had been interested in pulsing light off of the lunar surface itself," Faller said. "But only a tenth of [the light] is reflected back, and the uncertainty in the distance is about 1 kilometer," or the average height of the lunar mountains.

"The Lunar Laser Ranging Team was really very lucky to get the [retroreflector] package on the Apollo 11 flight," recalled Peter L. Bender, also a physicist at JILA and a lunar ranging veteran. "Our experiment was developed as a contingency which was actually used because they didn't yet have the confidence to plan on a longer stay on the lunar surface. Ours was very simple to set up because it was completely passive."

When the reflectors were first installed, lunar ranging was accurate to about 1 meter. But over the past 20 years, the precision has steadily been honed down to the 3 centimeters achievable today—thanks largely to better measuring gear developed at the McDonald Observatory by Eric C. Silverberg. And now that President Bush is talking about returning to the moon with a permanent scientific colony early in the next century, laser zappers are talking excitedly about what a new generation of ranging devices might offer.

Sighting is one problem that could be easily solved. "If we do go back, it would be really lovely to put an infrared pulsed-laser diode [near each retroreflector] that would blink every second or so and that would serve as a beacon," Faller said.

As for accuracy, 3 centimeters is far from being the outer limit. By implanting active transponders on the moon that could be modulated to lock phase with and return a continuous-wave laser signal from Earth, "we could get down to 1 millimeter for the absolute range and something like 30 microns for differences in range to the different transponders," says Bender.

Such microscopic accuracies would contribute greatly not only to further unraveling the riddles of relativity, but also to plumbing the mysteries of the moon's liquid core. Even if the federal budget deficit conspires to forestall a return to the moon, however, the retroreflectors already up there show no signs of wearing out.

"We hope they will last pretty much forever," said Jean O. Dickey, director of NASA's Lunar Ranging Working Group at JPL. "They're passive devices, so there's no energy source up there. The only way that they would be disrupted is if moon dust gradually accumulated on them over a long period of time. But we don't see any sign of that." ■ DAVID C. MORRISON

*David C. Morrison is a correspondent for* National Journal *in Washington, D.C.*

# Can Psychotherapy Delay Cancer Deaths?

*A new study says yes, but that does not necessarily mean that cancer patients have mental control over their disease*

FOR HARD-NOSED ONCOLOGISTS who have for years shunned the notion that the mind can influence the fate of cancer patients, the news in the 14 October issue of *Lancet* will be unsettling. Stanford psychiatrist David Spiegel reports there that psychotherapy lengthened by a year and a half the lives of women with metastatic breast cancer, while reducing their anxiety and pain as well. And he's not just another Shirley MacLaine.

Having undertaken the study to disprove what he calls "the wish-away-your-cancer types," Spiegel spent several years trying to poke holes in its conclusions. Though he now stands solidly behind them, he hurries to point out that his results do not mean that psychotherapy cures cancer. Nor do they prove that patients have mental control over their disease. But, he says, they do suggest that psychotherapy can improve both the quality and quantity of life for cancer patients.

"It is the first study that I think is scientifically sound that has shown some change in survival," says Jimmie Holland, chief of psychiatry at New York's Memorial Sloan-Kettering Cancer Center. But she nevertheless has qualms. "What I am fearful of is that the 'alternative' field will go crazy with this and say, 'Aha, we told you all along, psychotherapy cures cancer, so stop your radiation therapy.' "

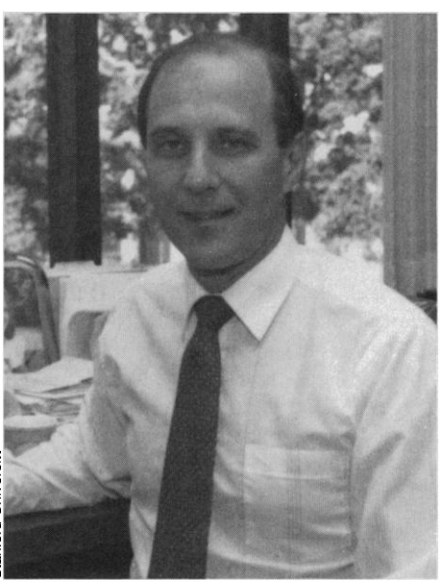
Spiegel never conceived of such an outcome when, 13 years ago, he began an evaluation of the short-term effects of group therapy on patients with advanced breast cancer. "The whole point of the original study was that we could make them feel better," says Spiegel. "We didn't in any way imply you were going to wish away your illness. In fact we were saying 'face your mortality.' " The result was that patients who received therapy became less anxious, fearful, and depressed and learned to reduce their pain through self-hypnosis.

Then a few years ago, Spiegel got irritated with popular psychology programs that claim to help patients conquer cancer through positive thinking. So he decided to follow up on his earlier study. "Here was a perfect setup," he recalls thinking. "I had shown this great psychological impact, and I knew there would be no difference in survival."

But when he tracked down information on the 86 participants in his study, he was stunned. While those in the control group lived an average of 19 months after joining the study, those who received a year of group therapy lived an average of 37 months. And the three women who were still alive after 10 years had all received group therapy. "I nearly fell off my chair," Spiegel says. "I just couldn't believe it."

"I echo his views; I am also surprised," says Boston University psychologist Bernard Fox, a well-known skeptic in the field of psychosocial oncology. Fox, and Sloan-Kettering's Holland, were among the colleagues Spiegel asked to scrutinize the manuscript before he submitted it for publication.

While at least one study has purported to show an effect of psychotherapy on cancer survival, and another has shown no effect, Fox says Spiegel's is more rigorous than the former two because assignment to therapy or control groups was random, and all patients received standard medical treatment, including surgery and radiation or chemotherapy. "They are very careful experimen-



Stanford University

**Surprising results.** *Stanford's Spiegel found a positive effect from psychotherapy.*

talists," he says of Spiegel and his colleagues. But, he warns, "one shouldn't draw inferences for the population on the basis of [this single] study."

Fox also cautions that randomization may not be reliable when the number of subjects is relatively small, as it was in the Spiegel study. He warns that there could be hidden differences between the two groups that might account for their different survival times.

"Obviously if you could do it with 1000 patients you'd feel more certain of it," Spiegel agrees. But he points out that his coauthor, respected Stanford biostatistician Helena Kraemer, felt the numbers were large enough. The researchers also specifically checked to see if the two patient groups were equivalent in every clinically used predictor of cancer outcome.

They found no significant difference between the control and intervention groups in the kind and amount of surgery, chemotherapy, and radiation the patients received; their ages at the time of diagnosis; time between diagnosis and metastasis (a strong indicator of the aggressiveness of the cancer); and time between metastasis and entry into the study or activity levels at the time of entry into the study. Women in the psychotherapy group tended to have less advanced tumors at the time of their original diagnosis, but the difference was not quite significant and Spiegel and his colleagues showed statistically that it did not cause the difference in survival.

Although Spiegel's study has been judged sound, he shares Holland's and Fox's worries that it will encourage practitioners who would substitute psychotherapy for proven medical treatments. Spiegel points out that the women in his study all underwent standard cancer treatment. And the psychotherapy itself was benign, he says, unlike some therapy programs that tell patients they are personally responsible for their cancers and make them feel like failures when they are unsuccessful in keeping their disease at bay mentally.

Spiegel does not suggest that the psychic change brought about by group therapy necessarily had a direct effect on his patients' physiology or disease. Rather, he says, the therapy may have caused a change in mental attitude that made the subjects comply better with their doctors' orders regarding medication and diet. He also suggests the pain reduction may have allowed them to remain more active than the control group. He plans follow-up studies to investigate how the therapy may extend lives.

"What I am flat out certain of is that something about being in the groups helped these women live longer," he says. "But what that is, I don't know."

■ MARCIA BARINAGA

# Teller, Chu "Boost" Cold Fusion

Cold fusion research may get renewed attention now that two well-respected researchers from outside the field have come to its support. Last week, after participating in a 2½-day workshop in Washington, D.C.,* Paul Chu and Edward Teller both called for additional experiments to understand the anomalous effects that have been attributed to cold fusion.

The National Science Foundation and the Electric Power Research Institute, which jointly sponsored the meeting, decided to include Chu, a leading researcher in high-temperature superconductivity, and Teller, a dean of American nuclear physicists, in order to have some disinterested, even skeptical, observers who would make sure the discussions were properly scientific. Chu, who is at the University of Houston, even agreed to serve as co-chairman. By the end of the meeting both were convinced that the experimental evidence for cold fusion, or at least some unknown nuclear phenomenon, is too great to ignore.

"New, positive results in excess heat production and nuclear product generation have been presented," Chu said in a statement prepared jointly with John Appleby of Texas A&M, the other co-chairman. "Based on the information that we have, the effects cannot be explained as a result of only artifacts, equipment, or human error." Teller was impressed enough to issue a personal written statement to the press. "Numerous interesting and partially contradictory results on cold fusion are in disagreement with the solidly established nuclear theory of fusion," he wrote. "There is a possibility to reconcile the results with the theory."

In his release, he offered a highly speculative scenario in which an "as yet undiscovered neutral particle" acts as a catalyst to remove neutrons from deuterium atoms and transfer them to other atoms, resulting in a new type of nuclear process. And he suggested that one way to test this hypothesis would be to run cold fusion experiments using uranium-235, because uranium's response to absorbing a neutron is well known.

But beyond that, few details from the meeting were available since it was closed to the press. Appleby said at a press briefing that they did not want to fall into the trap of releasing reports to the media that had not been carefully reviewed, something that was all too common in the early days of the cold fusion saga.

According to a few workshop participants who spoke with *Science*, several researchers are still seeing excess heat from fusion cells similar to the ones originally described 7 months ago by Stanley Pons and Martin Fleishmann at the University of Utah. The anomalous heat measurements are coming not only from researchers who have already announced positive data, such as Appleby's team, but also from new entries to the field, such as Richard Oriani at the University of Minnesota. "Anomalous heating appears to be real," Appleby said. "If the temperature turns out not to be an artifact, then nuclear phenomena are involved. There is no other explanation."

If nuclear phenomena are involved, there should be nuclear by-products, such as neutrons and tritium, in addition to the excess heat production. Several of the workshop participants had reported seeing these by-products in the past, only to have their experimental procedures questioned. These scientists now say that they have refined their techniques to eliminate various sources of error and have run blank controls, and still they detect these products.

But cold fusion research is still bedeviled by a major problem—the difficulty in detecting excess heat and nuclear by-products in the same experiment. A second frustrating obstacle has been the now-you-see-it, now-you-don't nature of the cold fusion experiments. Most researchers report that some of their experimental cells will work and others not, apparently at random, and even the working cells work only part of the time.

The question remains of where funding for further series of experiments will come from. The Electric Power Research Institute is providing some money this year and could spend up to $2 million next year if experimental results are promising, but neither the Department of Energy nor the National Science Foundation has any plans for a cold fusion program. However, Paul Werbos of NSF's Division of Electrical and Communications Systems, which co-sponsored the workshop, said at the press briefing, "When we get recommendations [from the meeting participants], then we will look at the possibility of funding."

■ ROBERT POOL

*NSF/EPRI Workshop on Anomalous Effects in Deuterated Materials, Washington, D.C., 16 to 18 October.