NATURE douses dilution experiment

An investigative team organized by NATURE reports in the July 28 issue that the results of a controversial dilution experiment published in the journal four weeks ago are "not reproducible in the ordinary meaning of that word." A repeat performance got four positive and three negative results at the University of Paris-Sud laboratory of Jacques Benveniste, who led the original 13 researchers.

In the original experiment, a solution of antibodies appeared to evoke a reaction from certain white blood cells and change their ability to hold a stain even after the antibody solution had undergone 120 tenfold dilutions (SN: 7/2/88, p.6). After a succession of so many dilutions, it is unlikely that even one molecule of antibody would be left in the solution. That scientists from six laboratories worldwide reported a reaction brought hosannas from many practitioners of homeopathic medicine, a 200-year-old practice that has endured criticism for its use of infinitesimal doses of drugs to stimulate a cure.

NATURE's skepticism was clinched by the final three runs of the experiment — the only ones performed double-blind, meaning all test tubes had been randomly coded twice. The person measuring the cells' reaction to the antibodies could not have been influenced by a preconcieved idea of the results. All three of these runs were negative.

One partially blind run of the experiment, however, produced positive results. For this, the mixtures of antibodies and cells were randomly transferred from the test tubes onto slides by one of the observers, Walter Stewart of the National Institutes of Health, well known for uncovering scientific fraud. "It was a blind reading," Stewart explains, "but not a blind preparation of the experiment."

Also on hand were James Randi (known as The Amazing Randi, a former magician who has devoted the past 20 years to disproving pseudoscience), NATURE Editor John Maddox and Randi's assistant, José Alvarez.

In his editorial reply, Benveniste blasts NATURE for a "mockery of scientific inquiry." He maintains the last three tests "worked poorly mainly due to erratic controls." Also, Benveniste writes, the workload imposed by the week-long inquiry influenced the results of the final runs. The whole series of experiments was carried out primarily by Elizabeth Davenas, whose name appears first on the original paper.

"That's ridiculous," says Maddox, referring to the French scientist's explanation. "We were astonished at the atmosphere of the lab. They had done nothing to figure out why they had gotten these [original] results."

Also surprising to NATURE, he says, was that the first paper did not report that one of the coauthors from Israel had dropped out at the last minute in a dispute over the results, or acknowledge that a homeopathic drug company is a financial supporter of Benveniste's lab.

Benveniste says these facts distort the journal's report. "Does homeopathic companies paying two researchers ... mean that they order them into improper conduct?" he writes.

For his part, Randi says he could spot no trickery on the part of the researchers, although he did describe Davenas as a woman "very fond of rounding numbers," who recorded her data in pencil. "They just couldn't perform under pressure," he remarks. "That's the smoking gun."

The dilution research is not completely blown out of the water, however. NATURE will now begin closely examining data from other laboratories whose positive results were reported in the original paper, especially the one in Israel, which most strongly supports Benveniste's experiment. Says Maddox, "We shan't leave it alone."

— L. Beil

Chaos in a cold cloud of trapped ions

In isolation, a cloud of magnesium ions, each carrying a positive charge, would push itself apart. But at sufficiently low temperatures and trapped in an electromagnetic field, such ions can settle into an orderly array — a fragile, crystal-like structure in which the ions are many times farther apart than atoms in a crystal. Small changes in the strength or geometry of the confining electromagnetic field or in the wavelength or intensity of the laser beams responsible for cooling the ions to less than a degree above absolute zero (SN: 7/23/88, p.52) readily shift the array back into a disordered state.

Now researchers have turned up theoretical and experimental evidence suggesting that this phase transition from an ordered to a disordered state may be an example of a transition to chaos. In other words, the complicated motion of the ions in the disordered state, rather than being truly random and unpredictable, is deterministic. Describable by a set of equations, this type of motion is so sensitive to minute variations in local conditions that even neighboring particles follow rapidly diverging paths.

In the July 18 PHYSICAL REVIEW LETTERS, Richard G. Brewer of the IBM Almaden Research Center in San Jose, Calif., and his co-workers report the results of experiments on a pair of cooled, trapped barium ions and computer simulations of the equations governing their motion. By detecting the faint light given off by the ions, the researchers can actually see when the ions are essentially fixed in place and when they are moving chaotically. They can shift their two-ion system into a chaotic state simply by changing the radio-frequency voltage that defines the electromagnetic trap.

The results demonstrate the delicate interplay of the repulsive electrical forces between the ions, the confining electromagnetic field and the effects of the cooling laser beams, which leads to chaos. "I think this is a new way of studying chaos," Brewer says. "The complexity and the richness of phenomena that occur in chaos is so overwhelming that one could spend quite a bit of time both on the computer and in the laboratory trying to verify predictions. Here, we have one of the simplest systems possible: two particles in a potential well."

In the July 28 NATURE, Herbert Walther and his colleagues at the Max-Planck-Institut für Quantenoptik in Garching, West Germany, report similar transitions among groups of from two to 100 magnesium ions. Their results show that the ordering of ions into a crystal-like structure takes place under somewhat different conditions from their breaking apart into a disordered cloud, an effect also seen in the IBM experiments. That observation is analogous to a situation in which a crystalline material melts and freezes at different temperatures.

David J. Wineland and his colleagues at the National Bureau of Standards in Boulder, Colo., have experimented with as many as 15,000 laser-cooled beryllium ions in a magnetic trap, as reported in the May 16 PHYSICAL REVIEW LETTERS. They, too, have seen transitions between disordered clouds of ions and more orderly structures. In this case, however, the ions appear to organize themselves into a number of concentric, spherical shells. The ions move about readily within or on a shell — a liquid-like phase — but rarely diffuse from one shell to another.

"The study of simple phase-transition dynamics in clouds of trapped ions will allow non-equilibrium statistical mechanics to be investigated directly with relatively few particles," Peter Knight and Richard Thompson of the Imperial College of Science and Technology in London comment in the July 28 NATURE. "Indeed, the changing nature of the transition as the number of particles increases offers new insights for correlated statistical systems."

— I. Peterson