to work, the role of antiscience in the advocacy of alternative therapies, and the relationship between alternative practices and cultural relativism.

The first five articles in this issue are based on five of the papers presented at that symposium. A sixth paper, on assertions about shark cartilage, was submitted independently to the SKEPTICAL INQUIRER and has been included because of its relevance.

Alternative Medicine and the Laws of Physics

The mechanisms proposed to account for the alleged efficacy of such methods as touch therapy, psychic healing, and homeopathy involve serious misrepresentations of modern physics.

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So-called "alternative" therapies, mostly derived from ancient healing traditions and superstitions, have a strong appeal for people who feel left behind by the explosive growth of scientific knowledge. Paradoxically, however, their nostalgia for a time when things seemed simpler and more natural is mixed with respect for the power of modern science (Toumey 1996). They want to believe that

"natural" healing practices can be explained by science. Purveyors of alternative medicine have, therefore, been quick to invoke the language and symbols of science. Not surprisingly, the mechanisms proposed to account for the alleged efficacy of such methods as touch therapy, psychic healing, and homeopathy involve serious misrepresentations of modern physics.

The No-Medicine Medicine

Homeopathy, founded by a German physician, Samuel Hahnemann (1755–1843), is a relative newcomer. Homeopathy is based on the so-called "law of similars" (*similia similibus curantur*), which asserts that substances that produce a certain set of symptoms in a healthy person can cure those same symptoms in someone who is sick. Although there are related notions in Chinese medicine, Hahnemann seems to have arrived at the idea independently. Hahnemann spent much of his life testing natural substances to find out what symptoms they produced and prescribing them for people who exhibited the same symptoms.

Although the purely anecdotal evidence on which he based his conclusions would not be taken seriously today, homeopathy as currently practiced still relies almost entirely on Hahnemann's listing of substances and their indications for use.

Natural substances, of course, are often acutely toxic. Troubled by the side effects that often accompanied his medications, Hahnemann experimented with diluting them. After each successive dilution, he subjected the solution to vigorous shaking, or "succussion." He made the remarkable discovery that although dilution eliminated the side effects, it did not diminish the effectiveness of the medications. This is rather grandly known as "the law of infinitesimals."

Hahnemann actually made a third "discovery," which his followers no longer mention. "The sole true and fundamental cause that produces all the countless forms of disease," he writes in his *Organon*, "is psora." Psora is more commonly known as "itch." This principle does not seem to involve any laws of physics and is in any case ignored by modern followers of Hahnemann.

By means of successive dilutions, extremely dilute solutions can be achieved rather easily. The dilution limit is reached when the volume of solvent is unlikely to contain a single molecule of the solute. Hahnemann could not have known that in his preparations he was, in fact, exceeding the dilution limit. Although he was contemporary with the physicist Amadeo Avogadro (1776–1856), Hahnemann's *Organon der Rationellen Heilkunde* was published in 1810, one year before Avogadro advanced his famous hypothesis, and many years before other physicists actually determined Avogadro's number. (Avogadro showed that there is a large but finite and specific number of atoms or molecules in a mole of substance,

specifically 6.022×10^{23} . A mole is the molecular weight of a substance expressed in grams. Thus, a mole of water, H_2O , molecular weight $2 + 16 \approx 18$, is 18 grams. So there are 6.022×10^{23} water molecules in 18 grams of water.)

Modern day followers of Hahnemann, however, are perfectly aware of Avogadro's number. Nevertheless, they regularly exceed the dilution limit—often to an astonishing extent. I recently examined the dilutions listed on the labels of dozens of standard homeopathic remedies sold over the counter in health stores, and increasingly in drug stores, as remedies for everything from nervousness to flu. These remedies are normally in the form of lactose tablets on which a single drop of the "diluted" medication has been placed. The "solvent" is usually a water/alcohol mixture. The lowest dilution I found listed on any of these bottles was 6X, but most of the dilutions were 30X or even, in the case of *oscillococcinum*, an astounding 200C. (*Oscillococcinum*, which is derived from duck liver, is the standard homeopathic remedy for flu. As we will see, however, its widespread use poses little threat to the duck population.)

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What do these notations mean? The notation 6X means that the active substance is diluted 1:10 in a water-alcohol mixture and succussed. This procedure (diluting and succussing) is repeated sequentially six times. The concentration of the active substance is then one part in ten raised to the sixth power (10^6), or one part per million. An analysis of the pills would be expected to find numerous impurities at the parts-per-million level.

The notation 30X means the 1:10 dilution, followed by succussion, is repeated thirty times. That results in one part in 10^{30} , or 1 followed by thirty zeroes. I don't know what the name for that number is, but let me put it this way: you would need to take some *two billion pills*, a total of about a thousand tons of lactose, to expect to get even one molecule of the medication. In other words, the pills contain nothing but lactose and the inevitable impurities. This is literally no-medicine medicine.

And what of 200C? That means the active substance is sequentially diluted 1:100 and succussed two hundred times. That would leave you with only one molecule of the active substance to every one hundred to the two hundredth power molecules of solvent, or 1 followed by four hundred zeroes (10^{400}). But the total number of atoms in the entire universe is estimated to be about one googol, which is 1 followed by a mere one hundred zeroes.

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This is the point at which we are all supposed to realize how ridiculous this is and share a good laugh. But homeopaths don't laugh. They've done the same calculation. And while they agree that not a single molecule of the active substance could remain, they contend it doesn't matter, the water/alcohol mixture somehow *remembers* that the substance was once there. The process of succussion is presumed to charge the entire volume of the liquid with the same memory. Is there any evidence for such a memory?

Smart Water?

Homeopaths have been administering this sort of no-medicine medicine for two centuries. Most scientists, however, first became aware of their extraordinary claims when *Nature* published a paper by French epidemiologist/homeopathist Jacques Benveniste and several colleagues, in which he reported that an antibody solution continued to evoke a biological response even if it was diluted to 30X—far beyond the dilution limit (Davenas

et al. 1988). Benveniste interpreted this as evidence that the water somehow “remembered” the antibody.

In reaching that conclusion, Benveniste turned conventional scientific logic on its head. A large part of experimental science consists of devising tests to insure that an experimental outcome is not the result of some subtle artifact of the conduct or design of the experiment. “Infinite dilution” is one such procedure used by chemists. The effect of some reagent, for example, is plotted as a function of concentration. If at low concentrations, the plot does not extrapolate through the origin, it is taken as proof that the observed effect is due to something other than the reagent. By Benveniste's logic, it's evidence that the reagent leaves some sort of imprint on the solution that continues to produce the effect.

Attention had been called to Benveniste's article by the editor of *Nature*, John Maddox, who pointed out in an editorial that Benveniste

had to be wrong (Maddox 1988). Because the reviewer could not point to any actual mistake, *Nature* had agreed to publish the article in the spirit of open scientific exchange. Reviewers, of course, have no way of knowing if the author faithfully reports the results of the measurement, or whether the instruments employed are faulty. Nevertheless, the existence of this one paper published in a respected journal has been widely trumpeted by the homeopathic community as proof that homeopathy has a legitimate scientific basis.

The Maddox editorial encouraged other scientists to repeat the Benveniste experiments. An attempt to replicate the work as precisely as possible was reported by Foreman and colleagues in *Nature* in 1993 (Foreman et al. 1993). The authors found that “no aspect of the data is consistent with [Benveniste's] claim.” I am aware of no work that replicates Benveniste's findings. Why was Foreman's water dumber than Benveniste's? We will return to that question.

Quite apart from the matter of how the water/alcohol mixture remembers, there are obvious questions that cry out to be

asked: 1) Why does the water/alcohol mixture remember the healing powers of an active substance, but forget the side effects? 2) What happens when the drop of solution evaporates, as it must, from the lactose tablet? Is the memory transferred to the lactose? 3) Does the water remember other substances as well? Depending on its history, the water might have been in contact with a staggering number of different substances.

A number of mechanisms have been proposed to account for this miraculous memory. These mechanisms are discussed by Wayne Jonas in his recent book, *Healing with Homeopathy*, coauthored by Jennifer Jacobs (Jonas and Jacobs 1996). Jonas is the Director of the Office of Alternative Medicine of the National Institutes of Health and is identified on the book jacket as one of "America's leading researchers of homeopathic medicine." Jonas appears, at the very outset, to acknowledge the possibility that the effect of homeopathic medicine may "turn out to be only a placebo effect." But as we will see, in alternative medicine circles the placebo effect can be the weirdest explanation of all.

If it is not a placebo effect, Jonas says, the "information" from the active substance must be stored in some way in the water/alcohol solution, perhaps in the structure of the liquid mixture. There has been an abundance of speculation about what sort of "structure" this might be: clusters of water molecules arranged in specific patterns (Anagnostatos 1994); arrangements of isotopes such as deuterium or oxygen-18 (Berezin 1990); or "coherent vibration" of the water molecules (Rubik 1990). I could not find a single piece of evidence supporting any of these speculations, and there are sound scientific reasons for rejecting each of them. Jonas refers to structural studies showing regions of local order in liquids. A "snapshot" of the structure of a water/alcohol mixture will of course show regions of local order, but these are transient; they cannot persist beyond the briefest of relaxation times depending on the temperature. That not even local order can persist is the definition of a liquid. The problem, of course, is entropy. The *second law of thermodynamics* is the most firmly established of all natural laws, but even if you could somehow repeal the second law, you would still confront the question of how this stored information can be communicated to the body.

The Illusive Biophoton

One possibility, according to Jonas, is that information is transferred by "bioelectromagnetic energy." Here he cites, as "some of the most carefully executed work in this area," studies of the effect of serially agitated dilutions of frog thyroxine on highland frogs that are in the climbing stage of metamorphosis (Endler et al. 1994). Thyroxine is reported to increase the climbing rate of the frogs—and the response continues even after the thyroxine dilutions are taken far beyond the dilution limit. In other words, when it is certain that there is no thyroxine.

That would appear to be clear evidence that something other than thyroxine is responsible for the stimulation of the

frogs. In this case, for example, it might be the alcohol that is producing the climbing response, or some impurity, or the frogs might be stimulated by the act of administering the medication, or there might be subconscious bias on the part of the experimenter in deciding whether the frogs are stimulated. Once again, however, scientific logic is turned on its head; the results are interpreted as evidence that an imprint of thyroxine has somehow been left in the water.

But even if the water contains information about thyroxine, how is this information communicated to the frogs? Rather than administering the water/alcohol solution directly to the frog, the researchers tried putting the solution in a sealed glass test tube and placing it in the water with the frogs. The frogs still responded. Why am I not surprised?

What conclusion did the researchers come to? They concluded that information that once resided in the molecular structure of the active substance, and which was then somehow transferred to the succussed water, must have been transmitted to the frogs via a "radiant" effect, perhaps an illusive "biophoton." No evidence of such radiation has been reported. Benveniste, however, now claims that a 50Hz magnetic field can erase the memory of his antibody solutions (Benveniste 1993), which might explain why other researchers do not find a memory. This electromagnetic link led Benveniste to the further discovery that he can "potentize" your water over a telephone line.

One possibility, according to Jonas, is that information does not pass from the solution to the frog—or from a medication to a human patient—but the other way. The unhealthy state of the patient might be "released through the remedy." "Such speculative theories," Jonas admits, "need further experimental work to confirm or disprove them."

The Case Against Butterflies

Jonas also speculates that chaos theory might offer insight into the effect of homeopathic remedies on the body's self-healing mechanisms:

One concept in chaos theory is that very small changes in a variable may cause a system to jump to a very different pattern of activity, such as a small shift in wind direction drastically affecting climatic patterns of temperature and precipitation. Under this way of thinking, the homeopathic remedy can be seen as a small variable that alters the symptom pattern of an illness. (Jonas and Jacobs 1996, 89)

This dreadful shibboleth betrays a total misunderstanding of what chaos is about. "Chaos" refers to complex systems that are so sensitive to initial conditions that it is not possible to predict how they will behave. Thus, while the flapping of a butterfly's wings might conceivably trigger a hurricane, killing butterflies is unlikely to reduce the incidence of hurricanes. As for homeopathic remedies that exceed the dilution limit, a better analogy might be to the flapping of a caterpillar's wings.

Psychic Healing

But if none of these mechanisms work, Jonas says, "highly speculative and imaginary [*sic*] explanations may be necessary." What he has in mind is the placebo effect. "Belief in a therapy," Jonas explains, "may be an important factor in healing." Who would disagree? If it is a placebo effect at work in homeopathy, all of the pseudoscientific trappings of *similia similibus curantur* and the law of infinitesimals merely serve as props to deceive people into believing that sugar pills are medicine. But "placebo effect," as used by Jonas and other proponents of alternative medicine, turns out to be the strangest beast of all. It is suffused with the New Age notion of a universal consciousness. The placebo effect becomes psychic healing. Again from Jonas:

Some theorists suggest that intentionality and consciousness must be brought to any explanation of how nonlocal, and nonspecific quantum potentials might be "collapsed" into so-called informational coherence patterns (molecules), which then have specific effects. Once these previously unstable and nonlocalizable coherence patterns (such as thoughts and beliefs) nudge potential effects into existence (by an intention to heal in the person or practitioner), they are then seen by the body as locally acting, stable, "molecular" structures that produce specific biological signals and have predictable effects in the person. (Jonas and Jacobs 1996, 90)

This all sounds very much like Deepak Chopra (1989 and 1993), who asserts that: "Beliefs, thoughts, and emotions create the chemical reactions that uphold life in every cell." The notion that by thought alone the medicines needed to cure illness can be created within the body comes from Ayurveda, the traditional religious medicine of India that dates back thousands of years. Chopra has, in any case, created vast personal wealth by simply invoking "quantum healing" in book after book. His books reveal no hint that he has any concept of quantum mechanics.

Nevertheless, there are quantum mystics, including a few physicists, who interpret the wave function as some kind of vibration of a holistic ether that pervades the universe. Wave function collapse, they believe, happens throughout the universe instantaneously as a result of some cosmic consciousness. That, of course, would violate causality in the relativistic sense, and it would also violate quantum field theory (Eberhard and Ross 1989).

Biofield Therapeutics (Touch Therapy)

Alternative medicine consists of a wide spectrum of unrelated treatments ranging from the barely plausible to the totally preposterous. At the preposterous end, I place those therapies that have no direct physical consequences of any sort, such as homeopathy and psychic healing. One must also include "biofield therapeutics" or "touch therapy," though in fact it would be more accurate to call it "no-touch therapy," since the practi-

tioner's hands do not actually make contact with the patient. Instead, it is claimed that the patient's "energy field," "qi," or "aura," is "smoothed" by the hands of the therapist or shifted from one place to another to achieve balance. The energy field is said to extend several inches outside the body, and the patient's field interacts with the field of the practitioner.

The nature of this supposed energy field is obscure, but proponents often link it in some way with relativity and the equivalence of matter and energy. It has also been suggested that the body's energy field is electromagnetic. Quantum mechanics, despite its popularity in many alternative medicine circles, rarely seems to be invoked in touch therapy. Indeed, B. Brennan, author of *Hands of Light* (1987), writes: "I am unable to explain these experiences without using the old classical physics framework." I confess that classical physics does not make it any easier for me to explain. Practitioners claim to be able to "feel" the energy field and often employ hand-held pendulums to locate the "chakras," or vortices, in the field that must be smoothed out to promote healing. It would seem to be a simple matter to examine a field that can be felt tactually, or that affects the motion of a pendulum, but so far no one has claimed to detect the energy field with any instrument that is not hand-held. This is quite remarkable since there are said to be tens of thousands in the United States who have been trained in some form of this therapy. In the United Kingdom there are 8,500 registered touch therapists (Benor 1993).

The public is spending billions of dollars annually on sugar pills to cure their sniffles, hand waving to speed recovery from operations, and good thoughts to ward off illness, all with assurances that it's based on science. Society has been set up for this fleecing in part by the media's sensationalized coverage of modern science. Popular discussions of relativity, quantum mechanics, and chaos often leave people with the impression that common sense cannot be relied on—anything is possible. Scientists themselves often feed the public's appetite for the "weirdness" of modern science in an effort to stimulate interest—or simply because scientists, too, can be beguiled by the mysterious.

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