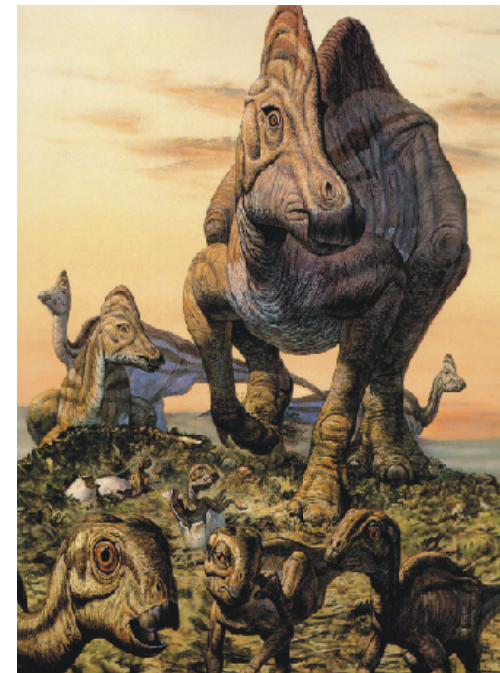
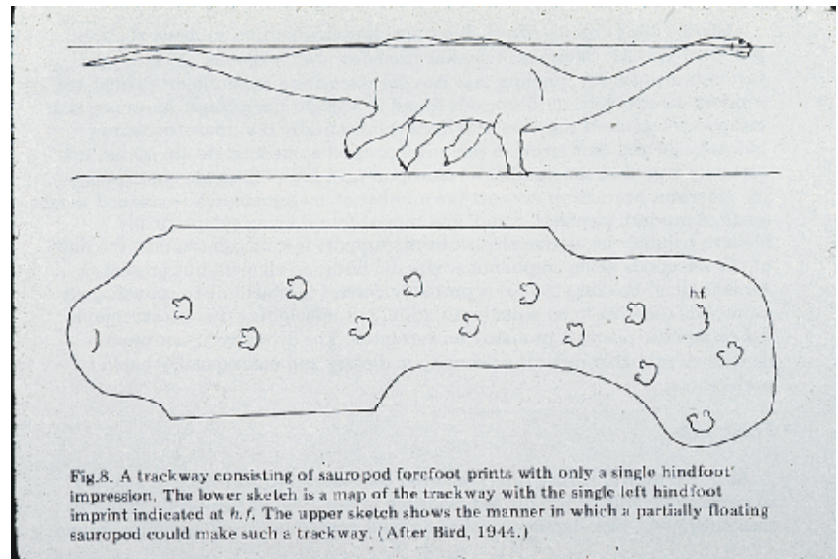


# Dinosaurs in Fact and Fiction



What do we really know about them  
and  
why were they so successful?



Why were dinosaurs successful when mammals just remained as small inconsequential nocturnal animals?

A case study of science gone bad:  
Media sycophant Robert Bakker



Ca. 1967 Robert Bakker decided that there must be some fundamental aspect of dinosaurs that gave them a competitive edge over mammals!

*‘Mammals are successful because they are warm-blooded.  
Therefore, there is only one possible solution to this puzzle.’*

*Dinosaurs were warm-blooded like mammals!!!*

*‘How do I prove that dinosaurs were warm-blooded? What  
similarities can I find between dinosaurs and mammals?  
Such similarities must show similar metabolism.’*

## POSTURE



sprawling condition



semi-improved condition



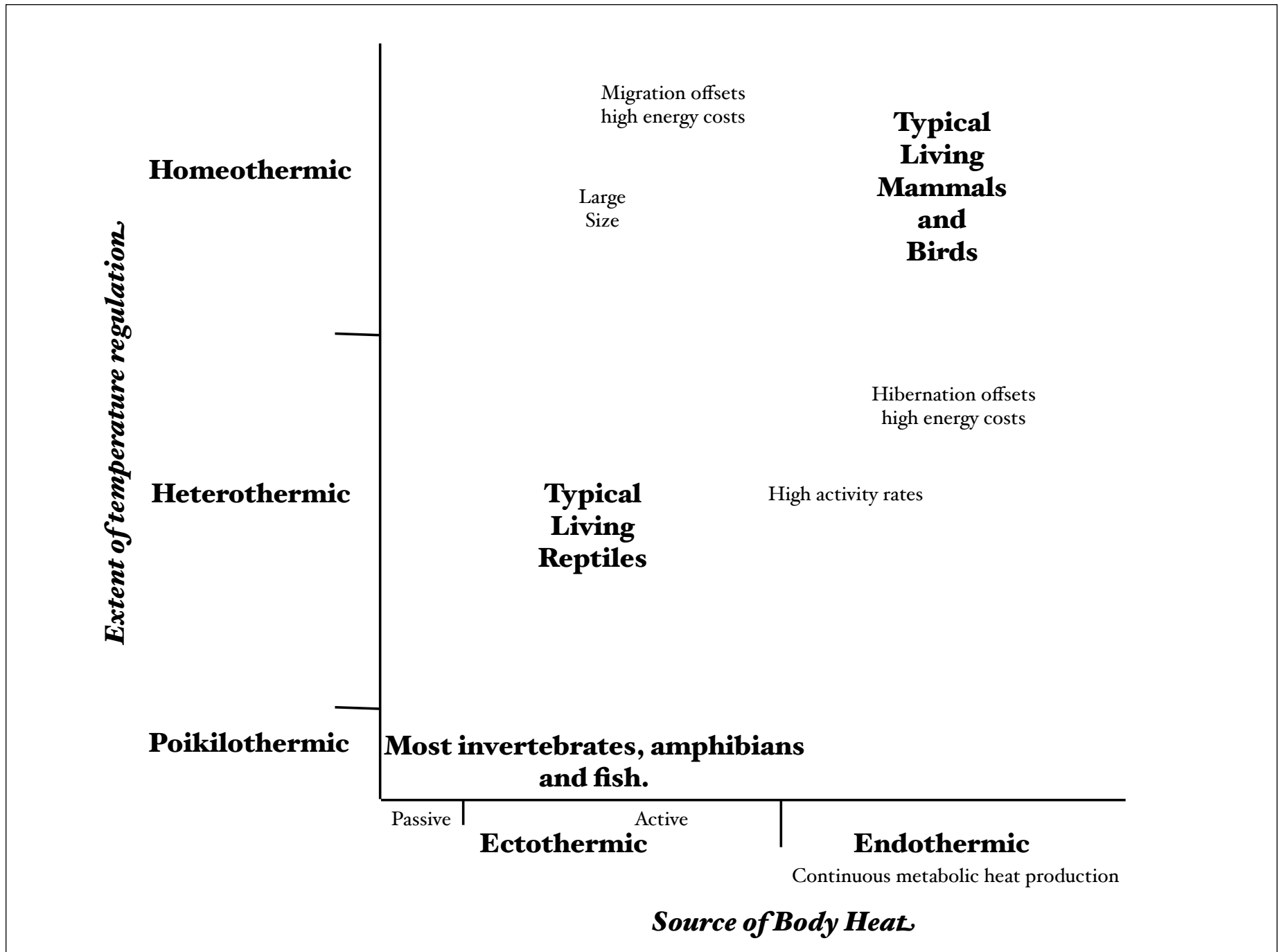
fully improved condition

A comparison between modern mammals and modern reptiles shows that there is a big difference in posture. *“Mammals have ‘upright’ postures but reptiles (turtles, crocs and lizards) have a sprawling gait. Therefore ‘uprightness’ is an indicator of ‘warm bloodedness’.”*

Bakker proceeded to look at a large number of dinosaurs and ‘discovered’ that most dinosaurs were ‘incorrectly restored and really had totally upright postures’!!!!

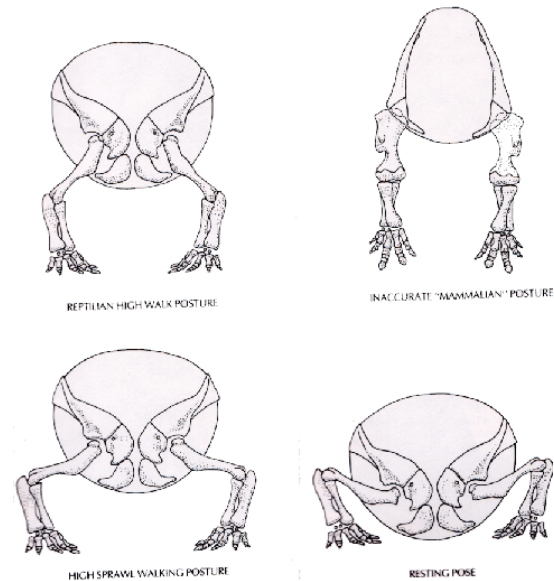
*THEREFORE, DINOSAURS WERE WARM-BLOODED LIKE MAMMALS*

He also postulated that their activity levels were like mammals - not slow and lethargic but rapid running!!!



## PROBLEMS WITH POSTURE

- Did Bakker correctly restore the postures or is his work more wishful thinking than anything else?
- Do physiologists know of a causal link between posture and metabolism?



Physiologists know of no causal link. Bakker's own experiments, which were never published except in an obscure abstract, showed that a mammal and a reptile of similar size running consumed the same amount of oxygen.

Trackways and other calculations of maximum speeds show that large dinosaurs were indeed slow movers. Only small dinosaurs are seen running at high speed in trackways.

This line of investigation turned sterile and had the effect of making Bakker well known and causing some to begin to be suspicious of his 'brand' of science. His studies, though, renewed interest in the biology of dinosaurs and led to our current interpretation of sauropods as dominantly terrestrial animals.

One of the great disservices was that it led to the proliferation of illustrations of dinosaurs in impossible positions with impossible postures.

Also, researchers began to notice that Bakker paid no attention to serious scientific criticism of his work - he continued to put forward the posture case as though it were proved beyond doubt! This pattern persisted and persists.

# Fallacy

- In philosophy a fallacy is an argument involving an invalid form of reasoning.
- Bakker seems to be guilty of a basic logical fallacy: *Post Hoc, Ergo Propter Hoc* - 'after this, therefore because of this'

Premise 1 - Last night I drank red wine

Premise 2 - This morning I had a headache

Conclusion - Therefore, the wine caused the headache

## TROPHIC PYRAMID AND PREDATOR/PREY RATIO

Stymied by the posture gambit, Bakker came up with hypothesis #2. *'There should be big differences between the trophic pyramid of a community of ectotherms versus a community of endotherms and that such differences should be preserved in the fossil record.'*

*'Endothermic carnivores must eat more frequently than ectothermic carnivores. Therefore, there should be fewer herbivores to carnivores in an ectothermic community and more herbivores to carnivores in an endotherm community.'*

In other words, ectothermic communities should have high predator/prey ratios and endotherms should have a low ratio.

Few carnivores

Few carnivores

Many herbivores

Few herbivores

Endothermic

Ectothermic

Bakker looked at the existing literature on numbers of animals in African populations and calculated the predator/prey ratio. He got between 2% and 5%.

He looked at the single existing study of an ectothermic community - spiders and flies. The ratio was 50%!

*'One could tell ectothermic from endothermi communities!!'*

Bakker now poured through the literature, went to many collections and looked at field notes and eventually produced incredibly detailed counts of various dinosaur faunas with numbers of carnivores and herbivores.

His results indicated that most dinosaur predator/prey ratios were 2% to 5% - just the number for modern mammal populations - how handy!

*Therefore - dinosaurs were endothermic!!!!*

# PROBLEMS WITH PREDATOR/PREY RATIO

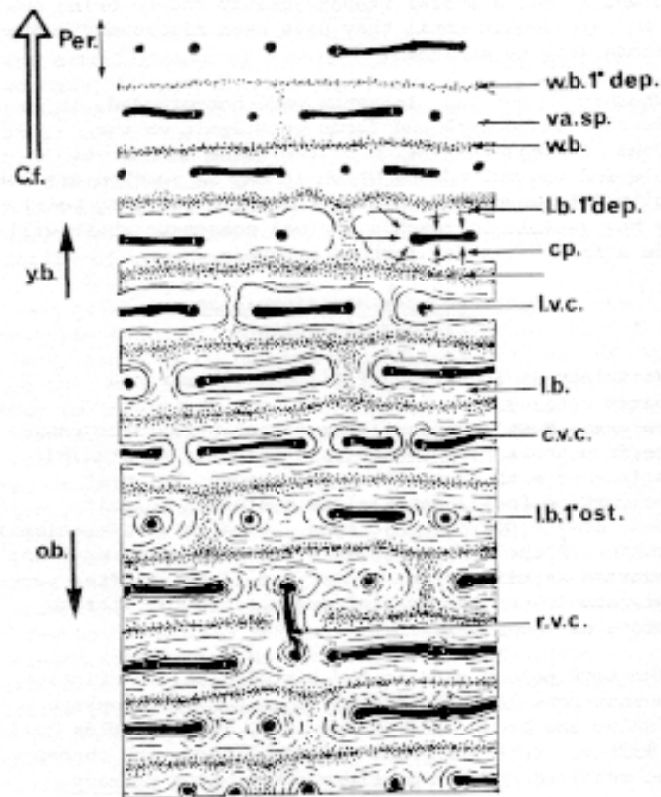
- No modern biologists had ever demonstrated a causal relationship between ratios of trophic levels and metabolism of the animals involved. In fact, when physiologists and ecologists looked into the matter they could not even really postulate a meaningful relationship.
- How reliable is Bakker's data? It is 2008 and he has continued to refuse to release the actual data (published in the early '70s).
  - ◆ Fossil preservation is biased.
  - ◆ Museum collections are imperfect and biased.
  - ◆ Paleontological collections are biased.
  - ◆ Bakker mentioned to friends he was modifying the data - like doubling the number of herbivores he found.
  - ◆ No subsequent workers can reproduce his 'data'.
- Subsequent study shows 2% ratio for population of monitor lizards - 'Komodo Dragon'.

## BONE HISTOLOGY - Gambit #3

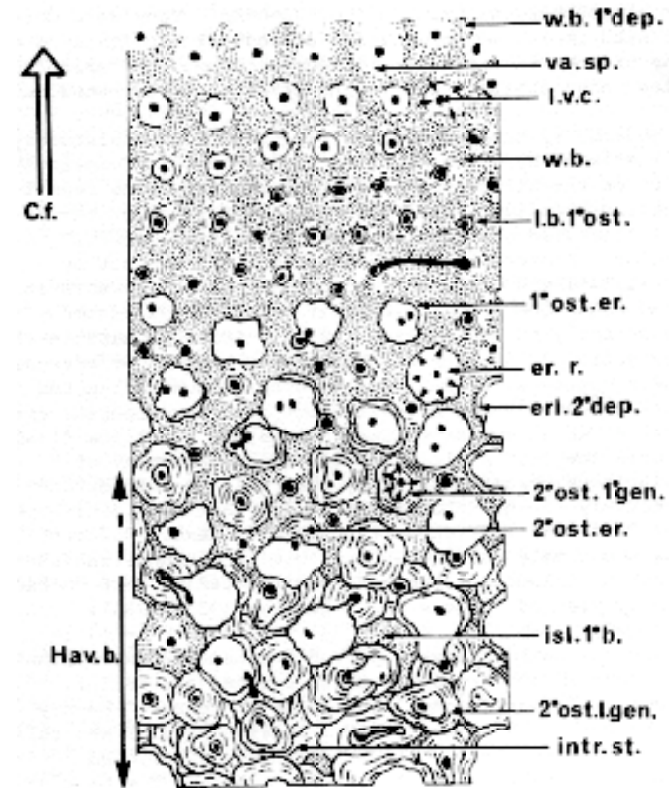
With the scientific community rejecting his latest hypothesis Bakker began to search for another (again, never acknowledging the criticism of his first two theories).

About this time Dr. Armand deRocquès was visiting Harvard from Paris. He was doing pioneer work on the histology of ancient bony tissues (first started by some Texas histologists back in the 1940s but never pursued).

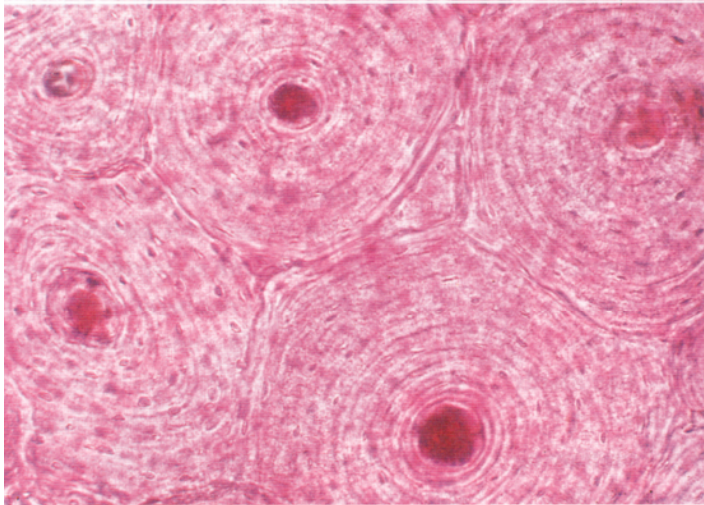
In his talks, deRocquès noted that there were some interesting differences in the histology of vertebrate bones, including what appeared to be strange differences and similarities between mammal and dinosaur bone.



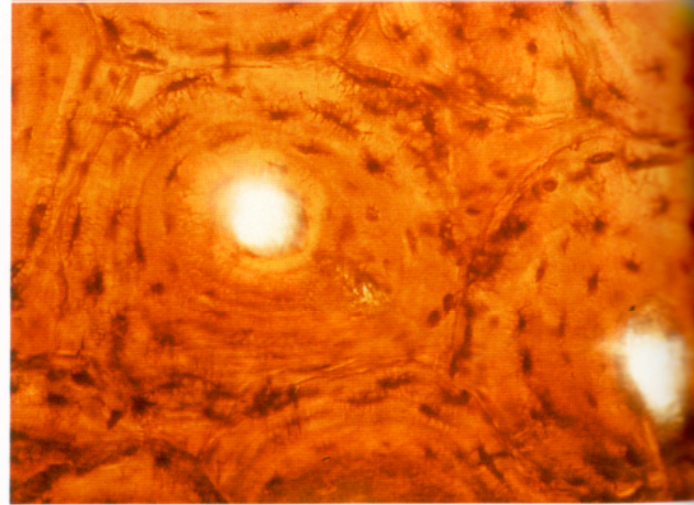
Primary bone



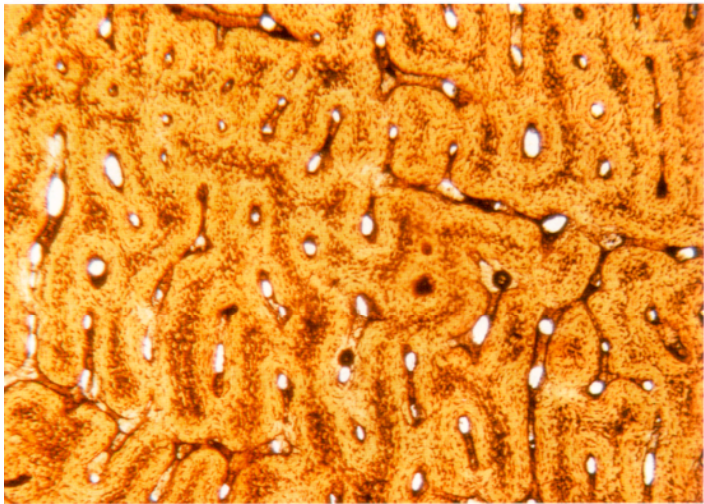
Secondary bone  
(haversian)



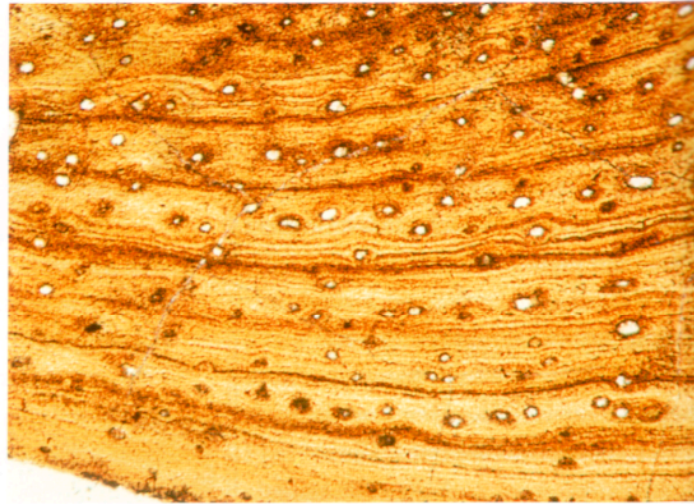
NEAR THE BONE. Haversian bone has many blood vessels with dense bony rings around them. Today's large warm-blooded mammals have this type of bone. This section is from the rib of a horse.



Some dinosaurs also had Haversian bone. This section of a *Baryonyx* rib shows the same bony ring structure as the horse. Does this mean that dinosaurs with Haversian bone were warm-blooded?



Dinosaurs, birds and mammals all have similar primary bone with many blood vessels. This type of bone, called fibro-lamellar bone (shown here from a sauropod limb bone), is the first to be formed during rapid growth.



Modern cold-blooded reptiles show growth rings in their bones indicating that they grow at different rates. But some dinosaurs, as in this iguanodont limb bone, also show this feature.

Bakker lifted deRicqlès' work and published it before deRicqlès had a chance, taking credit for the work and postulating that the possession of Haversian tissue by both mammals and dinosaurs was a clear indicator of the presence of endothermy.

However, he had neglected to pay close attention to what Armand was saying about why he thought the patterns were different!

Bakker also neglected to listen to deRicqlès when deRicqlès noted that his collections were still very incomplete and he could not be sure about the real distribution of the bone types.

# PROBLEMS WITH BONE HISTOLOGY

- No modern biologist has demonstrated a causal relationship between bone histology and type of metabolism in a vertebrate. There is no reason why endothermy should require haversian tissue.
- Haversian tissue isn't present in the smallest mammals that have the highest levels of endothermy, bats and rodents.
- Haversian tissue isn't present in all dinosaur bones and is present in some bones in large modern reptiles (turtles and crocs).
- deRicqlès suggested that Haversian tissue might be related to body size (characteristic fracture rate) - Bakker paid no attention to this. Now it looks like deRicqlès was mostly correct and that haversian tissue is also very much related to rapid growth rates.

Subsequent to the rejection of bone histology gambit, Bakker did not come up with other ideas. Instead, he continues to trumpet his original three ideas in any public forum (usually TV dinosaur specials) paying no attention to scientific disapproval of his ideas.

A consultant now - did not get tenure at John's Hopkins for many reasons including stealing from his graduate students and shoddy scholarship. He does make a bundle and has made a great impact on the public image of paleontology - unfortunately it is a bad impact.

However, what he did do was to fuel a resurgence in interest about dinosaurs that continues 30 years later.

## Other Endothermic Problems

Heat problems with modern reptiles in tropics.

Modern ectothermic large reptiles have a problem dumping heat - much less generating additional amounts! A *Komodo Dragon* spends hours a day in the shade panting to dump heat! The problem of surface to volume ratio!

Modeling heat flow in an 'endothermic' sauropod suggests impossible core temperatures in the vicinity of boiling water! Suggests that large dinosaurs must have actually had physiological and anatomical features to help dissipate heat (air sac system of sauropods or similar structures)

Jim Farlow's work on 'eating time'.

Modeling the physiology of sauropods as either endotherm or ectothermic resulted in an interesting result. An endothermic sauropod would have to eat 22 hours a day! An ectothermic sauropod would have had to eat about 14 hours day - similar to how long elephants feed.

# Current view of Dinosaur Physiology

- Dinosaurs had unique physiological adaptations that made them different from modern reptiles, mammals and birds.
- For the most part dinosaurs lived in a time with warm, constant temperatures over the year. Large dinosaurs had to develop heat dissipation adaptations. They were homiothermic ectotherms.
- Small dinosaurs and/or juvenile dinosaurs had rapid growth rates and could move rapidly. This changed as they grew older.

# Current View of Dinosaur Success

- The current view of dinosaur success in the late Triassic suggests that Bakker's initial question might be malformed at its root
- Dinosaurs did not competitively 'subdue' mammals or other large archosaurs in the late Triassic. They were lucky enough to survive a major extinction that wiped out most other archosaurs and surviving cynodont synapsids