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OTHER MEDIA REVIEW

Paleontology and Evolution in the News

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Abstract This paper is a review of recent media publications and journal articles about evolution and paleontology.

Keywords Plankton-eating ammonites · Sixth extinction · Lucy walked upright · Prehistoric birds in Alaska · *Tyrannosaurus rex* · Texas pterosaur · Cambrian wormlike arthropod · Algal origins · African antelope fossils · Chiton–protein complex in Paleozoic arthropods · Plankton in the Earth's first breathable atmosphere · Horse teeth

Plankton-eating Ammonites

"Ammonites Dined on Plankton" is the headline of a press release from the American Museum of Natural History on January 6, 2011 (http://www.amnh.org/news/2011/01/ammonites-dined-on-plankton/#more-2705) that describes the study of the ammonite *Baculites* found during expeditions to the Great Plains in Belle Fourche, South Dakota, a place known for the excellent preservation of fossils, which shows these animals had jaws and teeth (a tongue-like structure called a radula) adapted for eating small prey floating in the Cretaceous sea between 83 and 70 million years ago (Ma). Using a powerful synchrotron scan at the European Synchrotron Radiation Facility in Grenoble, France to produce 3D X-ray images, the authors Isabelle Kruta (Muséum National d'Histoire Naturelle), and Neil Landman (American Museum of Natural History) and their colleagues found one of the ammonites with a meal of tiny larval snails and tiny pieces of crustaceans in its mouth, a meal consumed just before its death. Kurta said "For the first time we could observe these delicate, exceptionally well-preserved structures and obtain information on the ecology of these enigmatic animals." Landman explains that "when you take into consideration the large lower jaws of ammonites in combination with the new information about their teeth, you realize that these animals must have been feeding in a different way from modern carrion-eating Nautilis." He also said that "our research suggests several things. First, the radiation of aptychophoran ammonites might be associated with the radiation of plankton during the early Jurassic. In addition, plankton were severely hit at the Cretaceous-Tertiary boundary, and the loss of their food source probably contributed to the extinction of the ammonites." One of the better news articles for teachers related to the research is found in *BBC News* for January 6, 2011 (http://www.bbc.co.uk/news/science-environment-12127790) by Jonathan Amos. The article contains several images of the specimens, including a brief movie once the ad is over. Embedded in the article is a three-part graphic inset that shows how the X-ray machine produces the images using an intense high energy light that can pierce just about any material, revealing its inner structure. The advantage of the technique is that the specimen is not destroyed. The X-ray microtomography data also captures very fine details that can be rendered virtually in a 3-D form and manipulated on a computer. These descriptions and others are based on the research published in *Science* on January 7, 2011, volume 331, pages, 70–72, "The Role of Ammonites in the Mesozoic Marine Food Web Revealed by Jaw Preservation" (www.sciencemag.org). Accompanying the article is a well-illustrated, 12-page description of the supporting material for the research. In addition, there are excellent images and reconstructions in

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the paper showing the morphology of the radula and teeth that can be utilized by teachers.

Sixth Extinction

A new study concludes that three quarters of today's animal species could vanish within 300 years, the so-called sixth extinction, comparable to the fifth extinction that wiped out a whole host of animals including dinosaurs, pterosaurs, and invertebrates such as the rudist clams. The lead author of the study, paleobiologist Anthony Barnosky of the University of California, Berkeley, said that the "good news is we haven't come so far down the road that it's inevitable. [We] explained that species come and go over long periods of time but mass extinctions occur rapidly and in the past that has amounted to three quarters of all species." (Ann Gibbons in ScienceNOW, March 2, 2011, http://news.sciencemag.org). "Are We in the Middle of a Sixth Mass Extinction," reviewed Barnovsky's work. Barnovsky and colleagues, looking at the past record, calculated the rate at which mammals died off in the past 65 million years. They found an average of extinction rate of less than five species per million years. "But in the last 500 years, a minimum of 80 of the 5,570 species of mammals have gone extinct…a rate that translates to about 36 species in a million years, about 20 times faster and above the documented rates for past normal extinctions." To Barnovsky and his colleagues, that means we are at the beginning of mass extinctions. If it is assumed that if all currently endangered or threatened mammals will disappear within a century, then by 334 years from now, 75% of all mammal species will be gone. The paper was published in the journal *Nature* (volume 471, pages 51–57; http://www.nature.com/nature/journal/v471/n7336/full/nature09678.html) online March 2, 2011, "Has the Earth's sixth mass extinction already arrived?" As one would expect, numerous newspapers and other media reported on the conclusions of the paper including Elizabeth Weise's article in *USA Today* on March 2, 2011 (http://www.usatoday.com/tech/science/2011-03-02-next-mass-extinction_N.htm#). "The IUCN list 18,351 species on its 'Red List of Threatened species,' considered the global standard for the conservation status of animal and plant species. All are at risk based on the current and projected habitat loss or destruction due to human encroachment and climate change. Of these, 1,940 are listed as critically endangered, meaning the species' numbers have decreased, or will decrease, by 80% within three generations." She quotes Anthony Barnosky: "Walk outside, look around and imagine three-fourths of all the different kinds of life you see gone. Ask yourself if you'd be happy living in that world" Also quoted is David Jablonski of the University of Chicago, saying that the paper has "pushed the field forward significantly. It's exciting to have a group of people trying to work it through as rigorously as they can…One thing the fossil record shows us unequivocally is that ecosystems can be pushed to their breaking points."

Lucy Walked Upright

"Foot bone shows humans walked upright 3.2 million years ago" was reported by Thomas H. Maugh II of the *Los Angeles Times* (http://articles.latimes.com/2011/feb/12/science/la-sci-foot-bone-20110212) on February 12, 2011. He reports that the foot bone from Ethiopia indicates that human ancestors largely abandoned swinging from trees by 3.2 million years ago and were spending virtually all their time walking upright. He was reporting on the study by Carol V. Ward, William Kimbel, and Donald C. Johanson who found a metatarsial bone from *Australopithicus afarensis*, the same species that was made famous by the 1974 discovery of the skeleton know as Lucy, in the journal *Science* (http://www.sciencemag.org), volume 331, pages 750–753, "Complete Fourth Metatarsal and Arches in the Foot of *Australopithicus afarensis*." It was Donald C. Johansen who led the team that discovered Lucy. The authors claim that the specimen clearly shows that the species had stiff, arched feet just like modern humans. In the few days after the release of the research, Google (www.google.com) reports that there were 353 related articles published in a variety of news outlets. The author of the news article goes on to explain that "Such feet are stiff enough to push off from the ground when taking a step and flexible enough to absorb shock when the foot touches down. But they have lost the ability to grasp branches and other objects—a distinguishing characteristic of Lucy's predecessors, *Ardipithecus ramidus*." Carol V. Ward is quoted in the article saying "The development of an arched foot represented a fundamental shift toward the human condition because it meant giving up the ability to use the big toe to grasp branches, signaling that our ancestors had finally abandoned life in the trees for life on the ground. Lucy and her kin could leave the forest and roam the countryside to forage for food when necessary. With their powerful jaws, they could eat a variety of foods, including fruit, seeds, nuts and roots." The importance of this discovery stems from the fact that previously, researchers believed that the first member of the human tree to walk upright was *Homo erectus*, which flourished between 1.8 million and 70,000 years ago before giving way to modern humans. The study elicited responses from a number of researchers, some positive and others cautionary, which can be read in "Reaction round-up: Lucy's feet made for walking" by

Dan Vergano on February 12, 2011 in *USA Today* (http://content.usatoday.com/communities/sciencefair/post/2011/02/paleontology-lucys-feet-made-for-walking/1).

Prehistoric Birds, Alaska

Two new species of prehistoric birds have been found in Alaska, in the Cantwell Formation in Denali National Park. The *Anchorage Daily News* on February 25th, 2011 (http://www.adn.com/2011/02/25/1722303/paleontologist-addicted-to-alaska.html) reports in the article "Paleontologist addicted to Alaska discovers 2 new prehistoric birds." The paleontologist referred to is Tony Fiorillo of the Museum of Nature and Science in Dallas, Texas, a regular visitor to Alaska for summer fieldwork. It is said that the formation holds the world's greatest known cache of fossilized bird tracks. Fiorello said that "The diversity of fossil bird tracks in the Cantwell formation of Denali is second to none anywhere in the world" and "contains riches beyond our expectations… Every year we go in there, every year we find new things, every year we come out and have to readjust the [theoretical] models…We haven't even begun to hit the point where the data are hitting a plateau." One of the new species is the size of a large crane, and the other is smaller than a sandpiper. These footprints indicate that Alaska served, as it does today, as a major nesting ground for at least the last 70 million years. The scientific article, "Bird Tracks from the Upper Cretaceous Cantwell Formation of Denali National Park, Alaska, USA: a new perspective on ancient northern polar vertebrate biodiversity," was published in the *Journal of Systematic Paleontology*, volume 9, Issue 1, March 2011, pages 33–49 (http://www.informaworld.com/)

Tyrannosaurus rex, Again

"*T. rex* More Hyena Than Lion" is the headline in *U.S. News and World Report* for February 24, 2011 (http://www.usnews.com/science/articles/2011/02/24/t-rex-more-hyena-than-lion). The article is based on content provided by the National Science Foundation. This new study finds that *T. rex* was probably an opportunistic predator like the hyena in Africa today. The ferocious *T. rex* has been depicted as the top predator of the Cretaceous, ruthlessly stalking herds of duck-billed dinosaurs much as the lion reigns supreme in the African veldt. John "Jack" Horner, Museum of the Rockies, and Mark B. Goodwin, University of California, argue that the result of a new census of all dinosaurs skeletons unearthed in Eastern Montana shows that *T. rex* was too numerous to have subsisted solely on the dinosaurs it killed with its scythe-like teeth. The authors present data that argues for *T. rex* as an opportunistic predator, like the hyena in Africa today, subsisting on both carrion and fresh-killed prey and exploiting a variety of animals, not just large grazers. In their census, *T. rex* was equivalent in numbers to *Edmontosaurus*, which many people had thought was its primary prey. "This says that *T. rex* is not a cheetah, it's not a lion, it's more like a hyena." And it "is as abundant in the Upper layers of the Hell Creek Formation as the herbivores…and it's even more plentiful in the other two-thirds of the formation. This supports the view that *T. rex* benefitted from a much wider variety of food sources than live prey." Normally, top predators are one-third or one-fourth as abundant as their prey. Opportunistic hunters like the hyena can be twice as abundant as the top predators. The Hell Creek Formation of Montana dates from 65–95 Ma. The census provides an emerging picture of what the dinosaur fauna looked like during the late Cretaceous. Horner notes that there is a greater variety of dinosaurs in the older sediments, the Lower Hell Creek Formation, compared to the "Upper" formation. "Definitely, there was change in population leading to the Cretaceous–Tertiary boundary, so something was happening to the faunas prior to impact by the meteor. During the 10 million years after dinosaur diversity peaked 75 million years ago, the dinosaurs dwindled pretty fast, and there weren't many left at the end." The research was published in PloS ONE on February 24, 2011, "Dinosaur Census Reveals Abundant Tyrannosaurus and Rare Ontogenetic Stages in the Upper Cretaceous Hell Creek Formation (Maastrichtian)," Montana, USA (DOI: 10.1371/journal.pone.0016574)

Oldest Fossils Ever Found may not be Fossils

An article by Craig P. Marshall and others, "Haematite pseudomicrofossils present in the 3.5-billion-year-old Apex Chert" in *Nature Geoscience* (http://www.nature.com/ngeo/journal/vaop/ncurrent/full/ngeo1084.html) published online February 20, 2011, describes material that was initially described over 20 years ago as the oldest bacterial fossils on Earth. While the structures resemble cycanobacteria, the authors determined the petrology and geochemistry of the structures from the original Apex Chert locality in Western Australia using thin sections and Raman spectroscopy. Their study shows that the structures are really a series of quartz and haematite-filled fractures, and there is no carbonaceous material associated with the structures. There is carbonaceous material disseminated in the surrounding quartz matrix, however. The authors suggest that although the microstructures analyzed are not microfossils, the presence of carbonaceous material in the surrounding matrix is consistent with the existence of microbial life at the time and with evidence of early Archaean life found at

other sites. A description of the work at PHYSORG.com, "Oldest fossils ever found may not be fossils after all" (http://www.physorg.com/news/2011-02-oldest-fossils.html, February 21, 2011), contains a photomontage of nine photomicrographs showing the locations of three of the microstructures. The rock formation is located in "the Philbara craton in the northwest of western Australia, one of only two remaining areas of pristine Archaean (3.6–2.7 billion years old) crust remaining on Earth. (The other is in Kaapvaal in South Africa)."

Texas Pterosaur

Fossilized bones discovered in Texas from a flying reptile that died 89 million years ago may be the earliest occurrence of the prehistoric creature known as *Pteranodon* reports a press release from SMURESEARCH (Southern Methodist University) "Flying Texas reptile, World's Oldest Pteranodon?" (http://blog.smu.edu/research/2011/02/rare_fossil_of_89_mya_flying_t.html) on February 28, 2011. There is some question as to its identification, however. "If it wasn't crushed so badly, it would be possible to determine if it really is *Pteranodon*." While it it's difficult to narrow the humerus definitely to a specific genus and species, some features clearly identify the specimen as part of the Pteranodontidae, most likely *Pteranodon*. The article states that previously, *Pteranodon* bones have been found in Kansas, South Dakota and Wyoming in the Niobrara and Pierre geological formations. This likely *Pteranodon* specimen is the first of its kind found in Texas, according to paleontologist Timothy S. Myers at Southern Methodist University in Dallas, who identified the reptile. The fossils do not solve the mystery of the reptile's cause of death, Myers said. But it appears the animal probably died in flight over the sea and then fell into the water. Its carcass probably floated for some time, so that when the flesh decomposed the bones separated at the joints, known as "disarticulation," before they settled to the sea floor and were buried. The specimen was discovered north of Dallas by an amateur fossil hunter who found various bones belonging to the left wing. *Pteranodon* was a type of pterosaur that lived about the same time as some dinosaurs, about 100–65 Ma. The only reptiles to dominate the ancient skies, pterosaurs had broad leathery wings and slim torsos. The specimen identified by Myers is an adult pterosaur of the toothless variety and while larger than most birds, wasn't among the largest pterosaurs, Myers said, noting it had a wing span between 12 and 13 feet or 3.6 to meters. It was discovered in the Austin Group, a prominent rock unit in Texas that was deposited around 89 million years ago, early in the geological time period called the Late Cretaceous. Pterosaurs, many of which survived on fish, lived at a time when a massive ancient sea cut across the central United States. The Western Interior Seaway was a shallow body of water that split North America in half from the Arctic Ocean to the Gulf of Mexico. More than a thousand *Pteranodon* fossils have been unearthed from the middle part of the seaway. Included in the press release are images of the specimen and a two-minute, 40-second descriptive video. Myers reported and described the specimen in "Earliest Occurrence of the Pterandontidae (Archosauria: Pterosauria) in North America: New Material From the Austin Group of Texas" in the *Journal of Paleontology*, November 2010, v. 84; no. 6; p. 1071–1081; DOI: 10.1666/09-082.1.

Cambrian Wormlike Arthropod

The headline for an article in *National Geographic News* by Christine Dell'Amore for February 23, 2011 says that the "Wormlike 'walking cactus' found" in China is actually a fossilized, ancient spiny creature, a new study says (http://news.nationalgeographic.com/news/2011/02/110223-walking-cactus-worm-new-species-fossils-animals/). The 2.4-inch long *Diania cactiformis* had a worm-like body and ten pairs of armored and probably jointed legs. An artist's reconstruction of the fossil species does justice to the description. This animal lived about 500 million years ago during the so-called Cambrian explosion when animals were undergoing a rapid period of evolution. The study leader Jianni Liu discovered the animal during a 2006 excavation in southwestern China's Yunnan Province, the site of numerous exotic discoveries. She said "I was really surprised…what's that strange guy with the soft body with very strong legs? When I [went] back and observed it under the microscope, [I realized] it's not only funny, it's very important." It appears that the animal belongs to a group of primitive creatures called lobophobians. Its robust appendages are like those of modern arthropods—joint-limbed animals such as spiders and crustaceans. The animal's unusual limbs strengthen the theory that modern arthropods evolved from lobopodians. The author thinks that the animal may have sucked up tiny creatures in the mud with its proboscis or used its bristly legs to capture larger prey. The scientific communication by Jainni Liu and others was published in the journal *Nature*, volume 470, pages 526–530, February 24, 2011 (DOI: 10.1038/nature09704), "An armoured Cambrian lobopodian from China with arthropod-like appendages." Excellent images of the animal display all of its important features. A better description of the importance of the find is described in the abstract of the paper which follows in part: "Cambrian fossil Lagerstätten preserving soft-bodied organisms have contributed much towards our understanding of metazoan origins. Lobopodians are a particularly interesting group

that diversified and flourished in the Cambrian seas. Resembling 'worms with legs', they have long attracted much attention in that they may have given rise to both Onychophora (velvet worms) and Tardigrada (water bears), as well as to arthropods in general. Here, we describe *D. cactiformis* gen. et sp. nov. as an 'armoured' lobopodian from the Chengjiang fossil Lagerstätte (Cambrian stage 3), Yunnan, southwestern China. Although sharing features with other typical lobopodians, it is remarkable for possessing robust and probably sclerotized appendages, with what appear to be articulated elements. In terms of limb morphology, it is therefore closer to the arthropod condition, to our knowledge, than any lobopodian recorded until now. Phylogenetic analysis recovers it in a derived position, close to Arthropoda; thus, it seems to belong to a grade of organization close to the point of becoming a true arthropod." In addition, Figure 4 of the paper is a cladistic analysis of all Cambrian lobophobians and some arthropod stem group taxa.

Algal Origins

John Timmer describes "New fossils push algal origins back to 600 million years" in *Ars Technica*, February 18, 2011 (arstechnica.com/science/news/2011/…/new-fossils-push-algal-origins-back-to-600-million-years.*ars*). He describes some fantastic fossils finds from China that date to the earliest era of multicellular life, the Ediacaran. Most Ediacaran fossils that have been described are members of an extinct group named the rangeomorphs. These new fossils seem to be older than the rangeomorphs but include forms that could be mistaken for modern algae. "Many of the major groups of multicellular life first evolved during the Cambrian, which started about 540 million years ago. There is evidence of multicellular life before that, of organisms that lived in the deep ocean in the Ediacaran, which started at the end of the last global glaciation. But the rangeomorphs look bizarre and unfamiliar to modern eyes, consisting of a collection of similar segments, odd fronds, and a few signs of complex specialized cell types." These new fossils come from the Lantian Formation in China and are probably over 580 million years old, and possibly over 600 million. Thus, they were living very close to the end of the last global glaciation of the Cryogenian period. The article is based on a letter published in the journal *Nature*, volume 470, pages 390–393, on February 17, 2001 by Xunlai Yuan and others, "An early Ediacaran assemblage of macroscopic and morphologically differentiated eucaryotes." The abstract, in part here, describes the result of the study. "The deep-water Avalon biota (about 579 to 565 million years old) is often regarded as the earliest-known fossil assemblage with macroscopic and morphologically complex life forms. It has been proposed that the rise of the Avalon biota was triggered by the oxygenation of mid-Ediacaran deep oceans. Here we report a diverse assemblage of morphologically differentiated benthic macrofossils that were preserved largely in situ as carbonaceous compressions in black shales of the Ediacaran Lantian Formation (southern Anhui Province, South China). The Lantian biota, probably older than and taxonomically distinct from the Avalon biota, suggests that morphological diversification of macroscopic eukaryotes may have occurred in the early Ediacaran Period, perhaps shortly after the Marinoan glaciation, and that the redox history of Ediacaran oceans was more complex than previously thought." Excellent images accompany the report.

African Antelope Fossils

Faysal Bibi of the Institut de Paléoprimatologie et Paléontologie Humaine at the Université de Poitiers, France published a review of the history and geographic locations of ancient bovine animals concentrating on Ethiopia Africa at the Public Library of Science (PloS ONE) website (http://www.PLoSONE.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0016688) on February, 16, 2011, "Mio-Pliocene Faunal Exchange and African Biogeography: The Record of Fossil Bovidae." Paul Hamaker provides the abstract of the paper in "New African antelope fossils rewrite early biogeographic history" in examiner.com (http://www.exam iner.com/paele-notology-science-news-in-national/new-afri can-antelope-fossils-rewrite-early-biogeographic-history). Here is the abstract: "The development of the Ethiopian biogeographic realm since the late Miocene is here explored with the presentation and review of fossil evidence from eastern Africa. *Prostrepsiceros* cf. *vinayaki* and an unknown species of possible caprin affinity are described from the hominid-bearing Asa Koma and Kuseralee Members (~5.7 and ~5.2 Ma) of the Middle Awash, Ethiopia. The Middle Awash *Prostrepsiceros* cf. *vinayaki* constitutes the first record of this taxon from Africa, previously known from the Siwaliks and Arabia. The possible caprin joins a number of isolated records of caprin or caprin-like taxa recorded, but poorly understood, from the late Neogene of Africa. The identification of these two taxa from the Middle Awash prompts an overdue review of fossil bovids from the sub-Saharan African record that demonstrate Eurasian affinities, including the reduncin *Kobus porrecticornis*, and species of *Tragoportax*. The fossil bovid record provides evidence for greater biological continuity between Africa and Eurasia in the late Miocene and earliest Pliocene than is found later in time. In contrast, the early Pliocene (after 5 Ma) saw the loss of any significant proportions of Eurasian-related taxa, and the continental dominance of African-endemic taxa and lineages, a pattern

that continues today." Also included is the article's conclusions: "The Ethiopian biogeographic realm appears to have had a distinct history of assembly through the Neogene, reflecting a pattern of ever-increasing isolation of African faunas since the late Miocene. The 'isolating barriers' of Wallace, defining the northern boundary of the Ethiopian realm, were in place by 7 Ma, though the geographic location of this boundary, and its permeability to African and Eurasian taxa, has changed over time. The presence of *Prostrepsiceros* cf. *vinayaki* and a possible caprin in the ASKM and KUSM, taken with the remainder of the bovid record reviewed above, highlights a greater rate of interchange of faunal elements between Eurasia and Africa in the late Miocene and up to around 5 Ma, than found later in time. The majority of the African Pliocene and Pleistocene record is exceptionally poor in Eurasian elements and an African-endemic fauna dominates. Of interest at this time is what appears to be a greater rate of faunal dispersal out of Africa than into it, documented also among other taxa. Throughout most of the last 7 million years, the Ethiopian realm covered the entirety of Africa and Arabia. The distinction of North Africa from Sub-Saharan Africa, and the delineation of the northern limits of the modern Ethiopian realm along the Saharo-Arabian desert belt, would come only in the late Pleistocene, presumably on account of increased sub-tropical aridification." A number of illustrations from the original paper are included." For the full paper and illustrations, it is recommended that the reader turn to the original article in PLoS ONE. For additional popular websites and more material on the distribution and history of African bovidae, the educator should search "fossil african antelopes" on the web.

Chiton–Protein Complex in Paleozoic Arthropods

A press release from Royal Holloway, University of London (http://www.rhul.ac.uk/research/news/newsarticles/powerfulmicroscoperevealschemicalstructureoffossils.aspx) on February 11, 2011, "Powerful microscope reveals chemical structure of fossils" describes the "surprising new research" that shows "contrary to conventional belief, remains of chiton-protein complex—structural materials containing protein and polysaccharide—are present in fossils of arthropods from the Palaeozoic era." Previously the oldest indication of chitin-protein complex was found in 25 million-year-old Cenozoic fossils, and remnants of structural protein have been discovered in 80 million-year-old Mesozoic fossils. The team of researchers led by George Cody of the Carnegie Institute for Science discovered the protein-complex relicts in fossil arthropods, a Pennsylvanian 310 million-year-old scorpion cuticle from northern Illinois and a Silurian 417 million-year-old eurypterid from Ontario. These arthropods have exoskeletons, or cuticles, the outer portions of which are made up of a composite of chitin fibers which are embedded in a matrix of protein. It was always thought that these materials would decompose with time and would never be found in Paleozoic fossils. Using a powerful microscope (scanning transmission X-ray microscopy) the researchers showed that the majority of carbon, nitrogen and oxygen found in these fossils were derived from a protein-chitin complex. Andrew C. Scott, Royal Holloway, University of London, one of the researchers said, "This research will aid our understanding of the fossilization process and this new technique allows us to reveal the chemical nature of the fossils without total destruction" and that "the vestigial protein complex may play a critical role in organic fossil preservation by providing a substrate protected from total degradation." The research was published in the journal *Geology*, volume 39, number 3, pages 255–258 (DOI: 10.1130/G31648.1) by GD Cody, NS Gupta, DEG Briggs, ALD Kilcoyne, RE Summons, F Kenig, RE Plotnick, AC Scott, "Molecular signature of chitin-protein complex in Paleozoic arthropods."

Plankton and the Earth's First Breathable Atmosphere

"Researchers studying the origin of earth's first breathable atmosphere have zeroed in on the major role played by some very unassuming creatures: plankton" is the opening statement of a press release from Ohio State University on February 21, 2011 (http://researchnews.osu.edu/archive/plankatmo.htm), "Plankton Key to Earth's First Breathable Atmosphere," written by Pam Frost Gorder. Matthew Saltzman, Ohio State University, and his colleagues show how plankton provided a critical link between the atmosphere and chemical isotopes stored in rocks 500 million years ago. This study is a continuation of previous work showing that upheavals in the earth's crust initiated a kind of reverse-greenhouse effect that cooled the world's oceans, spawned giant plankton blooms, and sent a burst of oxygen into the atmosphere. This new study goes further, detailing the events that caused oxygen to vanish from the Earth's ancient atmosphere during the Cambrian Period, only to return at higher levels than before. "Saltzman and his team were able to quantify how much oxygen was released into the atmosphere at the time, and directly link the amount of sulfur in the ancient oceans with atmospheric oxygen and carbon dioxide." He said, "We know that oxygen levels in the ocean dropped dramatically during the Cambrian, and that coincides with the time of global extinction…We still don't know why the anoxia spread all over the world. We may never know. But there have been many other extinction events in Earth's history, and with the exception of those

caused by meteor impacts, others likely share elements of this one—changes in the balance of oxygen and carbon dioxide in the atmosphere and the oceans." They suggest that plankton enabled oxygen to reenter the oceans and atmosphere. They say that during the Cambrian there was no life on land and except for trilobites, life in the ocean was not diverse. It has been proposed that what geologists call the Steptoean Positive Carbon Isotope Excursion (SPICE) was caused by the burial of huge quantities of organic matter in ocean sediments, which pulled carbon dioxide from the atmosphere and released oxygen. By studying isotopes in a variety of places around the world, the researchers determined that the SPICE event happened around the same time as an explosion of plankton diversity. The study, "Pulse of atmospheric oxygen during the late Cambrian," was published in the *Proceedings of the National Academy of Sciences*, volume 108 (10), 3876–3881 (DOI: 10.1073/pnas.1011836108). A portion of the abstract details that "A rise in atmospheric O_2 has been linked to the Cambrian explosion of life. For the plankton and animal radiation that began some 40 million years later and continued through much of the Ordovician (Great Ordovician Biodiversification Event), the search for an environmental trigger(s) has remained elusive. Here we present a carbon and sulfur isotope mass balance model for the latest Cambrian time interval spanning the globally recognized SPICE that indicates a major increase in atmospheric O_2. We estimate that this organic carbon and pyrite burial event added approximately 19×10^{18} moles of O_2 to the atmosphere (i.e., equal to change from an initial starting point for O_2 between 10–18% and a peak of 20–28% O_2) beginning at approximately 500 million years… Ecologically diverse plankton groups could provide new food sources for an animal biota expanding into progressively more ventilated marine habitats during the Ordovician, ultimately establishing complex ecosystems that are a hallmark of the Great Ordovician Biodiversification Event." The reader may also want to access the following related paper published in the journal *Nature*, "Geochemical evidence for widespread euxinia in the Later Cambrian ocean" by Benjamin C. Gill and others, volume 469, pages 80–83, January 6, 2011 (DOI: 10.1038/nature09700). "Widespread anoxia in the ocean is frequently invoked as a primary driver of mass extinction as well as a long-term inhibitor of evolutionary radiation on early Earth. In recent biogeochemical studies it has been hypothesized that oxygen deficiency was widespread in subsurface water masses of later Cambrian oceans, possibly influencing evolutionary events during this time. Physical evidence of widespread anoxia in Cambrian oceans has remained elusive and thus its potential relationship to the palaeontological record remains largely unexplored. Here, we present sulphur isotope records from six globally distributed stratigraphic sections of later Cambrian marine rocks (about 499 million years old). We find a positive sulphur isotope excursion in phase with the SPICE, a large and rapid excursion in the marine carbon isotope record, which is thought to be indicative of a global carbon cycle perturbation… These results identify the SPICE interval as the best characterized ocean anoxic event in the preMesozoic ocean and an extreme example of oxygen deficiency in the later Cambrian ocean. Thus, a redox structure similar to those in Proterozoic oceans may have persisted or returned in the oceans of the early Phanerozoic eon. Indeed, the environmental challenges presented by widespread anoxia may have been a prevalent if not dominant influence on animal evolution in Cambrian oceans."

Horse Teeth

A press release on March 3, 2011 from the New York Institute of Technology (http://www.nyit.edu/index.php/about_nyit/news-full/fossils_of_horse_teeth_indicate_you_are_what_you_eat_according_to_nycom_res/) describes research that agrees with "the long-standing theory that horses evolved through natural selection." Matthew Mihlbachler and Nikos Solounias of the New York College of Osteopathic Medicine (NYCOM), New York Institute of Medicine and their colleagues arrived at the conclusion after examining the teeth of 6,500 fossil horses representing 222 different populations of more than 70 extinct horse species. The records, spanning the past 55 million years, indicate a "critical" lag time between the evolution of horse teeth and dietary changes resulting from climate change. "One of the advantages of studying extinct creatures like prehistoric horses is we can look at how animals responded to their environments over millions of years—something that biologists who study living species cannot do," Mihlbachler said, adding that the biggest surprise of the study was that while some of the extinct populations they examined had extremely abrasive diets, much of the time, it seemed horses had it surprisingly easy." This suggests that "strong natural selection" for different types of teeth only happened occasionally during brief intervals in horse history. Solounias helped develop a methodology known as dental mesowear analysis to reconstruct the diets of extinct species by measuring food-related wear and tear on fossil teeth. He and Mihlbachler used the process to investigate wear patterns on the molars of thousands of fossil horses. They later analyzed their data alongside records of North American climate changes that would have shifted the animals' diets from rainforest fruits and woody, leafy vegetation to the more abrasive diets found in grasslands. "Lag time in the evolution of horse teeth in comparison to dietary changes is critical,"

Mihlbachler explained. "We found that evolutionary changes in tooth anatomy lag behind the dietary changes by a million years or more." While paleontologists have long held horses as classic examples of evolution through natural selection, the theory has been difficult to test because the majority of horse species are extinct. However, Mihlbachler and Solounias' observation that dental changes in horses follow their dietary changes is consistent with evolution due to adaptation. "'You are what you eat,' we hear this all the time, but now we know it is true," explained Thomas Scandalis, dean of NYCOM. "This study shows that the evolutionary path of horses as we know them today was affected by the food available to their prehistoric ancestors." The research shows that not only has the number of horse species been greatly reduced in the past few million years, but also that the diets of horses have been narrowly restricted. "Living horses are anything but typical examples of the dietary ecology of this once great group of mammals," Solounias said. The study was published in the journal *Science*, volume 331, number 6021, pages 1178–1181 (DOI: 10.1126/sci ence.1196166): "Dietary Change and Evolution of Horses in North America," by Matthew C. Mihlbachler, Florent Rivals, Nikos Solounias, and Gina M. Semprebon. Included here is the abstract of their paper: "The evolution of high-crowned molars among horses (Family Equidae) is thought to be an adaptation for abrasive diets associated with the spread of grasslands. The sharpness and relief of the worn cusp apices of teeth (mesowear) are a measure of dietary abrasion. We collected mesowear data for North American Equidae for the past 55.5 million years to test the association of molar height and dietary abrasion. Mesowear trends in horses are reflective of global cooling and associated vegetation changes. There is a strong correlation between mesowear and crown height in horses; however, most horse paleopopulations had highly variable amounts of dietary abrasion, suggesting that selective pressures for crown height may have been weak much of the time. However, instances of higher abrasion were observed in some paleopopulations, suggesting intervals of stronger selection for the evolution of dentitions, including the early Miocene shortly before the first appearance of Equinae, the horse subfamily in which high-crowned dentitions evolved."