

M.K. Brett-Surman
Department of Geology
Division of Geobiology
George Washington University
Washington, D.C. 20052

DINOSAUR EXTINCTION

Dinosaurs were the most spectacular creatures that ever inhabited the Earth. They were the longest, tallest, heaviest, fastest, fiercest, and most advanced terrestrial animals in their time. They ruled the Earth from 200 million years ago until 65 million years ago - a time longer than any other land animals and all this despite the fact that none of them could fly and none of them lived in the water. Considering how popular they are, one would suspect that many people would study them as a profession yet there are only about 25 paleontologists in the world who might rightly be called professional Dinosaur Specialists. Unfortunately, about 99% of all the popular dinosaur books are written by non-specialists who are unfamiliar with the science of paleontology, consequently most of what is written is largely outdated and often inaccurate. The problem for the layman is compounded by a vast number of movies where dinosaurs are seen attacking animals they never knew in real life while performing anatomically impossible feats. Because of this chain of events, dinosaurs are the most misunderstood animals of all time and their extinction is the greatest mystery in paleontology.

Before one can understand dinosaur extinction, one must

first understand extinction itself. All species go extinct sooner or later - NO EXCEPTIONS. Extinction is the rule. Not even humans are exempt. There are many ways to go extinct. The most common ways are by over predation and competition with "superior" species. (In life, "superior" is always a relative term based on the current environmental conditions and random events.) A species may also have its habitat disappear. Even the most advanced animal in the jungle couldn't live if it was suddenly thrown into the desert. The only way to go extinct and still leave something behind is to evolve into something else. The smaller meat-eating dinosaurs of the Jurassic Period did this by evolving into BIRDS.

One must also consider the problem of GEOLOGIC time. Suppose the entire history of the Earth was reduced down to a span of one month. Dinosaurs would not appear until the twenty-second day and then disappear on the twenty-fifth day. The entire process of their extinction would only last for ONE HOUR. Homo sapiens would only appear a minute or two before midnight on the last day. This is a crucial point. Dinosaur extinction appears to be instantaneous but this is only an artifact of time resolution over many millions of years. The time it took for the dinosaurs to go extinct was 60 times longer than the entire history of our species! Man as we know him today has only been around for less than 100,000 years. The dinosaurs slowly died out over a period of 6 MILLION years.

It seems that everyone has tried to explain the death of the dinosaurs whether or not they are paleontologists. Some of

the more colorful theories call for the dinosaurs to be carried away to the galactic zoo by extraterrestrials or that locusts ate all the plants. Others say the dinosaurs became so big that they all suffered from back problems and it became too painful to mate, or that their genes became too old and they all went senile. One theory has them all cooked by the radiation from a supernova. We do know that at the end of the Mesozoic (the age of reptiles) the angiosperms (flowering plants) made their appearance and gradually replaced the then dominant gymnosperms (seed plants). This has resulted in still more theories calling for the dinosaurs to die from allergies, constipation from eating the new angiosperms, and thinner eggs as a result of ingesting the tannic acids found in angiosperms. Two of the more credible theories stated that mammals ate all the dinosaurs eggs and that an appreciable decrease in the average world temperature caused the dinosaur's habitat to become too cold to support them. The first theory has merit in that some mammals surely ate dinosaur eggs when available but the mammals and the dinosaurs appeared together in the upper Triassic period (200 million years ago). They coexisted for over 135 million years without any evidence that the dinosaurs were adversely effected by this. The second theory is partly based on fact in that there was a decrease in world temperature down to about 27°C, but this still made the coldest day in the latest Mesozoic warmer than most days today. During the age of dinosaurs, there were no polar caps and coal swamps were present in Canada. The most recent, and regretably the most popular, theory current is the "asteroid theory". This

postulates that a large asteroid struck the Earth and injected billions of tons of dust into the atmosphere blocking out the sun and creating a night that lasted for several months. This theory was seized upon by the popular press because it is spectacular and because a nobel laureat (but not a paleontologist) proposed it. This theory fails to explain why such sensitive groups, such as birds and plants, were largely unaffected by the lack of daytime and why only certain groups of terrestrial animals in specific environments were affected and others were not. Any theory about dinosaur extinction must explain the extreme selectivity of the mass extinctions. Only FULLY TERRESTRIAL large vertebrates and shallow marine invertebrates suffered a major decline in the number of species. Other groups of large marine vertebrates such as the plesiosaurs and ichthyosaurs were already extinct before the dinosaurs went extinct. Some environments such as fresh water aquatic communities show little change. Most theories are based on the great dinosaur sequences of rocks of the western United States. A good theory must account for all the dinosaurs all over the world, especially those in the greatest refuge of all - the tropics.

What we do know, is that when the end came, about 65 million years ago, the Earth was very different from the world we know today. Large inland seas covered many of the continents. The western part of North America was attached to the eastern part of Asia in a land mass known as BERINGIA (after the Bering Straits). The eastern part of North America was connected to Europe and was called Euramerica. Beringia and Euramerica were

the two continents that made up the northern hemisphere supercontinent of Laurasia. Each continent was bordered by a seaway which today is occupied by the Ural mountains in Russia and the Rocky mountains in America. Over a period of 6 to 8 million years, the seas drained from the continents resulting a wider fluctuation of temperatures. The flowering plants achieved full dominance over the gymnosperms and in response to this, the animal faunas gradually changed. These changes proceeded from north to south following the retreating shoreline. The dinosaurs gradually decreased in diversity until at the end, there were only about 4 genera remaining - **Tyrannosaurus**, **Triceratops**, **Edmontosaurus**, and possibly **Hypacrosaurus** (a relative of **Nipponosaurus**, the Japanese duck-bill dinosaur). Except for birds, and a few species of mammals, dinosaurs were structurally and physiologically the most advanced terrestrial animals alive. If they were so efficient, why did they decline for millions of years instead of diversifying? There is a possible answer based for the present on theories yet to be tested. I propose it here for the first time.

A comprehensive extinction theory must explain the end of the dinosaurs in ALL environments ALL over the world. It must include mechanisms that operated for several millions of years and that only affected certain groups of organisms. This eliminates physical factors such as extraterrestrial causes because they would effect all species on land and be relatively instantaneous. The extinctions at the end of the Mesozoic were highly selective both taxonomically and ecologically and

gradually built up over time. This almost certainly implies a biological cause operating on a closed community of species where the number of species in any one trophic level is relatively well below that of an open community.

Dinosaurs, as reptiles, are subject to stereotyped behavior - that is, behavior which is highly genetically programmed and not subject to modification by learning experiences or parental teachings. For example, lizards outside their burrows, when confronted by humans, will respond with a territorial threat display exactly in the same manner as if the human were another lizard trespassing on its property. Some species of mammals eat only certain foods at specific times of the year. If these foods are removed during the appropriate interval and other foods substituted that are perfectly good for the animal, the animal will in some cases starve to death because at that particular time in its life cycle, it does not recognize the food as food. Any species that goes extinct due to lack of behavioral flexibility has succumbed to what I shall call LAWSONIAN EXTINCTION (named after Douglas Lawson, discoverer of Quetzalcoatlus). This is only one of three facets of this theory however.

The few remaining dinosaurs during the last eight million years were all large as adults. If they grew in the same manner as crocodiles, each individual dinosaur may have lived to be 200 years old. They may have undergone what I call NICHE ASSIMILATION. This can be seen in the Nile Crocodile today as reported by Hugh Cott. As juveniles, they are too small to

attack adult animals and they must hide from other adults of their own species in order to avoid being eaten, consequently they start out life in the trees eating insects. When they get older and larger, they move to areas away from the adults and become fish-eaters. Only when they near adult size do they compete as full fledged hunters. A similar community of mammals would have three species occupying these three niches but in this particular community, one species is occupying three niches. This almost certainly happened with the dinosaurs. Instead of a multitude of specialized species for each niche, the longlived dinosaurs occupied several niches as they grew up thus reducing the number of species in the biological community. This would result in a more fragile food web in the trophic structure as the loss of one species would effect numerous niches. It is also harder for larger animals to speciate into new adaptive zones because their size prevents them from becoming fossorial or arboreal and their size also requires, on an absolute scale, a much larger food supply. This is an aspect of a famous evolutionary hypothesis known as COPE'S RULE which states that over geologic time, species in a single lineage get larger.

The third facet has to do with the competition between angiosperms (flowering plants) and gymnosperms (seed plants). At the end of the Mesozoic, angiosperms gradually replaced gymnosperms because of their greater efficiency, especially in reproduction and the ability to repair damage caused by herbivores. A scientist at Yale University has compared this to the competition between Japanese cars ("angiosperms") and

American cars ("gymnosperms"). Although the rise of the angiosperms may have directly caused the successful radiation of the ceratopsians (horned dinosaurs) and the hadrosaurs (duckbill dinosaurs), it may also have led to their eventual downfall. As the gymnosperms gradually decreased in number and variety at the end of the Mesozoic relative to the angiosperms, the number of possible food sources for the herbivorous dinosaurs would also diminish. The dinosaurs may not have recognized the newer angiosperms as food especially if they were widely spaced and not of great size or if they bloomed only during precise and short periods during the year. Let us now put all these facts together.

At the end of the Cretaceous period, 65 million years ago, temperatures began to fluctuate more widely as the large inland seas drained from the continents. As the shorelines of the seas decreased in extent, so did the habitable area of the communities that lived and depended on the geography of those areas. The numbers of dinosaur species continued to decline because of Niche Assimilation, lower speciation rates because of their large size and longevity as adults, and their stereotypic behavior which did not allow them to adapt rapidly enough as a species to changing floras. The speciation rate of the angiosperms may have exceeded the speciation rate of the dinosaurs. If the plants were disappearing faster than the dinosaurs could adapt, then the dinosaurs would become victims of Lawsonian Extinction. In a closed community, the meat-eating dinosaurs would then go extinct as soon as the plant-eating

dinosaurs they fed on went extinct. This is what we see in the fossil record. At the end there were only two dinosaurs, Tyrannosaurus and Triceratops. The problem would be exaggerated if the food source was composed mostly of gymnosperms which were undergoing a relative reduction compared to the angiosperms. The last dinosaurs were all large so they would need a large food source. Tyrannosaurus was too large to feed on anything except other dinosaurs as an adult of reproductive age. Triceratops was also too large as a reproducing adult to feed on anything except the larger trees which were all gymnosperms. Such a closed community with few species in a minimum of trophic levels would be highly susceptible to extinction in the event of any major ecological change. Each facet by itself may not have been enough to cause the extinction of any group of dinosaurs but put them all together at the same time and the result changed the world forever.

The name DINOSAUR has regretablely become associated with the word EXTINCTION. As the most highly evolved reptiles and the longest lived group of terrestrial vertebrates, they should instead be associated with the word SUCCESS!