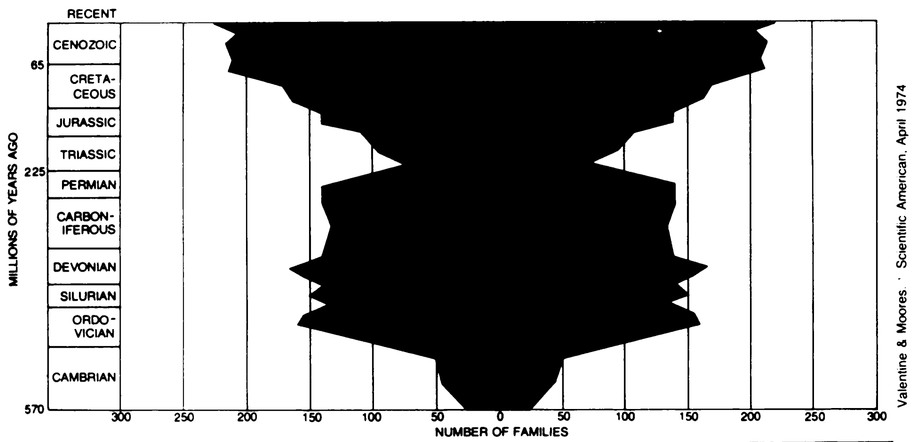
Permian extinctions: Super-salty sea?



End of Permian brought dramatic drop in variety of shallow-water marine organisms.

During a period ending 225 million years ago, life on earth underwent the greatest crisis of survival known before or since. Fifty percent of the kinds of animals and plants living at the beginning of the Permian, 280 million years ago, were extinct by its close, 55 million years later. The number of families of shallow-water marine invertebrates, for example, the most common forms of ocean life, plunged dramatically.

This great wave of extinction through the Permian has held the interest and imagination not only of geologists, paleontologists and biologists, but of astronomers and geophysicists as well. The low-point in diversity of life on earth at the end of the Permian defines the transition between two great eras of life on earth, from the Paleozoic to the Mesozoic, when life began rapidly to diversify again.

In the last decade, geologists and biologists have been given an entirely new framework—the theory of plate tectonics—in which to examine the conditions of the past and to explain fluctuations in the diversity of life. It is now known that the configuration of the earth's continents has gone through several dramatic cycles, a Precambrian supercontinent breaking into a Cambrian world 570 million years ago consisting of four continents, followed by welding of the continents back together to form the Pangaea supercontinent of 225 million years ago. In Mesozoic time Pangaea broke up into separate continents, which have gradually spread to their present positions.

In the past few years a number of geologists have been busy assessing what all this continent rearranging would have meant for life on earth. James W. Valentine and Eldridge M. Moores have been especially active in this area (SN: 11/21/70, p. 396 and 12/11/71, p. 395), and last year they published an important article showing how the breakup of Pangaea apparently triggered a long-term evolutionary trend that led to the present unprecedented diversity of life ("Plate Tectonics and the History of Life in the Oceans," SCIENTIFIC AMERICAN, April 1974).

In their view of events, the Permian extinctions of 225 million years ago were a consequence of the formation of the giant supercontinent Pangaea. The assemblage of Pangaea vastly reduced the total area of continental shelves (so important as habitats for marine life), lessened the number of shallow seas, and in general caused less geographically diverse and less seasonally stable conditions (because of the effects of land masses). Once Pangaea split up and its pieces spread apart, these trends were reversed, and the diversity of life flourished again.

Richard L. Bowen, a geologist and paleooceanographer from the University of Southern Mississippi, believes the Valentine-Moores hypothesis gives too much attention to the treatment of continents or crustal plates "as disposable jigsaw pieces" and too little attention to something else that changed: the nature of sea water. At the annual meeting of the Geological Society of America in Salt Lake City last week, he cited abundant data demonstrating that sea water has varied markedly in its characteristics, especially salinity and temperature, in the last 300 million years.

From the data, he pieces together this series of inferences: The Permian, he notes, began with extensive glaciation over the supercontinent. In his view, the glacial meltwater dropped the temperatures of deep ocean water, polar and subpolar waters to near-freezing. Cold, dense water has a greater capacity to hold certain chemical nutrients and thus is an aid to biologic diversification. In the middle and later Permian, when ocean temperatures warmed due to the absence of glacial meltwater, the supply of nutrients available for marine life was markedly reduced.

The same early Permian glaciation that produced the cooler temperatures vastly accelerated the weathering and erosion of the landscape, leaching large amounts of salts into the ocean. Bowen believes oceanic salinity increased by nearly one-third (to 46 to 48 parts per thousand) during the Permian and dropped correspondingly afterwards, generating great stress upon marine organisms of narrow salinity tolerance.

The combination of stresses from these salinity and temperature fluctuations resulted, Bowen proposes, "in the striking mortality and extinction rates recorded during the Permian."

Among the evidence Bowen cites for higher oceanic salinity in the Permian are data showing that since the beginning of the Permian, about 6 million cubic kilometers of salts have been permanently extracted from the world ocean. He says 4.5 million cubic kilometers of this amount were extracted in the Triassic, the period immediately following the Permian. Salt masses of this age are found in such places as Algeria, Morocco, Szechuan, Indochina, and the Gulf of Mexico. The Louann Salt, a huge salt deposit 1.5 km thick in the western Gulf of Mexico has a total volume of 4 million cubic km. "Extraction of the Louann Salt alone is sufficient to change oceanic salinity by 9 per mille," Bowen says. He believes the bulk of the deposit is of Triassic age.

Bowen's ocean-geochemistry hypothesis is not likely to replace the Valentine-Moores plate tectonics scenario for explanation of the great Permian extinction. But it offers a supplementary, and partly alternative, view that is sure to provoke discussion. In any event, he makes a strong case for not ignoring sea water itself when playing the plate-tectonics-and-the-history-of-life game. ☐

Genes mapped: Clues to cancer message

The same week that the Nobel Prize for physiology or medicine was shared by three researchers for their work on RNA tumor viruses and cancer, an important, related finding was being reported. Researchers from the University of California at Berkeley have mapped the specific sequence of nucleic acids in the so-called "onc" gene of an RNA tumor virus. This is the "on button," contained in the RNA of the Rous sarcoma virus, that causes cells of certain birds and animals to form tumors or leukemias.

The work was reported by virologists Peter H. Duesberg, Lu-Hai Wang, and Karen Beemon at the 7th International Symposium on Comparative Leukemia Research in Copenhagen in mid-October. In addition to mapping the oncogenic gene, they mapped a gene ("env") that directs the formation of the protein envelope that surrounds each virus particle. The knowledge of these base pair sequences, in addition to those of two more viral genes now being decoded, may help cancer researchers recreate the cancer message carried in certain viruses and may help them understand how this message is translated by host cells into uncontrolled and sometimes malignant tissue growth.

The team was able to map the genes by comparing normal and mutant forms of the sarcoma virus. The mutant form, which has lost the ability to transform normal cells into cancerous ones, has 15 percent less genetic material than the sarcoma form. The genes for oncogenesis, it turns out, are contained within this missing sequence. By a technique called oligonucleotide fingerprinting, the RNA molecules from both the sarcoma and mutant viruses were broken into fragments and the pieces analyzed. The fragments were then assigned to an order along the RNA molecule by the team's mapping techniques.

The team is presently attempting to isolate and map two other viral genes, one which controls the formation of the virus's inner protein coating and another which ultimately controls the production of new virus particles in the host cell. □

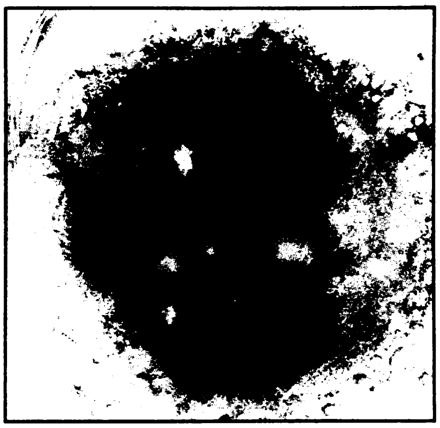
Bacteria: Metal beads and magnetism

Anton Mesmer, the notorious 18th-century Austrian physician and father of hypnosis, created from his readings in Greek astronomy and Renaissance medicine the theory that disease could be treated by restoring the body's proper balance of nervous fluids—fluids that, like the orbiting planets, are governed by magnetic fields. He turned this theory—"animal magnetism"—into what was even in the 18th century considered blatant medical quackery. He traveled Europe (often chased by local medical officials) sporting purple velvet robes and "healing" everything from melancholia to paralysis with his iron filings and magic wands.

A modern researcher, guided by fortuitous discovery rather than mystic theory, and using an electron microscope rather than a magic wand, has seen what could whimsically be called a modern instance of "animal magnetism." Or, better yet, bacterial magnetism. Richard Blakemore of the Woods Hole Oceanographic Institution reports in the Oct. 24 SCIENCE, finding bacteria that respond to magnetic forces by migrating toward the earth's magnetic north pole. And in a nearly mesmerizing show of life's creative adaptation, Blakemore's bacteria contain minute chains of iron beads that may orient the cells like living compass needles.

Blakemore calls this unique behavior "magnetotaxis," literally, movement oriented in response to magnetic force. Certain birds and marine animals are suspected of responding in some way to the earth's magnetic field, but these magnetotactic bacteria show the simplest, most direct response yet described. Blakemore discovered them while examining samples of marine mud from marshes near Cape Cod. He was attempting to isolate a certain type of bacterium under a light microscope when he noticed the tiny inhabitants of the mudpond beneath his cover slip repeatedly migrating toward the north. Indulging his curiosity with some simple tests, he eliminated light and oxygen as possible stimuli for the bacterial movement and settled on magnetic forces as an hypothesis.

Examination of the organisms under an electron microscope revealed small round cells with two tufts of flagella and one or two chains of electron-dense particles held in tiny membranous pouches. Analysis revealed the particles to contain mostly iron, perhaps, Blakemore says, a permanently magnetic substance. Whether exposed to the earth's magnetic field or to an artificial one, the cells orient and then migrate toward the preferred pole.



Adapted from Blakemore/Science

Iron-rich beads in marsh bacterium.

Since his initial discovery, Blakemore has observed magnetotaxis in four more distinct types of bacteria. He has viewed only one of them with electron microscopy, but it, like the first, contained the iron-rich beads. The bead chains may well have a relationship to cell orientation in magnetic fields, but this is still hypothetical. The relationship of the chains to taxis is still more hypothetical, Blakemore says, but there may be a fixed spatial relationship between the particles and cell propulsion. This, however, remains to be proved through future experimentation.

Probably the most intriguing question, at least for the armchair evolutionist, is what role does magnetotaxis play in the adaptation of these bacteria to their marsh mud niches? It might help direct the bacteria downward, Blakemore speculates, toward richer, less aerated sediments, and thus aid survival. "But the safest speculation I can really make at this point," he says, "is that if there is a selective advantage to magnetotaxis, it should be testable. And that's just what I plan to do." □

Imperatives for the new agriculture

Recent advances in genetic engineering and cell-culture techniques have given agricultural scientists a new opportunity to increase crop productivity and quality, while tailoring plants to meet the specific needs of a particular location (SN: 10/5/74, p. 218). Some 200 leading scientists from a half dozen fields met last week at a remote resort near Harbor Springs, Mich., to draw up a list of research imperatives to guide funding agencies as they encourage application of the new discoveries. One of the conference organizers, Sylvan Wittwer, director of the Michigan State University Agricultural Experiment Station, says that a funding increase of as much as 40 percent could now be profitably absorbed.

The list of imperatives reads like a what's what in recent biological advances: application of genetic engineering to improve nitrogen fixation in various bacteria species, introduction of new plant-growth regulators into major crops to alter maturation characteristics, and use of cell-culture manipulation to create new "broad crosses" incorporating the best features of two different crop species. But the recommendations, which will be published early next year, also point out some disturbing gaps in knowledge about fundamental processes. The key word that emerged time and again was "regulation." Although scientists have long recognized the intricate steps by which plants grow, demonstrate photosynthesis and reproduce, the genetic and hormonal controls of many processes are unknown.

Fundamental research in many of these areas has been "grossly neglected on a global scale," Wittwer says, but now "agriculture is being discovered by some very important people." Not surprisingly, as the discipline becomes more glamorous, more people want to get into the act. One professor told SCIENCE NEWS that many of his new students are from big cities and "would never have considered going into agriculture before." Another complained aloud to the conference that now, after the National Institutes of Health had sponsored much of the key basic research through university grants, the Department of Agriculture is exercising its territorial prerogatives and wants to place more of the work into its own staff-run laboratories.

As clumsy as the World Food Conference seemed at the time (SN: 11/30/74, p. 349), governments around the world have apparently given new priority to crop productivity, including related fundamental research. William Furtick of the UN Food and Agricultural Organization told the conference that within three years after the Rome meeting resources devoted to global agriculture will have tripled. □