Ptom-, Diken- and *Ariaspis*?

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FIELD MUSEUM PRESS

Dr. Denison studies some of the fossil fish specimens in the Museum's impressive collection.

At one time or another most of us have wondered what the world will be like in the 21st century. Some men translate their musings into movies, like *2001: A Space Odyssey*; others advance their controversial predictions phrased in peak-load words like "magnetoplasmadynamics," "hypnopaedia," and "mariculture."* All of this prophesying is good fun, of course, and is made even more so by the fact that no one can prove it's wrong—yet.

But suppose we turn back in time—not a mere hundred or thousand years, but millions—past cavemen, past the first flowering plants and first birds, even beyond the dinosaurs to a time earlier than that of trees and reptiles. We are in the beginning of the Ordovician period 500 million years ago. What was the world like then? Who or what, if anything, lived here then and what were they doing?

Well, the world was, naturally, physically a very different place. At the beginning of the Paleozoic in the United States there were no Appalachian Mountains, no Rocky Mountains, no coastal ranges on the west. Then, the spread of the Ordovician seas resulted in what was the greatest flooding of the North American continent during all of Paleozoic time and at least half of the continent was submerged beneath the warm water before it was over. The first and very primitive land plants grew during the Silurian period (430–400 million years ago) and it was during this time that they became sufficiently abundant in fresh water and on land to offer a stable food source for animals. The Devonian period (400–350 million years ago) is commonly referred to as "the Age of Fishes," because, for the first time in the history of the earth, a group of vertebrate animals, the fishes, occupied a prominent part of the organic world. The Devonian fishes were not like anything today's angler might reel in. For example, some had vacuum-cleaner-like mouths instead of movable jaws. Many of these jawless fishes had no scales, but were covered with bony plates.

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* Magnetoplasmadynamics: the science of putting the fourth state of matter—electrified gas—to work.

Hypnopaedia: sleep teaching.

Mariculture: cultivation of the seas of the earth.

Dr. Robert H. Denison, the Museum's highly respected Curator of Fossil Fishes, has centered his research on the Ordovician, Silurian and, especially, the Devonian periods. He has provided new information and added immensely to the knowledge of this very critical area in time—the very base of vertebrate life on earth. In "A Review of the Habitat of the Earliest Vertebrates" (*Fieldiana:* Geology, Vol. 11, no. 8, 1956), which is usually mentioned as his most significant work, Dr. Denison took issue with the classic view that early vertebrates were fresh water forms, some of which later migrated into the seas. He presented a thorough and careful review of all data on the occurrences, habitat and adaptation of the early vertebrates and concluded that "vertebrates originated in the sea and did not begin to enter fresh waters until some time in the Silurian." This publication reached and affected the thinking of a great many people and since Denison offered this independent conclusion, he has been joined in it by most American paleontologists.

Dr. David Bardack, Associate Professor, University of Illinois, Chicago Circle, and Museum Research Associate, cited Denison's "The Soft Anatomy of Bothriolepis" (Journal of Paleontology, 1941) as another important publication. The form of some of the internal organs of Bothriolepis, an armored fish from the Upper Devonian of Scaumenac Bay, Quebec, was preserved because, apparently, the fish swallowed extremely muddy water. The muddy water clogged up the respiratory apparatus and the fish died. The muddy water then filtered into those internal organs which opened into the exterior and, finally, the mud-filled fish was buried with coarser sand. Dr. Denison's examination of the preserved forms of these organs indicated several things, including the fact that the alimentary system was a primitive, straight, uncoiled tube without an expanded stomach region, but was specialized in having a complex spiral valve. Based on this investigation, Denison also offered the earliest evidence of lungs in vertebrates.

In "New Silurian Heterostraci from Southeastern Yukon" (*Fieldiana:* Geology, 1963) Dr. Denison made a unique contribution to paleontology by introducing three new genera, the Tom, Dick and Harry of the Silurian age—Ptomaspis, Dikenaspis and, with a cockney touch, Ariaspis.

Like the theories made about the future, Denison's paleontological statements are also phrased in exotic and strange-sounding words, but there the similarity abruptly and firmly ends. Denison's conclusions are not the product of idle day-dreams or wishful thinking, but are founded on expert interpretation of tangible evidence as well as years of training, research and hard work. Although it might be tempting and certainly understandable to speculate about the goings-on in the far distant past, Denison never does. He has published a great deal and all of his work has been described by his fellow paleontologists as "absolutely reliable," "thorough and sound," "accurate," "original" and—perhaps surprisingly—"imaginative." As Dr. Everett Olson, Professor of Vertebrate Paleontology, University of California and Museum Research Associate, says, Dr. Denison is a very methodical and orderly worker and, yet, "at the same time he has the ability to see past the mundane details to the greater possibilities as well as descriptive"—a combination not found in all paleontologists' work.

Denison is descriptive and theoretical about fossils. As Hugh Miller, an early expert in the Devonian, once said, "This interest in a science such as geology must consist in the ability of making dead deposits represent living scenes."

Dorsal shield of Ptomaspis canadensis, *shown X2, one of the three new genera of Silurian fossil fishes described by Dr. Denison in 1963.*

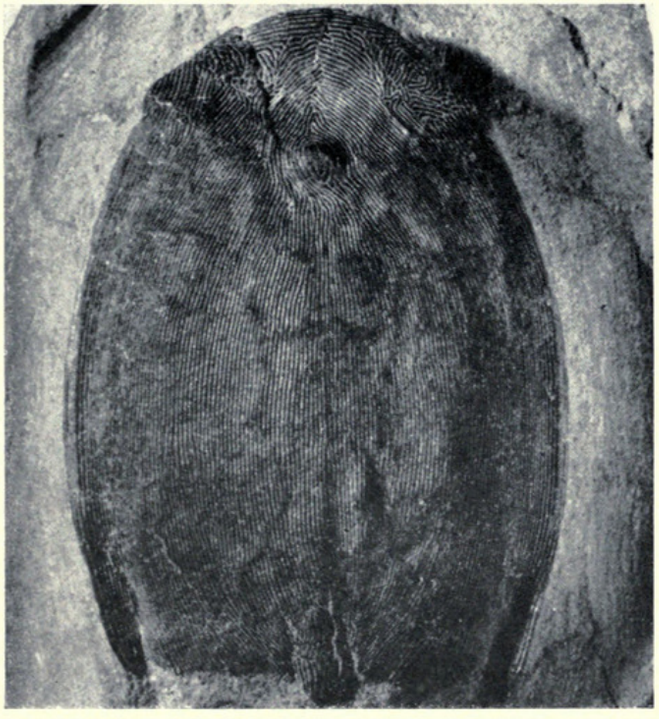
Obviously, then, the first thing the paleontologist must do is get hold of some "dead deposits."

To do this, Dr. Denison has gone on a number of field trips, including the famous Wendell Phillips University of California African expedition in 1947. Since joining the Museum staff in 1948, Dr. Denison has made many trips to the early vertebrate localities in North America and, as a Guggenheim fellow, he visited a large number of fossil localities in Norway, Sweden and Great Britain.

It was in Oslo in 1953 that Denison made a discovery that landed him on the cover of a Norwegian magazine. He had spent the entire day searching a well-known fossil site for new specimens and had found nothing. Giving up, he sat down on a rock to have a cigarette and wait for

a bus. As he smoked and waited, he looked down and there at his feet was a complete fossil of an eurypterid. (Eurypterids were scorpion-like creatures that inhabited the Silurian sea floor.) Denison took the eurypterid to the Paleontologisk Museum where Professor Heintz, the museum curator, and several of his students greeted it with great excitement and immediately piled into a bus and rushed

Dikenaspis yukonensis (above) *and* Ariaspis ornata; *fossils of the dorsal shields of these fishes, shown X2. The new genera of fishes were discovered in the Yukon.*



back out to the site. Although they had visited and examined the area many times before, they found several new fossils that day.

While the Norwegian eurypterid remained in Norway, Dr. Denison has added enormously to the Museum's collections. Dr. Rainer Zangerl, Chief Curator of Geology and a renowned paleontologist himself, says that Dr. Denison has enlarged the Museum's collection of fossil fishes "from virtually zero to one of the best in the country." Dr. Zangerl went on to say that almost the entire collection of primitive vertebrates has been gathered by Dr. Denison.

Dr. Denison is now studying pteraspids from a Lower Devonian site in the Big Horn Mountains of Wyoming where he has collected with groups from the Museum for at least three summers. While he is primarily working on the systematic relationships among the pteraspids, Dr. Denison is also interested in the growth of these creatures. Until now, no one has ever had any very young pteraspids to study and some workers assumed that the creature's shell was not formed until the pteraspid was an adult. However, Dr. Denison has now examined very young pteraspids and has determined that they possess a thin layer of dentine and that, later, bone forms below this dentine layer to create the shell.

Histology—a study of tissues—is particularly effective with the small fossil bits that Dr. Denison often has to work with and he is among the first American paleontologists to extensively apply the techniques of paleo-histology to his work. These techniques provide a way of analyzing paleontological material to determine ontogenetic and phylogenetic relationships. That is, both the relationships within an individual's life development and the development or evolution of a whole group. As Dr. Denison's work is so closely concerned with the evolutionary relationships among fish—who descended from whom? what evolved independently? did vertebrates evolve in the fresh water or the sea? —it is obvious why these techniques would be of use to him. With his characteristic modesty and reticence, Denison denies being an expert in histology, saying, "I've never even taken a course in it." How could he? The *only* course in paleohistology in North America is offered at the University of Chicago by Dr. Zangerl—and Dr. Denison.

As a child in Massachusetts, Denison did not dream and plan for the day when he would be acclaimed an expert in fossil fish—in fact, he got into that area of research by accident. He wrote his doctoral thesis at Columbia on fossil mammals and planned to concentrate his career on them. However, jobs were still scarce in 1937 and he accepted a position as Assistant Curator of the Museum at Dartmouth College where they had no collection of fossil mammals. They did, though, have a collection of early vertebrates and Denison began work on them.

Today Dr. Denison is one of three men in the United States working on vertebrate life of the early Paleozoic. There are paleontologists in Europe, most notably Scandinavia and Great Britain, working in this area as well. Without qualification, Denison's colleagues rank him as "one of the best," "a world expert," and "top ranking." Dr. Denison was invited to present a paper at the Fourth Nobel Symposium in Stockholm and the number of other scientists at the symposium who referred to Dr. Denison's work is most impressive. Denison is most often characterized as a typical New Englander because of his subtle wit, reserved manner and reluctance to admit to his many achievements. Dr. Bardack expressed the sentiments of many people when he said, "He's a great guy. I think a lot of him as a paleontologist and a human being."