

Florida Fossil Horse Newsletter

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Fossil Horses and Global Environmental Change Over the Past 20 Million Years

Over the past several years there have been some exciting innovations in the study of fossil mammals using techniques from chemistry. While I was on my sabbatical at the University of Utah I was fortunate to learn some of these techniques to study the ancient ecology, climate, local environments, and changes that have occurred over the past 20 million years from Florida and elsewhere in North America.

During the process of photosynthesis, plants fix carbon dioxide (CO₂) from the atmosphere and soil and combine the carbon in different ways. Most of the world's plants, including trees, shrubs, and high-latitude and high-elevation (cool growing season) grasses photosynthesize carbon into 3-chain compounds and are called **C₃ plants**. On land, C₃ plants represent about 90 % of the plant biomass. In contrast, most temperate and tropical grasses and some arid-adapted shrubs photosynthesize carbon into 4-chained compounds (**C₄ plants**). C₄ plants represent about 10 % of the world's plant biomass. (A third kind of photosynthetic pathway, the CAM cycle, mostly pertains to cactuses and their relatives and probably is not important to the discussion and results presented here.)

When herbivorous mammals eat, they incorporate the carbon into their bodies in the same proportions as were in the plant food. For fossils, the carbon is preserved within the mineral apatite of bones and teeth. Scientists have discovered that carbon dissolved in groundwater can enter and precipitate in the mineral lattice of bones, thus modifying the original carbon content of the bones. **Tooth enamel**, however, is composed of highly compact materials (almost exclusively apatite), which are relatively non-porous. Numerous studies have shown that the enamel is not prone to secondary modification. As such, fossil mammal tooth enamel preserves a wonderful record of the kinds of plant foods that the individual ate during its lifetime. In addition to understanding much about ancient diets of herbivorous mammals, we also can determine the local climate, and then actually reconstruct parameters about the local community and ecosystem. By comparing fossil mammals from different time levels in the geological column we then can compare local climates and environments and understand changes that have occurred over millions of years.

In order to analyze the carbon content of fossil mammals, a small sample of enamel (about 1/4 the size of a dime) is cut from the tooth, powdered, cleaned and then reacted with acid to liberate the CO₂ gas. (The kinds of carbon that we analyze are the stable forms represented by the isotopes ¹³C and ¹²C; not the radioactive ¹⁴C used in carbon dating of Pleistocene fossils.) The gas is purified and collected in glass sample tubes. The glass tubes are then placed in a mass spectrometer and cracked within a vacuum to analyze the purified sample gas. The different proportions of C₃ and C₄ compounds within the purified CO₂ gas sample can be detected in this decidedly high-tech machine. From these measurements we then can interpret the ancient diets and local surroundings of the fossil mammals. This kind of marriage between two previously disparate fields (paleontology and chemistry) is providing revolutionary new information to scientists.

I have begun several studies of fossil mammals and carbon isotopes. One of these studies seeks to understand the ancient climate shifts over the past 10 million years in Florida. I analyzed the tooth enamel carbon from over one hundred different fossil herbivores, including gomphotheres, mastodons, mammoths, horses, tapirs, rhinos, peccaries, camels, deer, and bison. These specimens came from 17 different fossil sites ranging from the late Miocene Love Bone Bed (about 10 million years old) to several of the late Pleistocene (probably several tens of thousand years old) river sites from Florida. Modern communities of herbivorous mammals in tropical and temperate climates normally contain a mix of **browsers** with low-crowned teeth predominantly feeding upon C3 plants (trees, shrubs, etc.), whereas the high-crowned **grazers** feed predominantly on C4 plants (mostly grasses). The question for the Florida sequence is: "who was eating what over the past 10 million years?" The carbon isotopic analyses produced very interesting results, some of which would have been predicted by the kind of teeth characteristic of the extinct mammal species.

During the late Miocene, from 10 to 7 million years ago, the extinct communities from Florida contain a mix of low-crowned (e.g., tapirs) and high-crowned (e.g., a diversity of horses) mammals. By modern analogy of herbivorous mammals with known diets, we would predict that these extinct forms represented, respectively, C3 browsers and C4 grazers. Our analyses of the tooth enamel revealed a surprising result. The carbon isotopic data indicated that all of these mammals at that time were feeding upon C3 plants! Science is wonderful because just when you think you have the answers, it fools you. Further research indicates that most of the ecosystems on land prior to about 7 million years ago were predominantly C3-based, including plants, shrubs, and grasses (as mentioned above, C3 grasses are rare in modern ecosystems; they apparently were very common in ancient ecosystems). After 7 million years ago in Florida, our tooth enamel data show a major carbon shift indicating ecosystems with a mix of C3 trees, shrubs, etc., and C4 grasses. What caused this shift in plant kinds? Research from elsewhere on land and in the oceans indicates that in the late Miocene, between about 6-7 million years ago, there was a major shift in climate to a global regime of increased aridity, increased seasonal extremes, and lower mean annual temperatures. These factors favored C4 grasses and other C4 plants and apparently resulted in the spread of these kinds of plants during and since the late Miocene.

In summary, all of those land mammals collected from the rich sequence of sedimentary deposits from Florida preserve a wonderful record of evolution of the fossils themselves. And, to this we now can add that captured in their teeth is preserved a detailed record of ancient diets, climates, and global environmental conditions. Combined paleontological and geochemical studies like this are an exciting new wave of research and will undoubtedly contribute much to our understanding of ancient geological and paleontological history in Florida and throughout the world.

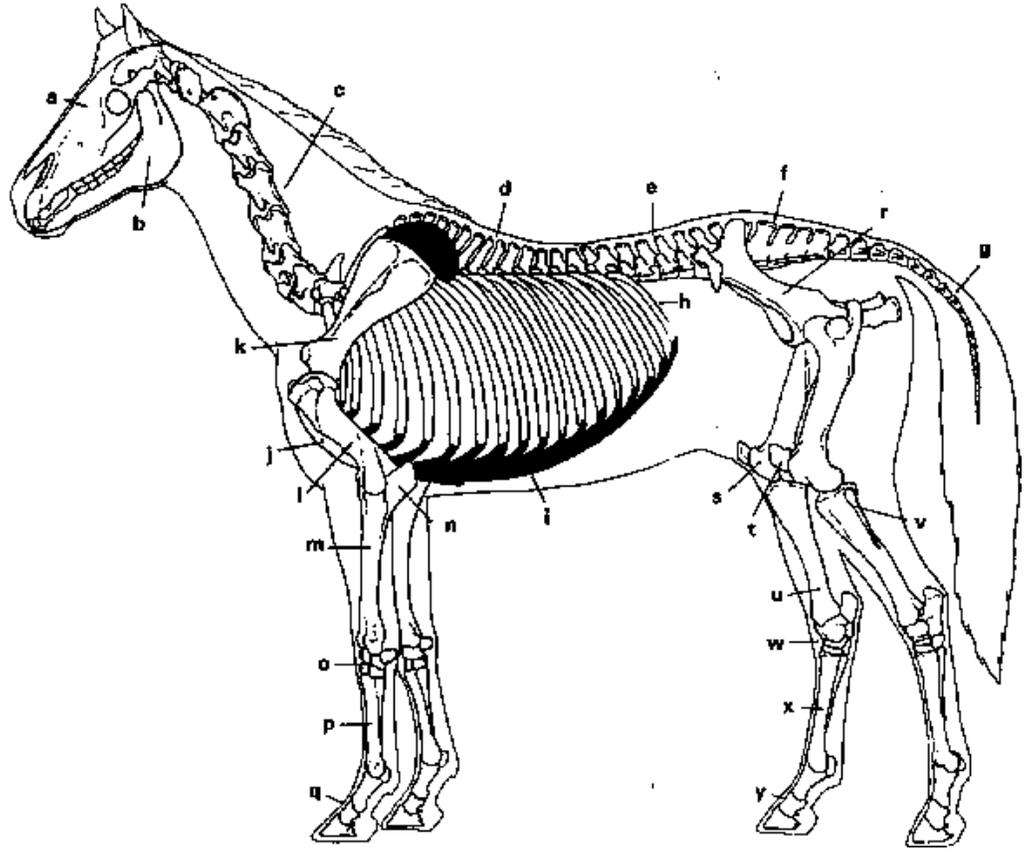
(Editor's note: more about this research is discussed in an article entitled "The Heyday of Horses" which appears in the April issue of Natural History magazine.)

Horse Anatomy

A letter from John R. Powell of Kernersville, NC suggesting more bone drawings initiated this new regular column for the Pony Express. In each of the following newsletters we will focus on how to identify individual fossil horse bones. We choose to start this series with an articulated horse skeleton which will serve as a reference for future articles. As always, we welcome your suggestions for the Pony Express. (Linda Chandler)

- a. Skull
- b. Mandible
- c. 7 Cervical Vertebrae
(1=atlas, 2=axis)
- d. 18 Thoracic Vertebrae
- e. 6 Lumbar Vertebrae
- f. Sacrum
(=5 fused vertebrae)
- g. Caudal Vertebrae
(average=18)
- h. Ribs
- i. Costal Cartilage
- j. Sternum
- k. Scapula
- l. Humerus
- m. Radius
- n. Ulna
- o. Carpus
- p. metacarpus
- q. Digits
- r. Pelvis
(ilium, ischium, pubis)
- s. Femur
- t. Patella
- u. Tibia
- v. Fibula
- w. Tarsus

- x. Metatarsus
- y. Digits

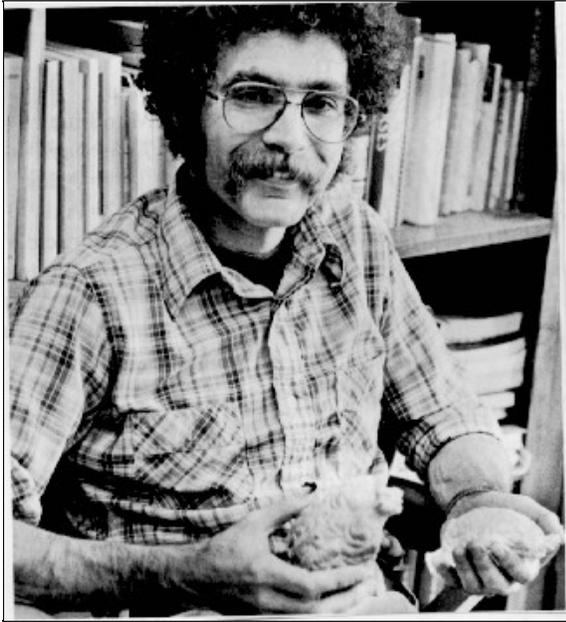


Famous Horseologists--Leonard B. Radinsky (1937-1985)

Len Radinsky was born in Brooklyn, NY and educated at Cornell and Yale universities. After stints teaching at Brooklyn College and Boston University he spent the better part of his professional career as an anatomy professor at the University of Chicago. Len's range of paleontological interests spanned from sharks to mammals, although the latter were his principal emphasis. Within mammals, he ranged from solid and fundamental taxonomic studies (e.g., some of the classic work on early fossil tapirs of the Eocene), to interesting papers about the origins of horses from condylarths, to wonderfully insightful papers on horse evolution.

One of Len's most interesting papers was on the evolution of the brain of *Hyracotherium* ("eohippus") from the Eocene as well as the brains of later horses. He re-examined the specimens originally studied by Edinger (see *Pony Express*, Vol. 2, No. 4) and discovered that the brain endocast that she had used to interpret the complexity of *Hyracotherium* was probably not a horse at all (it apparently belonged to another primitive mammal of similar size living in the same community). Whereas Edinger concluded that *Hyracotherium* was little changed from its condylarth ancestor, Radinsky studied other definite specimens of *Hyracotherium* and discovered that the brain was significantly more complex and had the beginnings of complex foldings in the mid-brain like those of later horses.

Len also studied the evolution of horse skulls using morphometrics, a technique in which many characters and dimensions are measured. Using these measurements he discovered that the shape of horse skulls changed relatively little until the late Miocene; at this time there were major reorganizations in many of the relative proportions. He concluded that this major change during the Miocene was related to the adaptive diversification of horses, including the advent of several of the larger bodied grazing lineages.



Len Radinsky, in his office and holding specimens of fossil mammal brain. He studied rare mud infillings of fossilized skulls ("endocasts"). (Photo courtesy of the Department of Organismal Biology & Anatomy, University of Chicago).

I found Len to be a very easy person to interact with. He was an avid jogger and I remember one time when we were both studying at the American Museum of Natural History in New York, we had some wonderful discussions about fossil mammals while jogging around Central Park. Another thing I remember about Len was that he was a truly excellent public speaker. I never missed his talks at our national meetings because they always were so well presented and always had some interesting scientific point. His talks in front of a large audience were communicated just as if he were talking one-on-one to you in your living room. Len's life was tragically cut short by cancer in 1985-- a fine person and brilliant paleontologist was taken from us.

Good-bye to Gary Morgan

Gary Morgan, VP Collections Manager for 15 years, is leaving the FlaMNH as of April 1994. Gary is moving to Albuquerque, New Mexico where he will join his wife, Mary Ann Joca. Gary looks forward to continuing his interest in old bones out west as well as pursuing new opportunities there.

Gary is a native of Findlay, Ohio. He received his bachelors degree from Miami University (Ohio, the one up north, not south of here). In 1974 he came to Gainesville to study for his masters in geology, which he received in 1977. His thesis on the cave faunas of the Cayman Islands was a masterful piece of scholarship. Since that time he has continued his scholarship and has become an expert in many fields, including bats, whales, Caribbean fossil mammals, and not surprisingly, Florida fossils. After a brief stint as a curatorial assistant in the Division of Mammalogy at the Smithsonian, he

was wooed back to the FlaMNH in 1981 to become our Collections Manager. During this time Gary has done an outstanding job of helping to build our VP collections to one that ranks in the top 5 nationally. He has led many of the field excavations programs at our important sites. He has befriended many graduate students and visitors that have used the collection over the past 15 years. And, he has been a mainstay of the public outreach program in VP, including answering many inquiries, identifying myriads of specimens, and presenting many popular lectures. He has been an exemplary and very dedicated employee of the FlaMNH and this fact was recognized when he received the van Hyning award in 1990 from the museum.

On a personal note, I have immensely enjoyed my association with Gary. He is invariably upbeat and exceedingly knowledgeable about VP. He is very approachable and has a great sense of humor. Gary is an extraordinary identifier of fossil specimens, enigmatic or otherwise. In fact, one Florida fossil club provides an award ("Fossil Bucks") for anyone who can stump Gary with a specimen that he cannot identify. To date, no-one has collected even one of these coveted "Fossil Bucks"! Gary also is a truly outstanding fossil hunter. There are two kinds of collectors, those who are OK or pretty good at finding fossils, and a rare few who have that sixth-sense to find the best ones. Gary definitely falls in the latter category. We have worked together in Bolivia and there were days when I would return from the field with what I thought was a good haul (some teeth and jaws, for example)- Gary, however, would come back to camp with the best finds of the day, including beautiful jaws and a skull or two of a rare or new kind of mammal.



Gary emerging from a cave in Marion county, Florida after extracting an Archeocete Whale vertebra. (photo by Erika H. Simons)

His departure will create a huge void in our program.

We already know that many of Gary's friends and contacts throughout the state will also miss his presence here. While on one hand we are sorry to see him go, on the other hand we wish him the best for the future. His legacy here remains in the collections and public outreach that our VP program currently enjoys.

Converse Award to Roxane and Steve Wilson



The Howard Converse award was established by the FlaMNH in 1988 to recognize the accomplishments of hobbyist paleontologists who have made scientifically important fossil collections. The recipient is chosen annually by the FlaMNH paleontologists. The award is presented at a meeting of the Florida Paleontological Society and the recipients receive a plaque.

This year's recipients of the Converse award are Roxane and Steve Wilson of Arcadia. The Wilsons are avid fossil collectors and active members of the SW Florida Fossil Club. Over the years they have developed an extensive collection of Florida fossils, both invertebrate and vertebrate, and have donated many important specimens to the FlaMNH. Of particular note, in recent years they have donated rare specimens of fossil horses from the Desoto pit to the FI. We congratulate them once more for their enthusiasm, collections, and the recognition that comes with the Converse award.

Steve and Roxane Wilson. (Photo by Tom Harrigan of the S. W. Florida Fossil Club.)

Pony Express

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Pony Express--Statement of Purpose:

The purpose of this newsletter is to communicate news and information and disseminate knowledge about fossil horses, particularly in Florida, and to develop a state-wide constituency that will support and enhance the research, exhibition, and educational programs offered at the FLMNH that pertain to fossil horses. Contributions to the Fossil Horse Fund are deposited into an account at the University of Florida Foundation, Inc., a tax-exempt entity, and will be used for the purposes stated here.

Coming next issue:

a survey for you to tell us what future articles you would like to see in *Pony Express*. Would you like us to cover more than Florida or more than just horses? Be thinking about it!

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