The more accepted theories stress the microphysics of precipitation within the cloud, says Vonnegut, of the State University of New York at Albany. According to these theories, variables such as the temperature and size of colliding rain, ice and hail particles determine the polarity of the thundercloud.

For 30 years, Moore and Vonnegut have advocated a second class of theories, so-called "induction" or "feedback" mechanisms. These theories hold that the kind of charge — usually positive — present in the atmosphere as a cloud develops will influence the cloud's polarity. They decided to test this idea by reversing the polarity of the air near Langmuir Lab in Socorro, N.M. With a voltage of −120 kilovolts on their wire, they branded the air with a negative charge.

Moore and Vonnegut report that when clouds grew from the negatively charged air, they were abnormally polarized — a large positive charge center was observed in the lower part of the cloud. An observing plane flying through the cloud also reported the presence of a negative charge center in the top of the cloud, again a reverse of the normal situation.

Positive charge regions are often observed in the lower part of an active thundercloud, but these regions are small and "are transient phenomena that exist only after lightning," says Moore, of the New Mexico Institute of Mining and Technology in Socorro. "Whatever we're seeing is very different."

That a small amount of negative charge released into the atmosphere could produce such a large anomalous positive charge in the cloud confirms, in Moore's opinion, that feedback may be involved in the electrification process, and that the polarity of the growing thundercloud is determined by whether the ambient charge is positive or negative.

Other researchers are reluctant to draw any conclusions without more evidence. Tom Marshall of the University of Mississippi in Oxford sent an instrumented balloon at Langmuir through one of Moore and Vonnegut's test clouds and says the cloud displayed a normal polarity. He measured a three-tiered charge structure in the cloud — positive top, negative middle and positive bottom. "The electric field profile [electric field as a function of altitude] looks very much like electric field profiles for other clouds," he says. "It's common to have a [small] lower positive charge."

If the cloud is of normal polarity, says Earle Williams of MIT in Cambridge, Mass., it suggests "that there's some microphysical mechanism going on to produce that positive charge."

However, Marshall adds that he's "very confused" by the magnitude of the charge. "I don't think the cloud was upside down, but on the other hand I don't think it was a normal cloud either."

— R. Monastersky

Reasons for boning up on manganese

Manganese may be an important factor not only in preventing osteoporosis but also in regulating the production and release of insulin and in fighting the cell and tissue damage caused by a number of environmental insults, according to research presented at the recent American Chemical Society meeting in Anaheim, Calif. Moreover, many individuals may be receiving insufficient levels of this essential trace metal. One reason, new data show, is that the body cannot absorb it from many of the richest dietary sources.

Biologist Paul Saltman of the University of California-San Diego (UCSD) in La Jolla became interested in the importance of dietary manganese six years ago after meeting the physician attending basketball-superstar Bill Walton. At the time, Saltman notes, Walton was constantly plagued by broken bones. Saltman recalls looking at the X-rays of an ankle of Walton's that was not healing, and realizing, to his shock, that "this guy has osteoporosis or an osteoporosis-type disease."

Examining Walton's blood, Saltman turned up no manganese, half the normal levels of zinc and copper, and lots of calcium. He says the calcium levels suggested Walton "was not synthesizing bone well." Other trace metal levels suggested a "remarkable" imbalance. Walton started taking mineral supplements, dropped his macrobiotic diet and "within six weeks was back playing [basketball]," Saltman says.

The first major clues to the cause of Walton's condition came in a one-year experiment by Saltman and his co-workers, in which rats on a low-manganese diet developed porous bones.

Bone tissue is constantly breaking down and being reformed. So in another test the UCSD team measured the activity of cells responsible for the breaking down and laying down of bone tissue. Manganese-deficient rats broke down half as much bone as rats on a minerally balanced diet. Cells responsible for laying down new bone were inhibited even more, he says, resulting in bone loss and increased porosity.

Most recently, working with rheumatologist J. Yves Reginster at the University of Liège in Belgium, Saltman and UCSD co-worker Linda Strause compared blood and bone samples from 14 Belgian women with "hard-core osteoporosis" to those from age-matched women without osteoporosis. Of the 25 factors they looked at, Saltman says the only statistically significant difference was in manganese. And it was striking. Blood levels of manganese in the osteoporotic women were a quarter of those in the other group.

Sheri Zidenberg-Cherr and her colleagues at the University of California at Davis have found reduced activity in one enzyme — manganese superoxide dismutase — in manganese-deficient rats. This enzyme is important in the body's defense against free-radical damage from ozone and other environmentally polluting oxidants (SN:3/31/84,p.197), explains co-worker Carl Keen. "We can link a reduction in the activity of this enzyme," he adds, "with increased tissue-lipid peroxidation — thought to be one of the major types of tissue pathology linked with a host of environmental insults."

By manipulating dietary manganese levels in rats, the Davis team has been able to block the production or release of insulin from the pancreas, producing a condition that resembles diabetes. This suggests, Keen says, "that pancreatic manganese concentrations may be one of the regulatory steps in insulin's synthesis or release."

Human studies at the University of Texas in Austin suggest that the National Research Council's recommendation of 2.5 to 5 milligrams of manganese daily is too low. Jeanne Freeland-Graves has found that at least 3.8 mg must be consumed daily to prevent the body from depleting its stores of the metal.

Ironically, the richest stores of manganese — in wheat bran, tea and spinach, for example — are unavailable to the body, according to studies by Constance Kies at the University of Nebraska in Lincoln. Factors like phytate and fiber in bran, tannins in tea and oxalic acid in spinach inhibit the absorption of many minerals, including manganese. Though manganese is present in far smaller quantities in meats, milk and eggs, Kies says its higher bioavailability in them can make them an important source.

Kies's studies also show that mineral supplements of iron, magnesium and calcium can inhibit manganese uptake. The calcium finding is particularly worrisome, she says, because U.S. women — who in general receive "far less manganese than even the NRC recommends" — are being encouraged to offset their risk of developing osteoporosis with calcium pills. In fact, Kies says, because of their effect on manganese absorption, it is possible "that taking these calcium supplements might make the osteoporotic situation worse." However, Kies's data indicate that when the source of calcium is milk, "there is no statistically significant decrease in manganese absorption."

— J. Raloff

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