0.8 to 2.5 billion years if only single islands or groups of islands are used, he says. Carlson and his colleagues point out that the difference between the strontium-rubidium age and the samarium-neodymium age might be explained by an erroneous assumption common to both methods. Rather than the assumed single geological event, in which a homogeneous mantle rapidly separated itself into a number of reservoirs, perhaps the mantle has had its chemical composition repeatedly altered over a longer period of time.

O'Nions and colleagues favor such repeated or even continuous mantle differentiation. They argue that repeated differentiation would produce the same distribution of isotopes as is observed. In addition, a single differentiation does not jibe, according to O'Nions, with what is known about the evolution of the mantle and the crust. Dating of continental crust rocks has shown that new crust has been added to the continents several times since 3.8 billion years ago. Because new crust is separated from the mantle during a differentiation process, an isotopic record of many episodes of differentiation during most of the earth's history should be found, not a single one at 1.6 billion years ago, O'Nions says.

His group's evaluation of the available isotopic data from basalts of the North Atlantic supports relatively recent differentiation as well as earlier activity. According to their view, the rubidium-strontium and the neodymium-samarium data suggest that the mantle's composition changed some 200 to 500 million years ago. However, the apparent neodymium isotope ratio at that time still differed from that estimated for the mantle before any differentiation took place. Thus, the composition of the mantle must have been altered by differentiation that took place more than 500 million years ago. Although the lead isotope analyses need not be interpreted as supporting a single differentiation event, they conclude, the lead data do require changes in mantle composition a billion or more years ago.

One improvement in the isotopic data that would help resolve the controversy over mantle structure and evolution, geochemists concede, would be the analysis of more rocks for all three isotopic systems. Heretofore, most labs did not have the capability to use all three methods, and cooperation between labs was limited. As the use of the new neodymium method spreads, geochemists will have the opportunity to compare the behavior of all three systems in the same rock.—RICHARD A. KERR

The Scrapie Agent: Is It a Viroid?

Investigators have known for many years that such degenerative brain diseases as scrapie in sheep and Creutzfeldt-Jakob (CJ) disease, a rare, premature form of senile dementia in humans, are caused by an unusual kind of infectious agent (*Science*, 29 June 1973, p. 1351). Their findings indicate that the diseased brains carry a very small pathogen, such as a virus. But attempts to isolate a causative virus—or a pathogen of any other kind—from the brains have produced more frustration than results. Moreover, some investigators even questioned whether the scrapie and other agents require nucleic acid for their activity, as all conventional viruses do. For example, the infectious brain extracts are not inactivated by ionizing or ultraviolet radiation that normally inactivates nucleic acids. Recently, however, evidence suggesting that the scrapie agent is a very small DNA molecule, possibly the first viroid to be discovered in animals, has appeared.

Viroids are pathogens known to cause a number of diseases in plants. They consist of a small molecule of RNA—one-tenth or less the size of the nucleic acids found in conventional viruses—and lack the protein coat that normally covers viral nucleic acids. Because the behavior of the scrapie agent and that of plant viroids are similar in many ways, Theodore Diener, a plant pathologist with the United States Department of Agriculture, proposed in 1972 that the scrapie agent might be a viroid. (Although the known plant viroids all consist of RNA there is no reason why other viroids could not be DNA. Conventional viruses may contain either DNA or RNA.)

After 6 years of searching, Richard Marsh of the University of Wisconsin and J. S. Semancik of the University of California at Riverside and their colleagues have finally turned up direct evidence that this is the case. They have shown that the scrapie agent has a DNA component that is necessary for infectivity. When they treat extracts of scrapie-infected hamster brains with an enzyme that breaks down DNA, they destroy 90 percent or more of the material's infectivity. Enzymes that break down RNA or protein have no effect. In addition, the molecular weight of the infectious DNA appears to be about 70,000 to 100,000. In other words, it is about the same size as the RNA of plant viroids.

According to Paul Brown, who is studying scrapie at the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS), the suggestion that the scrapie agent contains an essential DNA component is consistent with the properties of the agent with the possible exception of its resistance to radiation. But this may not be an insurmountable problem. Impure preparations of plant viroids are also resistant to radiation; they become sensitive only when purified. A similar phenomenon may occur with the scrapie agent, according to Marsh and Semancik. The material they are studying also becomes more sensitive to radiation as it is purified. The unpurified scrapie agent is closely associated with cellular membranes which may protect it from the harmful effects of the radiation.

The discovery of the chemical nature of the scrapie agent might throw some light on the chemical nature of the agents causing related brain diseases in humans, including CJ disease and kuru, a similar (perhaps identical) condition that was once common among the people in some areas of New Guinea. The symptoms and pathological changes occurring in the human diseases closely resemble those of scrapie. In fact, D. Carleton Gadjusek and Clarence J. Gibbs of NINCDS, who discovered the infectious nature of kuru and CJ disease, have suggested that the agents causing these diseases might actually be variants of the scrapie agent, which could have originally been transmitted to humans who ate scrapie-contaminated sheep brains. Moreover, there are suspicions that similar agents might cause other more common brain diseases, including Parkinson's disease.

Brown sounds a cautionary note, however. He points out that the work of Marsh and Semancik has not yet been reproduced by other investigators, although several now have experiments in progress. If the work cannot be duplicated, the researchers investigating the causes of scrapie and the human brain diseases will have to cope with still more frustration while they try again to corner the elusive agents causing the diseases.—J.L.M.