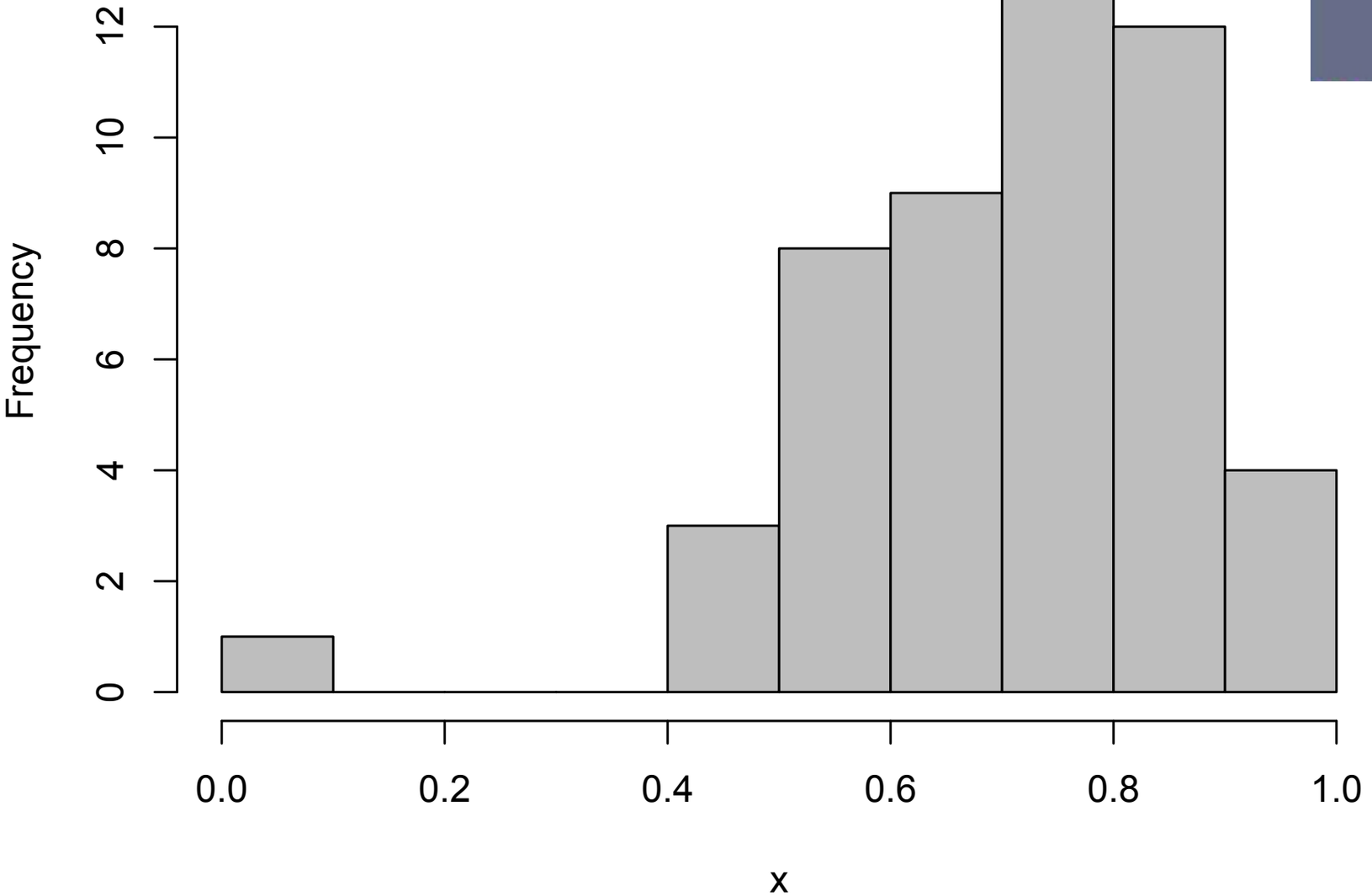
# Exam 2 Grades





Office hours:
Thursday 2-4
(instead of today)

Mean: 71.6%


# Section:

# Get back paper abstracts

✔ Start researching your topic
✗ Rewrite thesis; due in class on Friday, March 18th

Research paper:
4 pages, double spaced
5th page will be references
Due April 25th in section
Detailed instructions will be posted on website by end of week

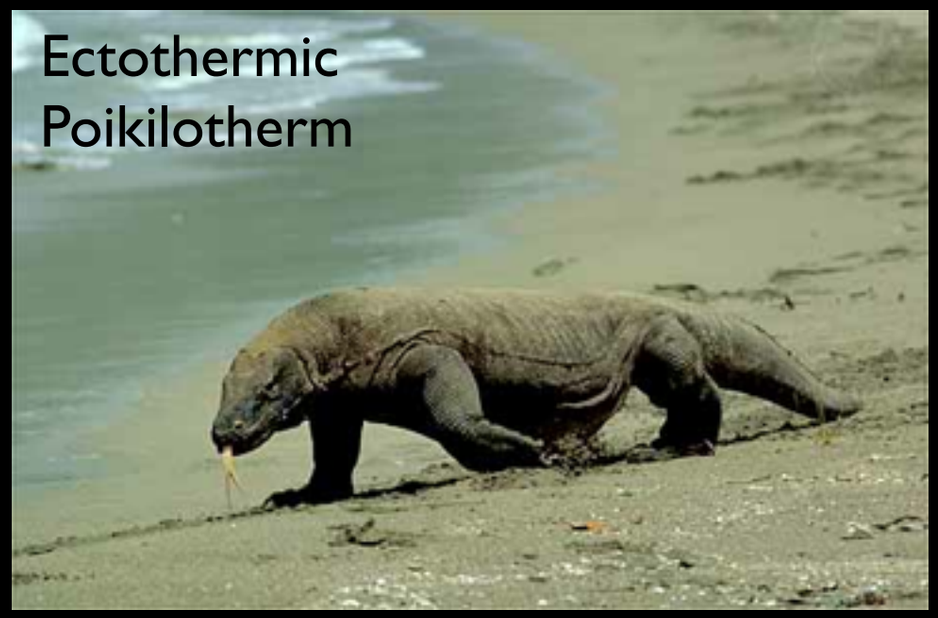
## Some Terminology... all animals regulate temperature; it's just a matter of HOW

Ectotherms = animals whose temperature is regulated by external temperature
Endotherms = Animals whose temperature is not regulated by external temperature

EITHER/OR

Poikilotherms = Animals whose temperatures fluctuate
Homeotherms = Animals whose temperatures are constant

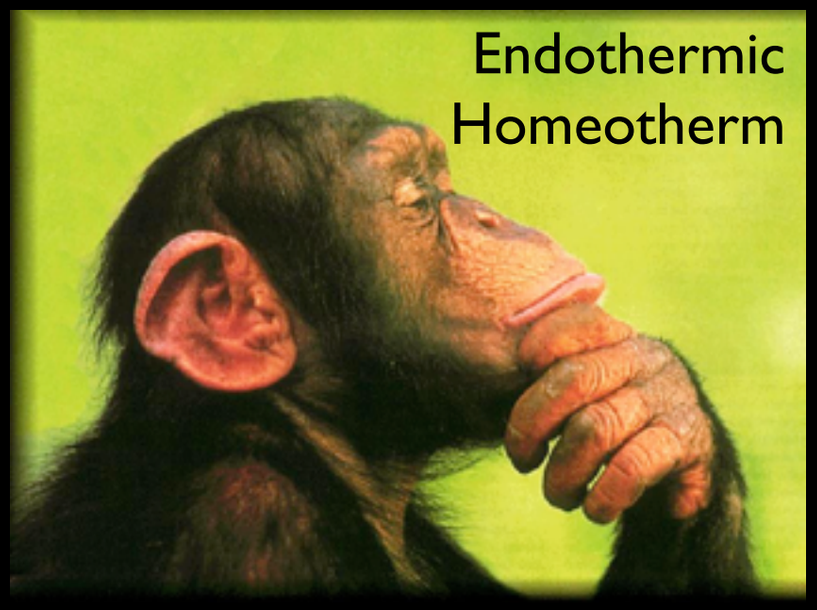
SPECTRUM




Ectothermic Homeotherm

Endothermic Poikilotherm

<u>FUNCTIONALLY</u>
homeothermic




# Dinosaur Metabolism: The evidence

1) Anatomy
2) Diet
3) Hearts
4) Brains
5) Bone Histology
6) Growth and LAGS
7) Plumage
8) Ecology / Zoogeography
9) Chemistry
10) Noses

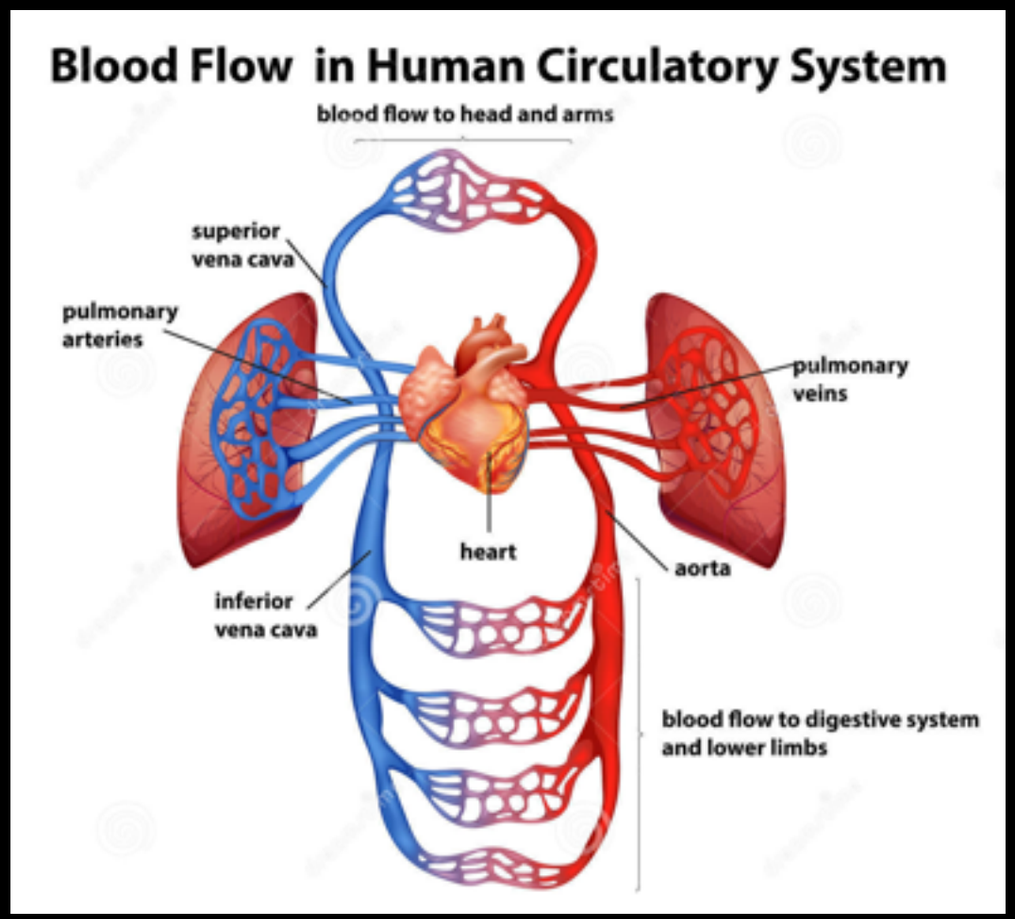
# Dinosaur Metabolism: The evidence

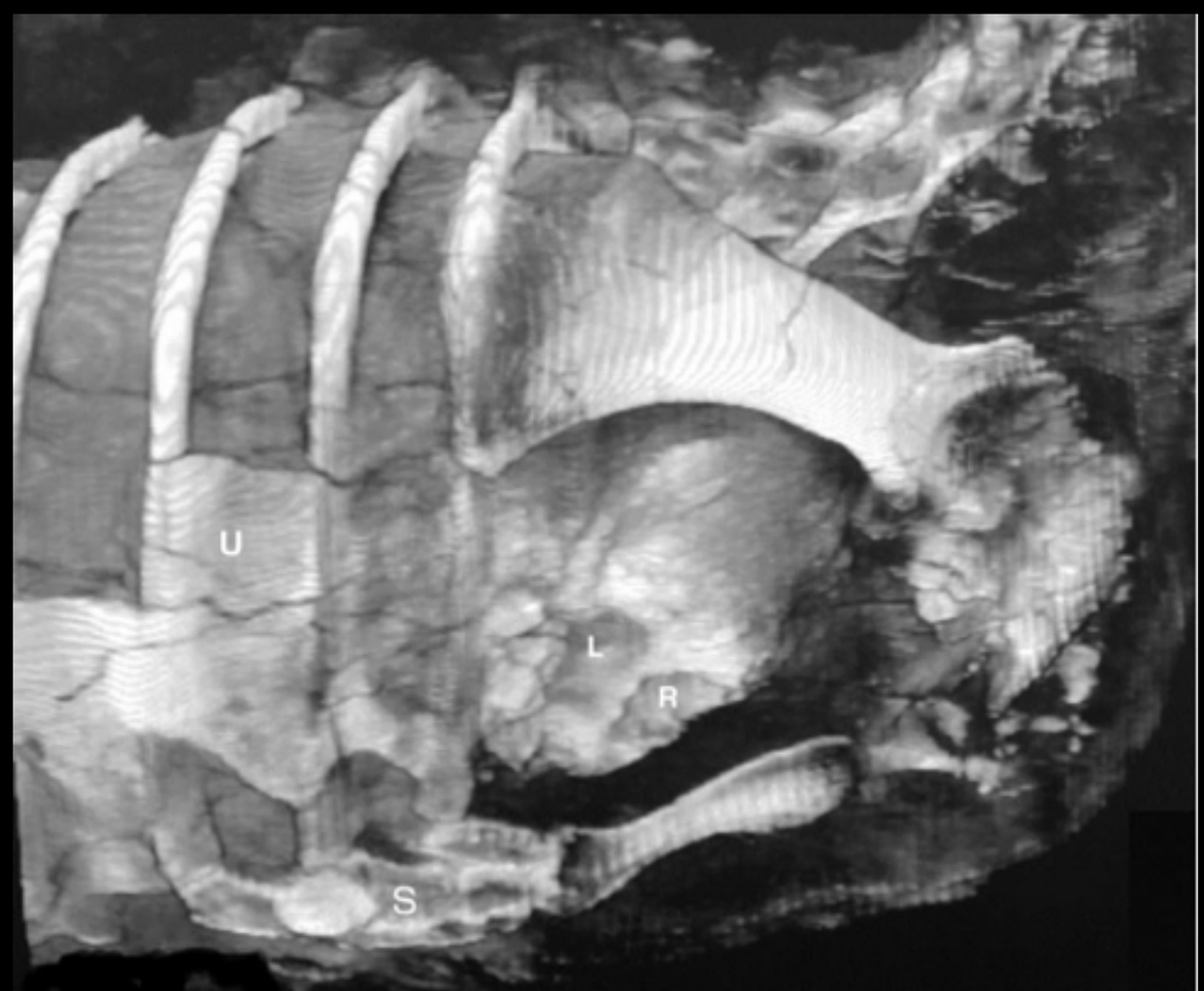
3) Hearts

1) All endotherms have a 4 chambered heart (prerequisite?)
   Endothermy require high blood pressure to infuse tissues with O2
   But, this would destroy lung tissue
   So you isolate blood flow to lungs from blood flow to body = 4 chambered

   Sauropods (requirement?)
   Crocs and birds have it => phylogenetically reasonable

## Heart Stone Brewhaha (2000)

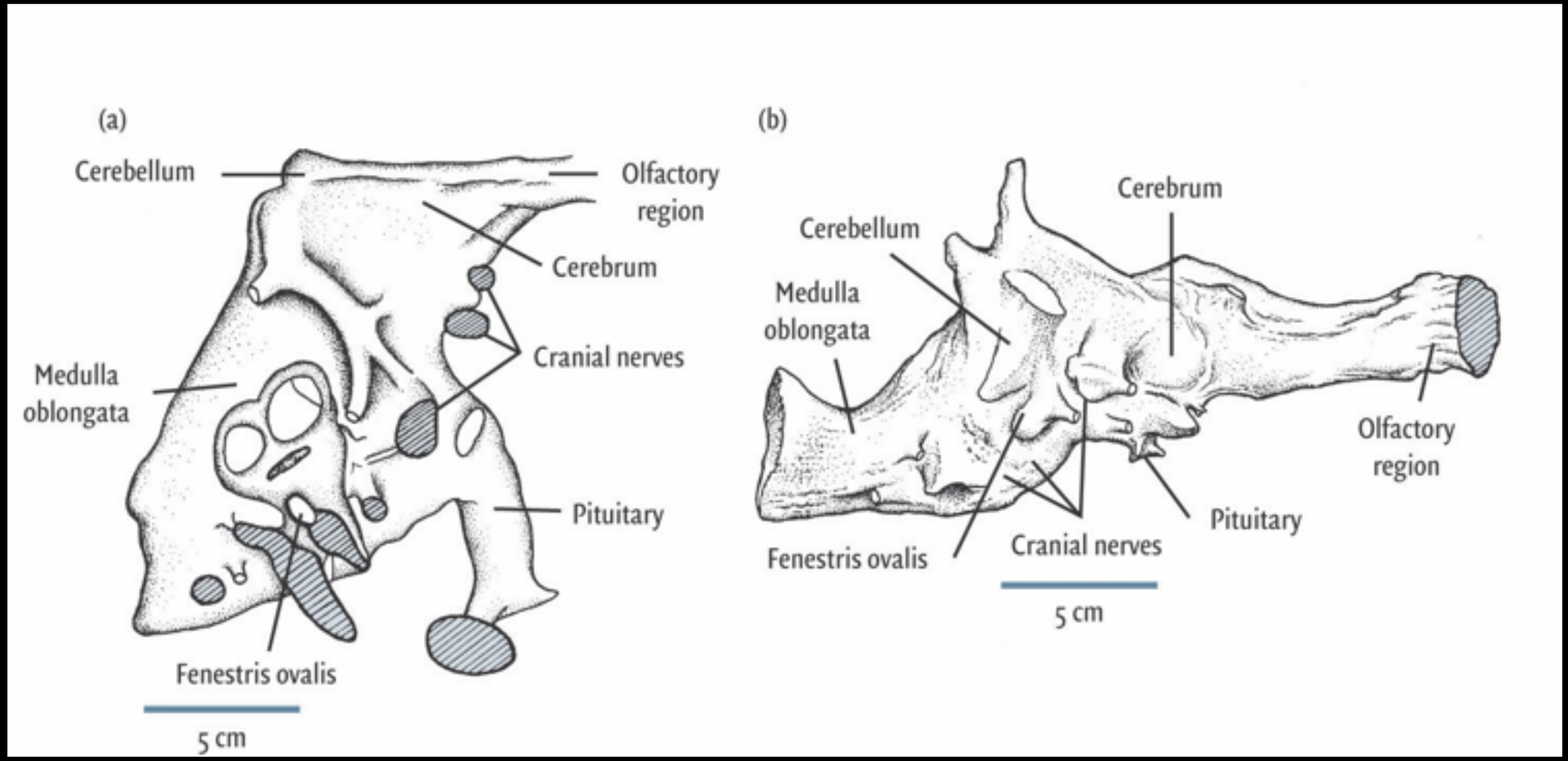


# Dinosaur Metabolism: The evidence

4) Brains

1) Some people think brain size is indicative of total activity level
   Some dinos have a high EQ... suggesting higher activity? Does that indicate endothermy?
2) Upright stance (in some dinos) might indicate high neuromuscular control



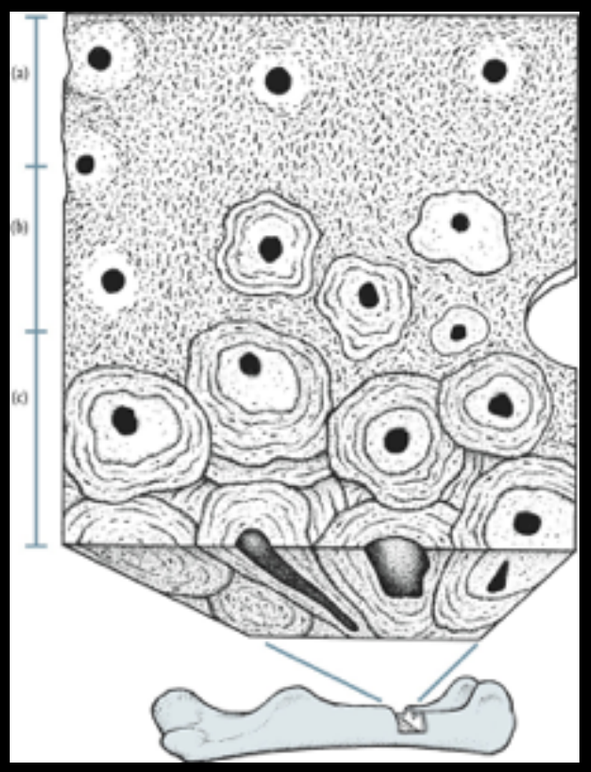
# Dinosaur Metabolism: The evidence

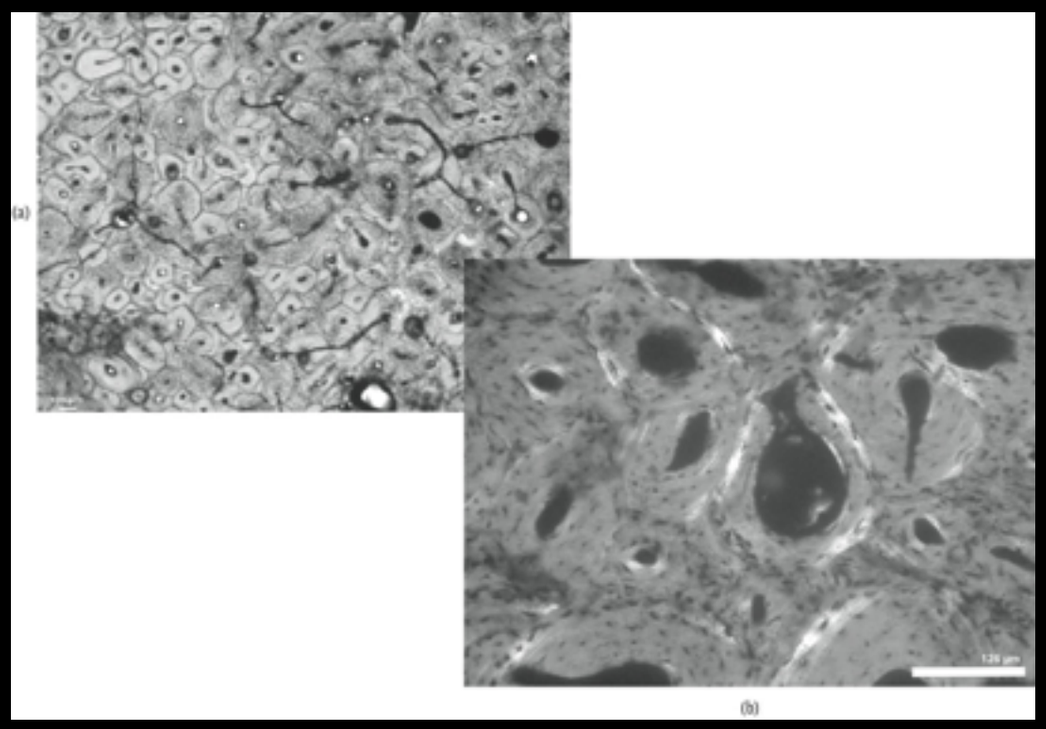
## 5) Bone histology

1) Bone remodels over time, forms Dense Haversian Bone (DHB)
   Large degree of remodeling may imply endothermy ~ Large amount of DHB
2) It's true that bone replacement is related to metabolism
   But this may or may not be reflected in the DHB

3) IF DHB formed similarly in Dinos as it does mammals, it is in agreement with Endothermy

Dino DHB certainly different than reptiles (both modern and fossil)



# Dinosaur Metabolism: The evidence

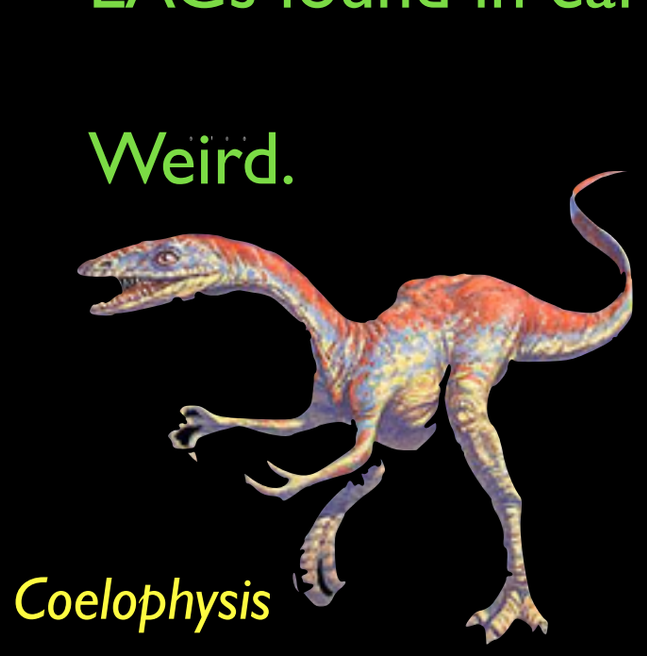
## 6) Growth and LAGS

1) Reconstructed growth rates are high, vascularized ~ birdlike
2) LAGs = Lines of Arrested bone Growth
   Found in ectotherms that slow growing during cold snaps

Growth rates slower than birds

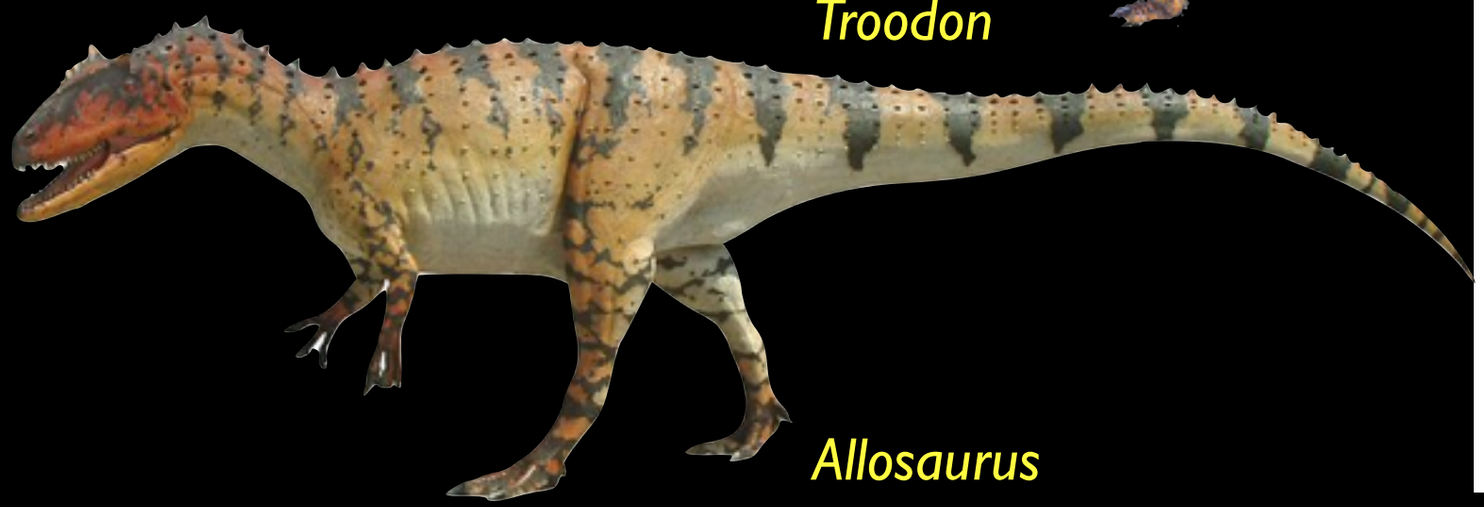
Some Dinos have LAGs (even most active)
LAGs found in early birds

Weird.

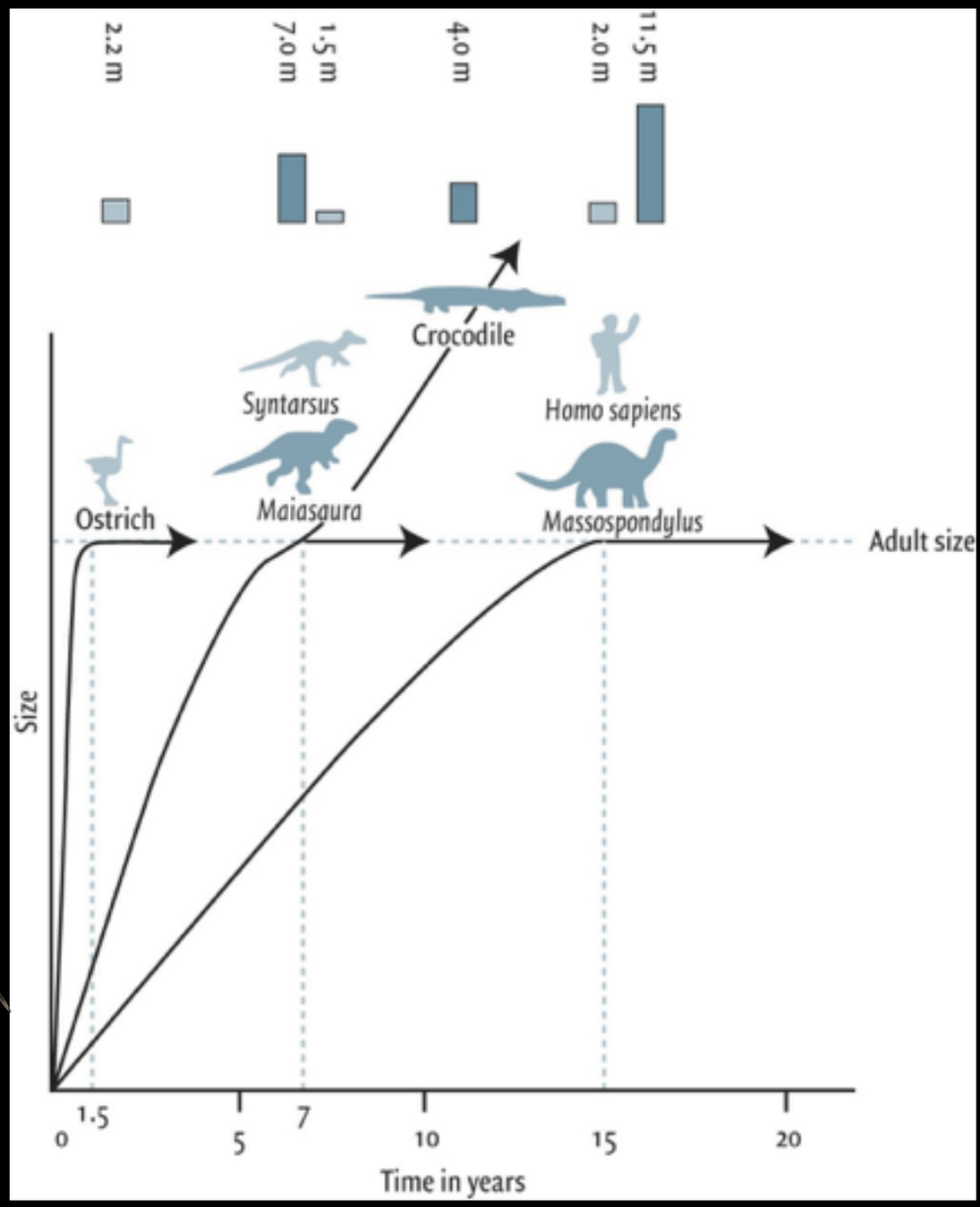


*Coelophysis*

*Troodon*



*Allosaurus*

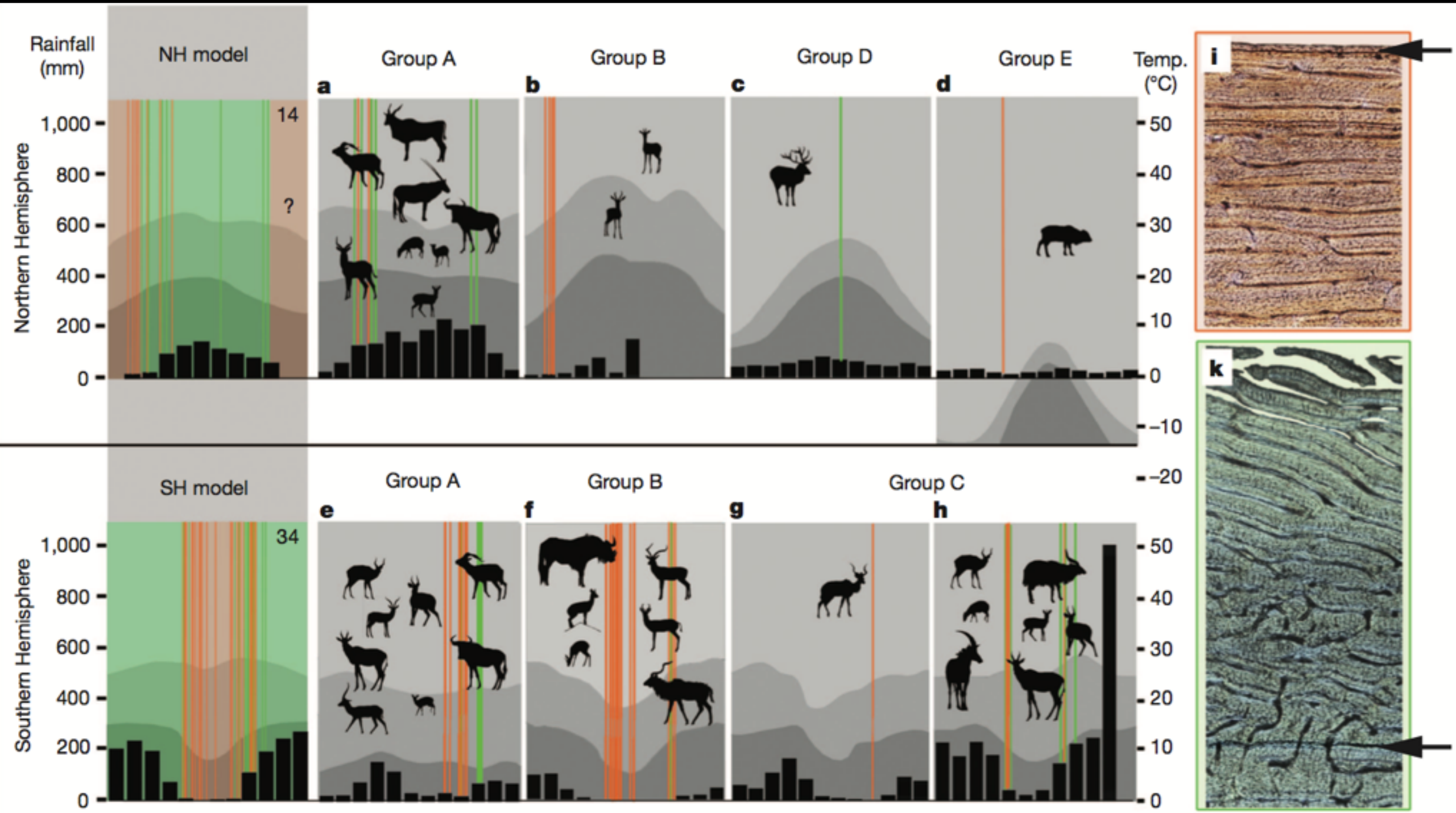


# Dinosaur Metabolism: The evidence

## 6) Growth and LAGS

*Problem: Modern endotherms all have LAGs…*

arrest




active growth

# Dinosaur Metabolism: The evidence

## 7) Plummage

If an ectotherm is warmed up by the environment, why slow this down by having plumage?

*Archaeopteryx*

# Dinosaur Metabolism: The evidence

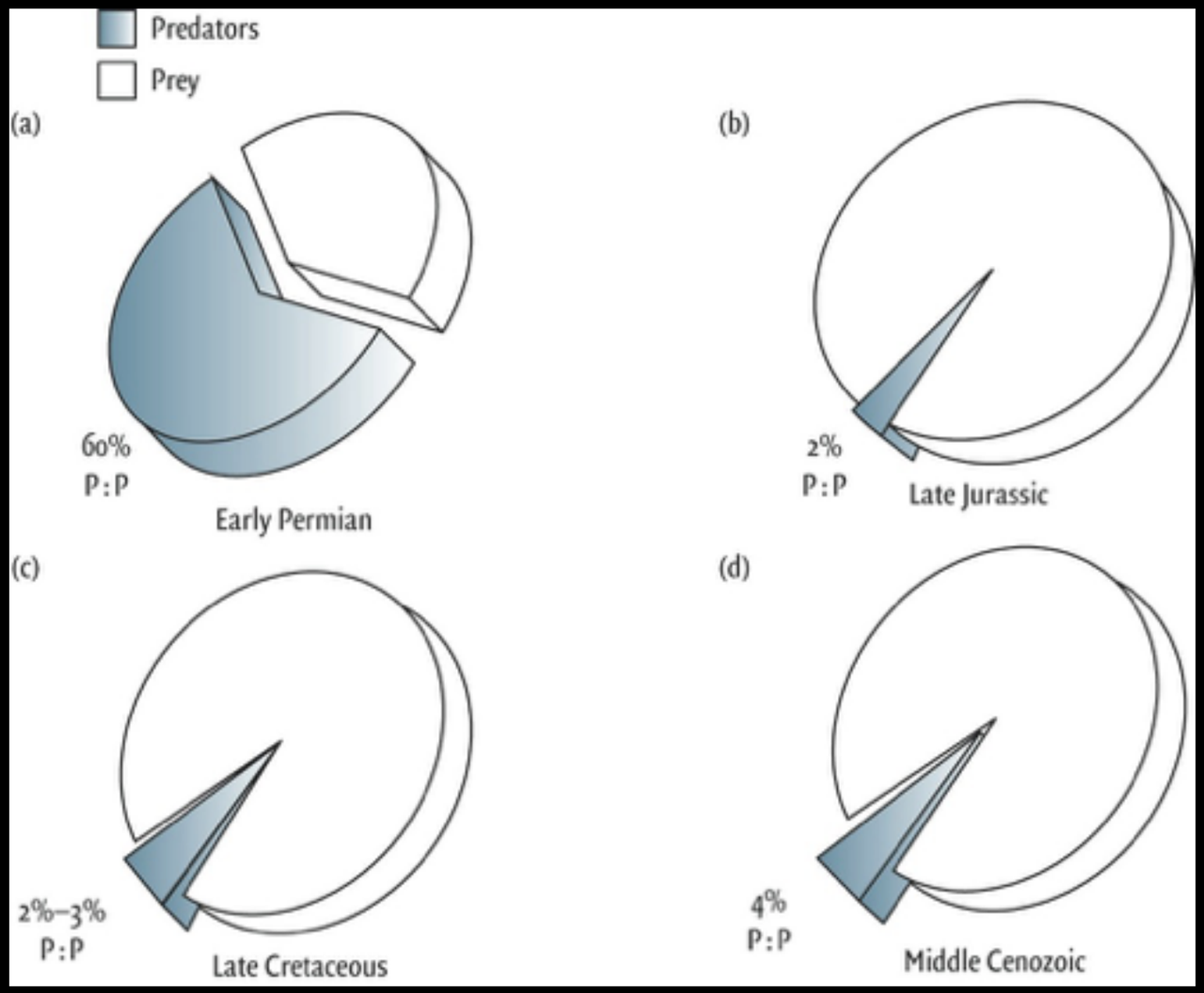
## 8) Ecology and Zoogeography

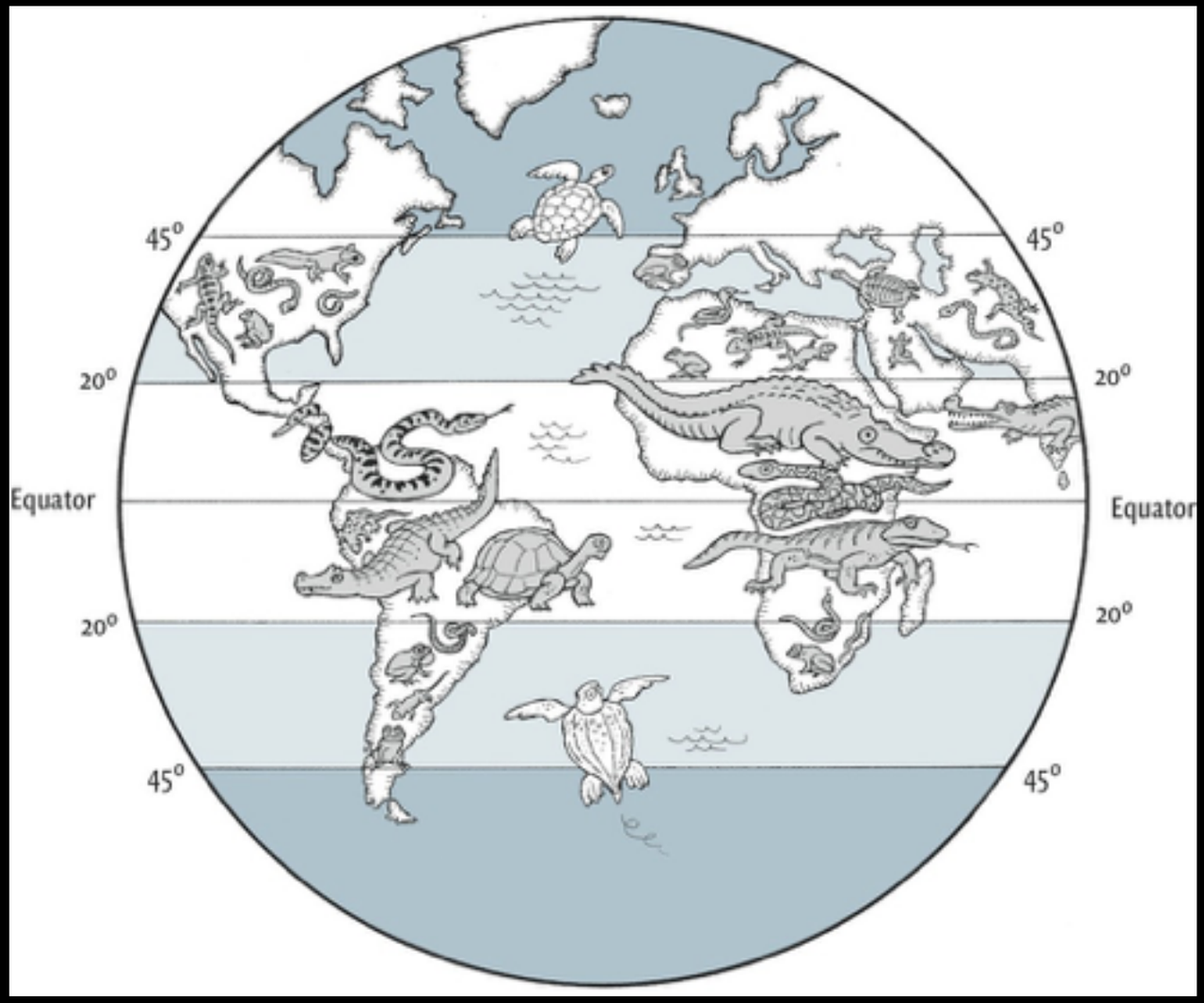
1) Endotherm predators require more energy; therefore endotherm ecosystems should support fewer predators per prey (measured in biomass)

Endotherm systems: 1-3% predators

Ectotherm systems: 40% predators!

2) Dinosaur geographical ranges exceed those of living ectotherms

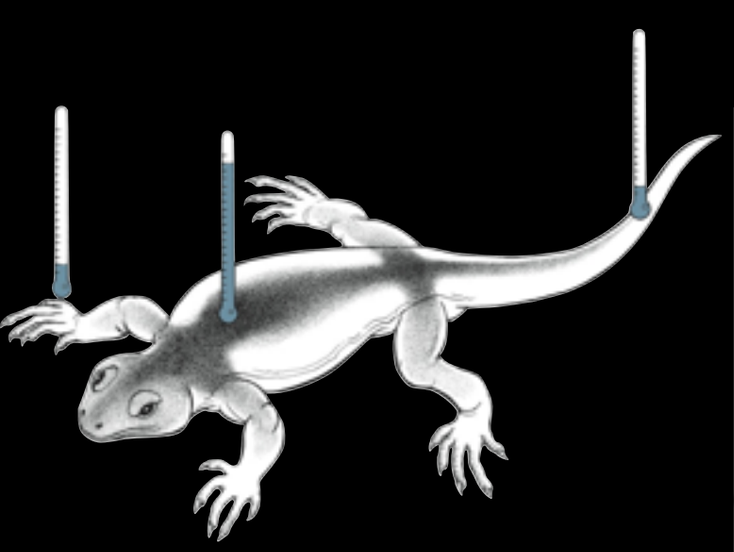


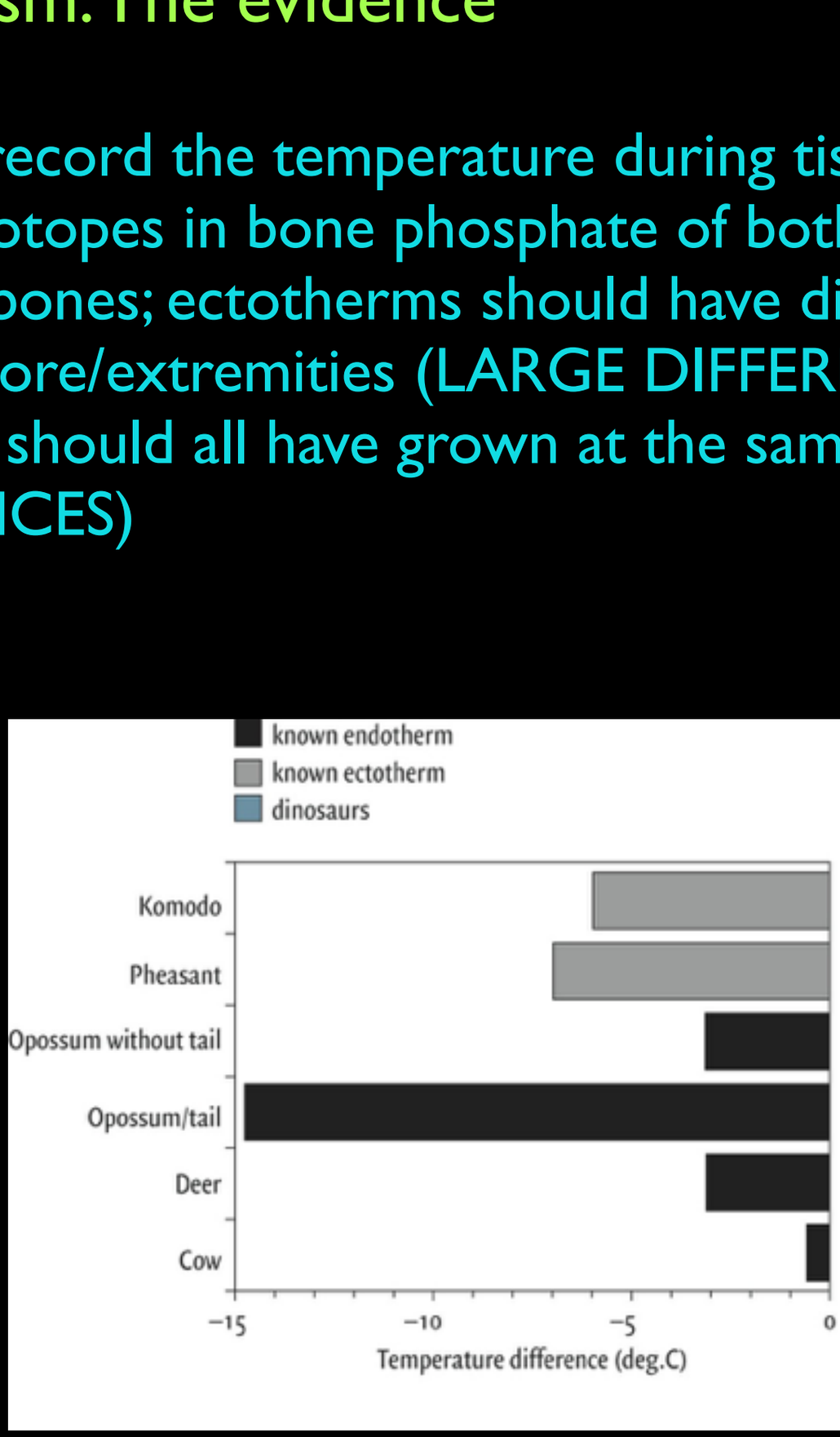



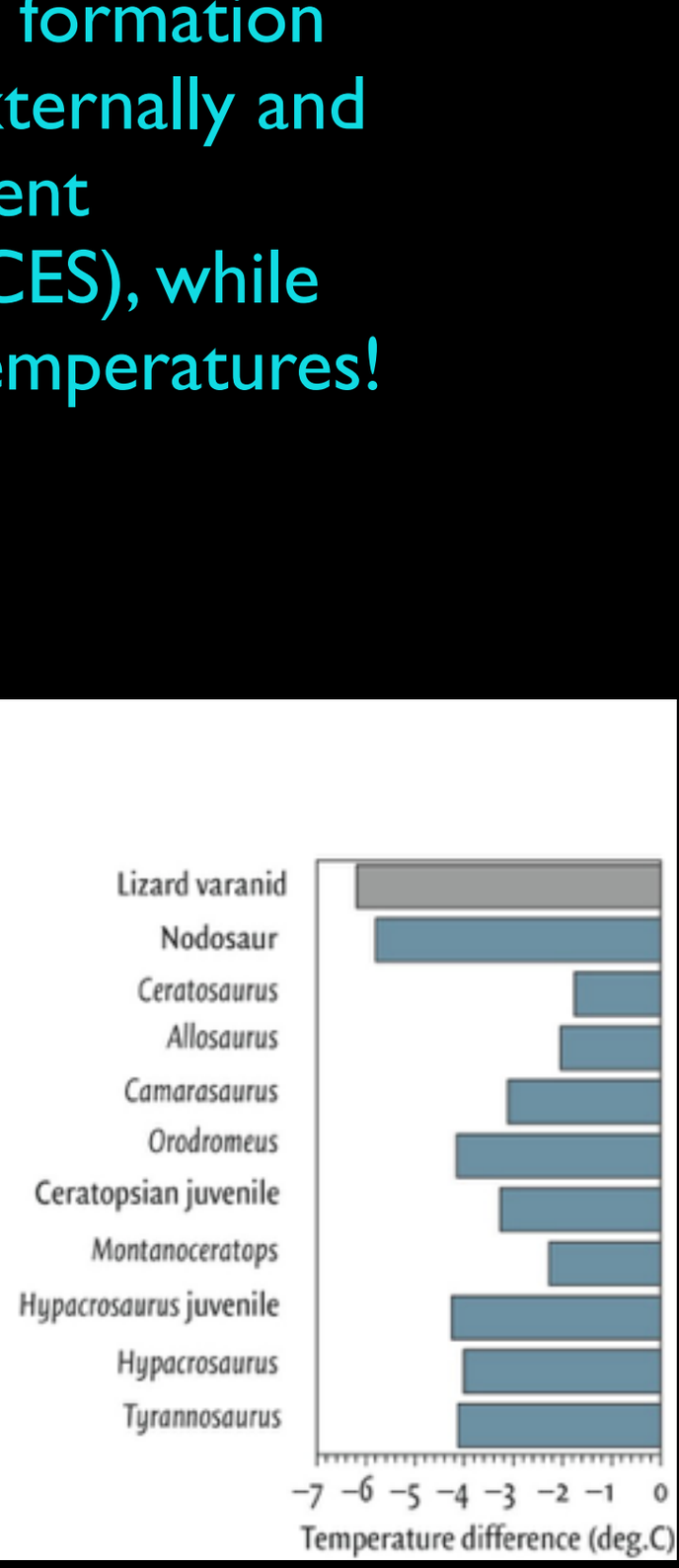
# Dinosaur Metabolism: The evidence

## 9) Chemistry

1) Oxygen isotopes record the temperature during tissue formation
   Measure oxygen isotopes in bone phosphate of both externally and internally situated bones; ectotherms should have different temperatures for core/extremities (LARGE DIFFERENCES), while endotherm tissues should all have grown at the same temperatures! (SMALL DIFFERENCES)



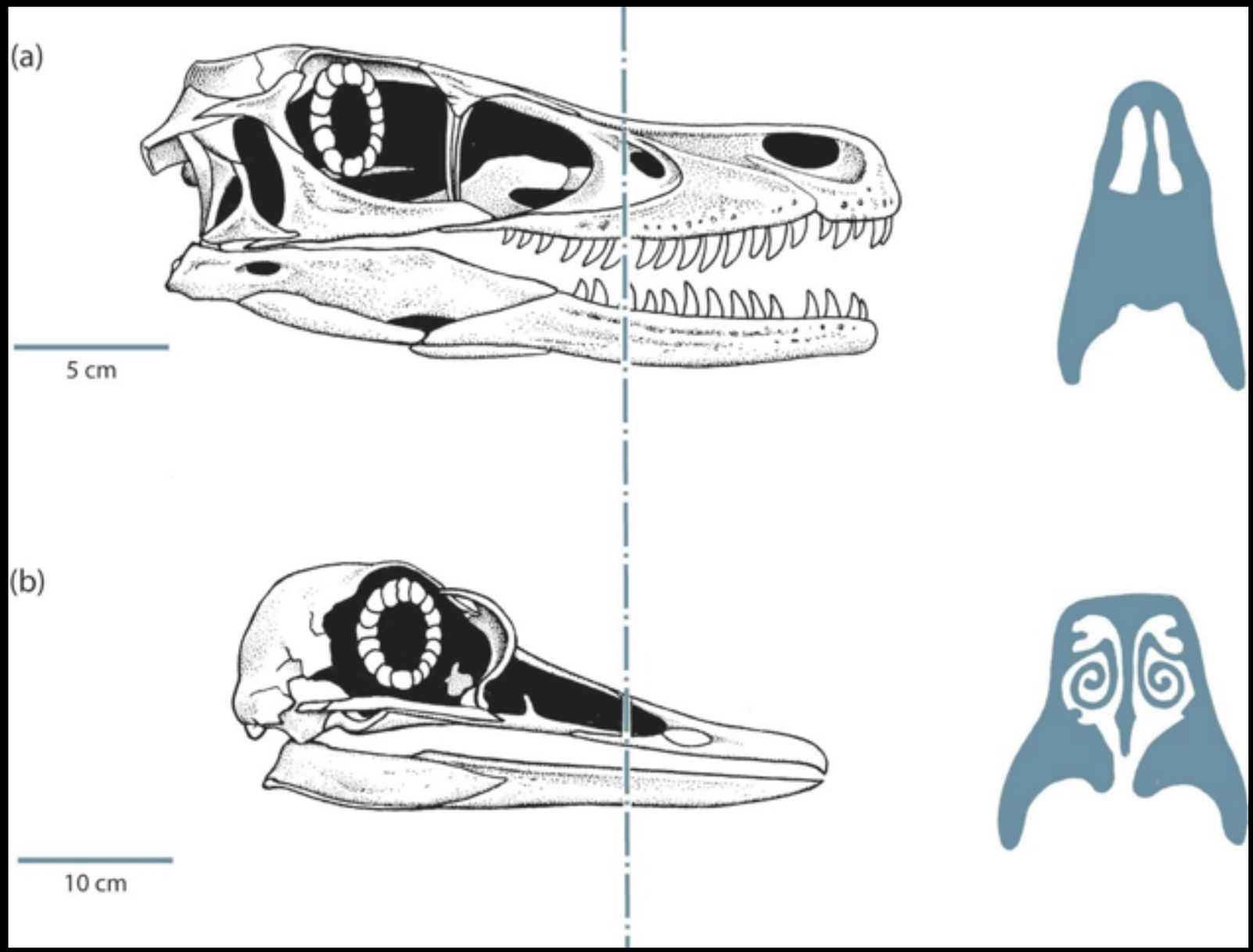


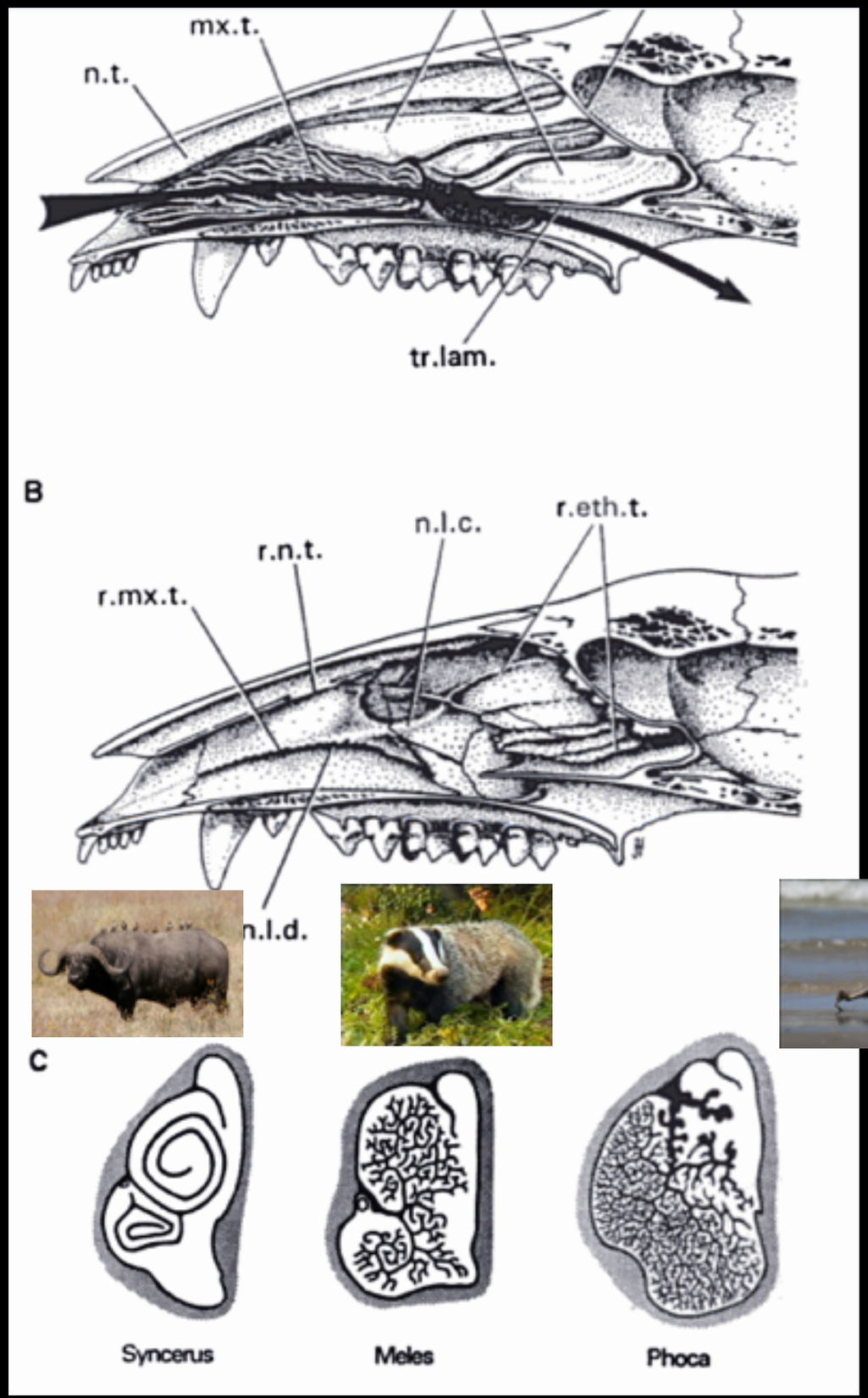
# Dinosaur Metabolism: The evidence

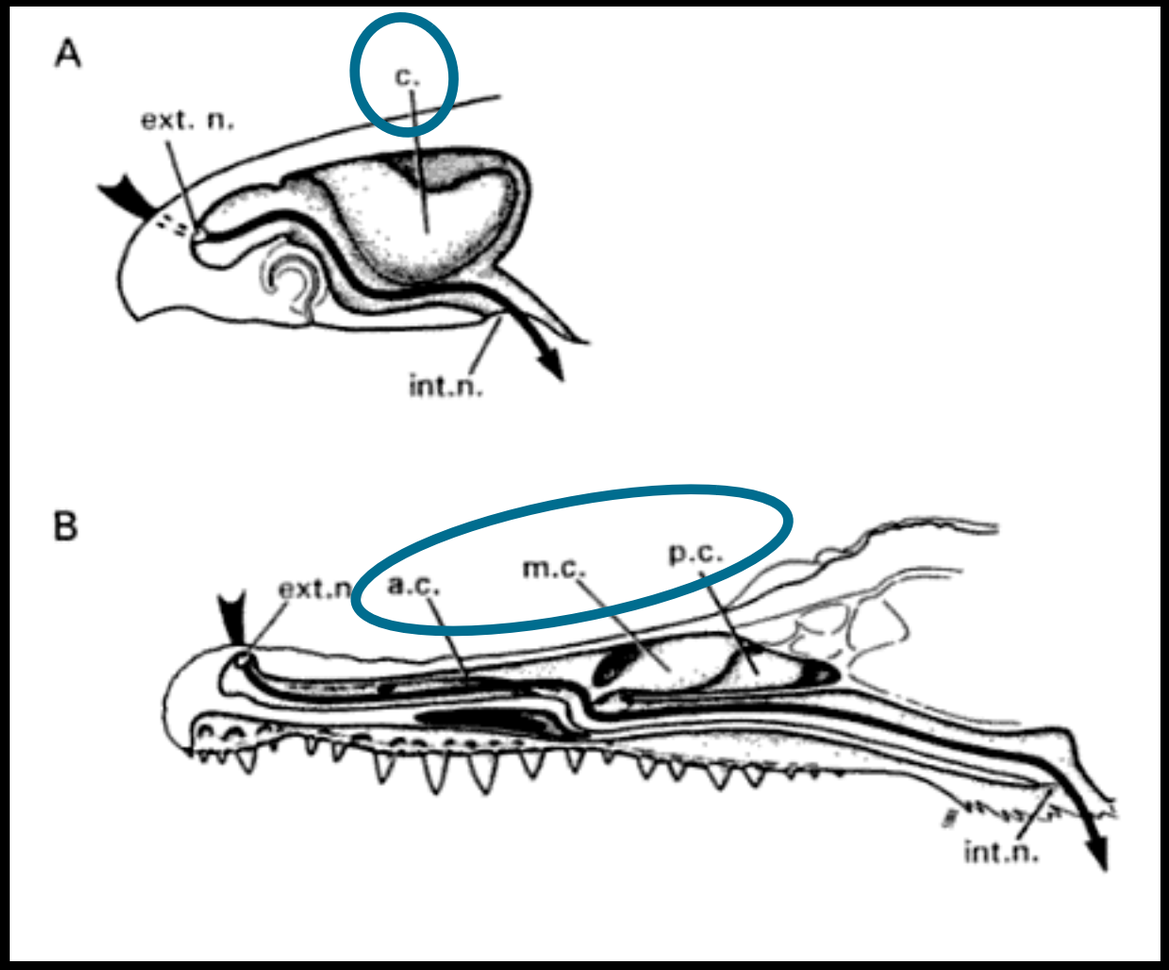
## 10) Noses

1) Endotherms require lungs to replenish air at a high rate
   Leads to high water loss
   Respiratory turbinates resorb water
   Respiratory turbinates may indicate endothermy indirectly
   No respiratory turbinates in Dinosaurs

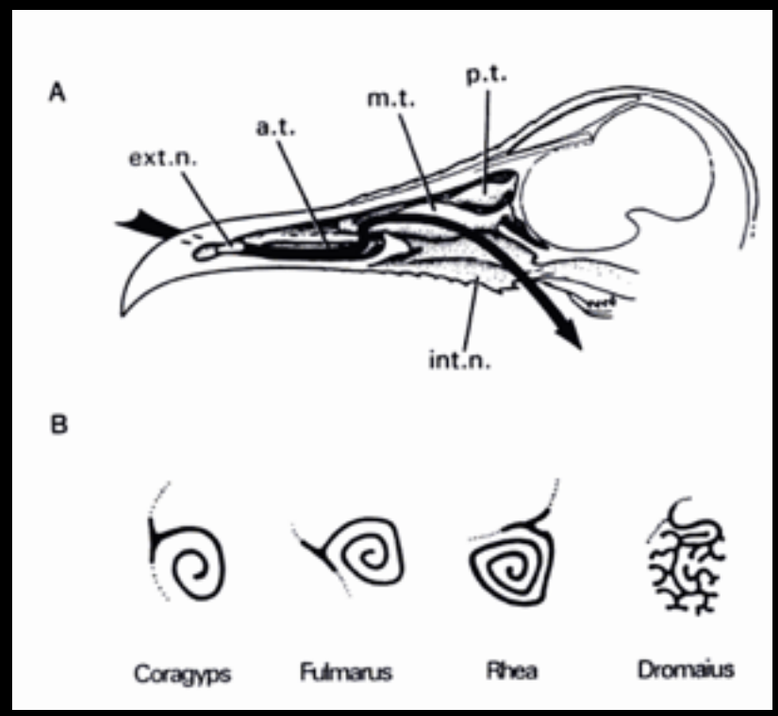


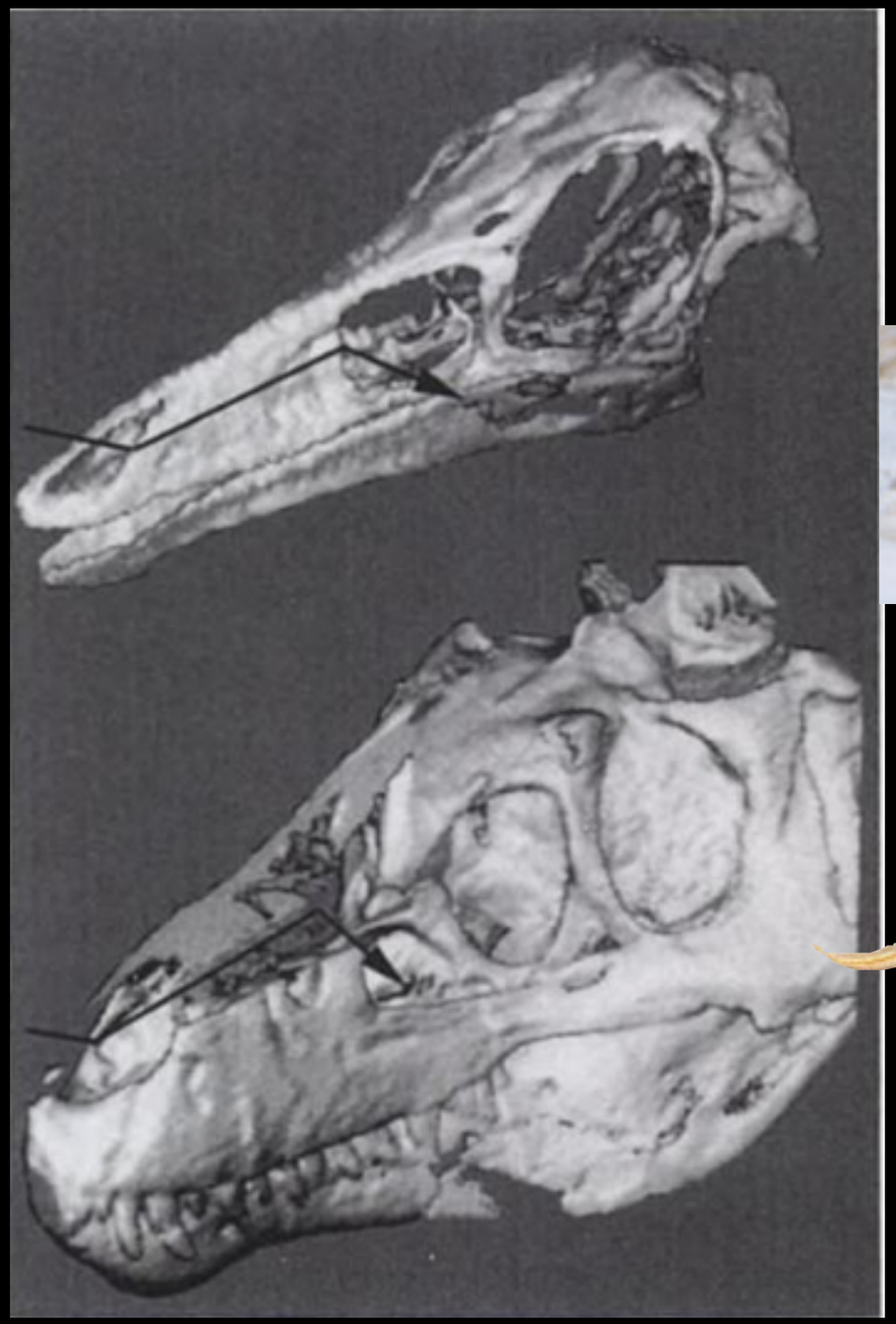
# Mammal turbinates



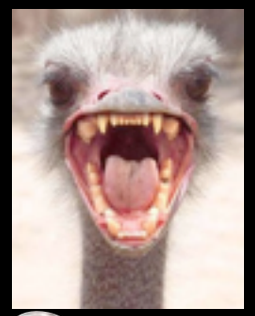




# Reptilian turbinates: Exclusively olfactory in function



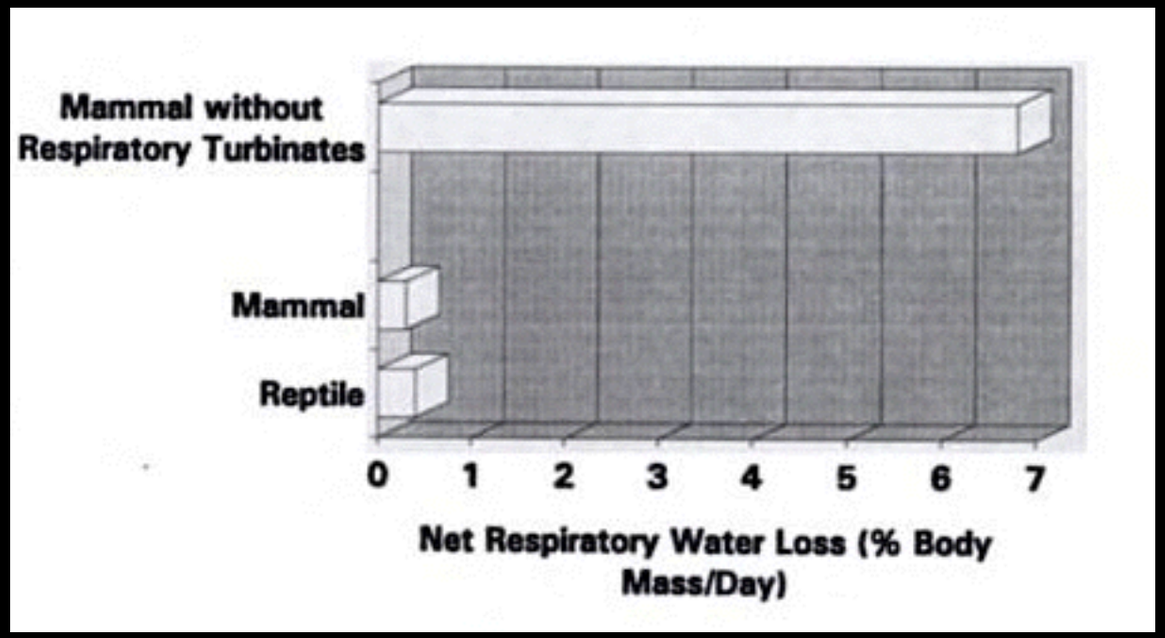


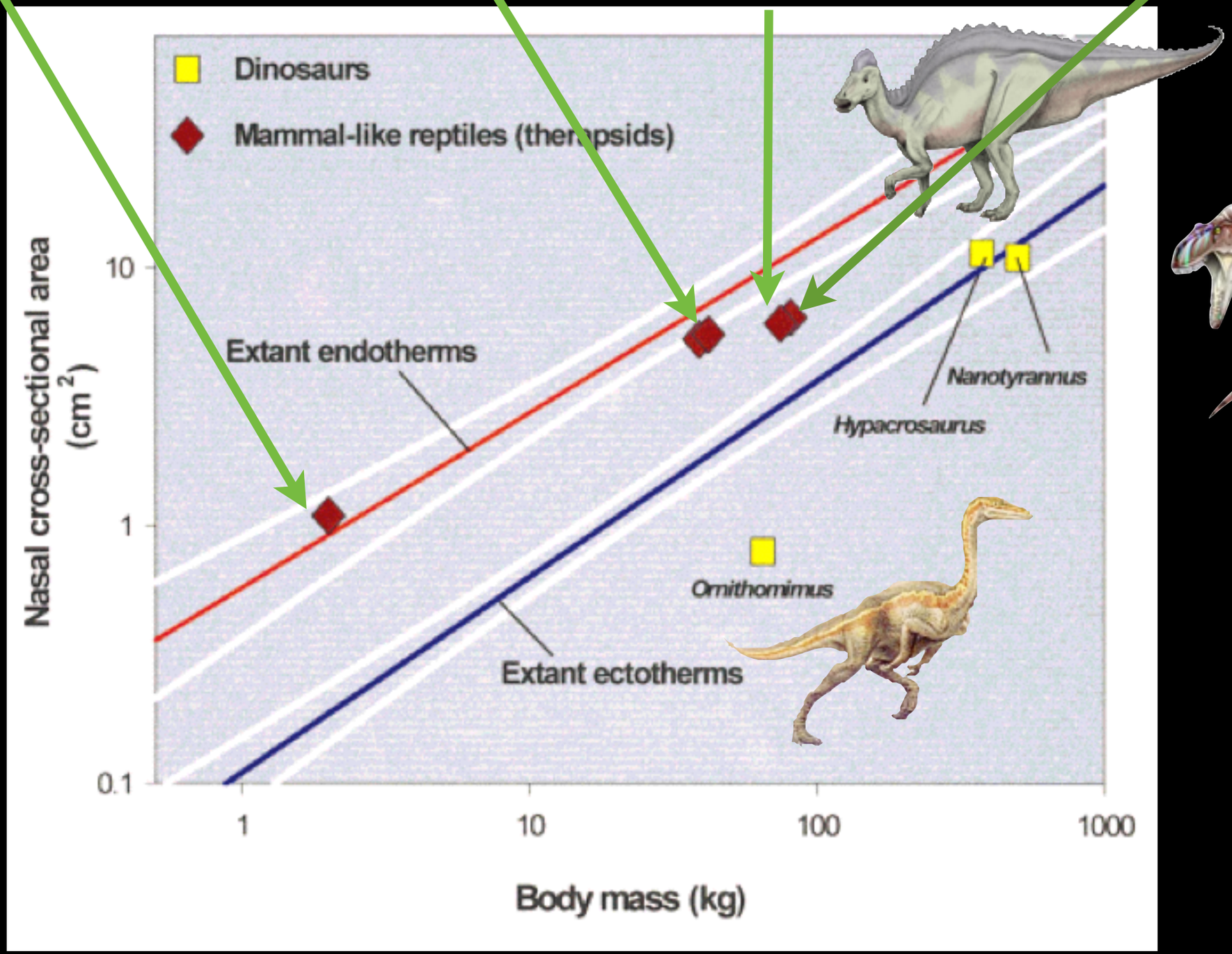
*Ornithomimus*

*Nanotyrannus*

*Hypacrosaurus*




Dinosaurs
Mammal-like reptiles (therapsids)
Extant endotherms
Extant ectotherms
Nanotyrannus
Hypacrosaurus
Ornithomimus
Nasal cross-sectional area (cm²)
10
1
0.1
1
10
100
1000
Body mass (kg)



# Dinosaur Metabolism: Conclusions

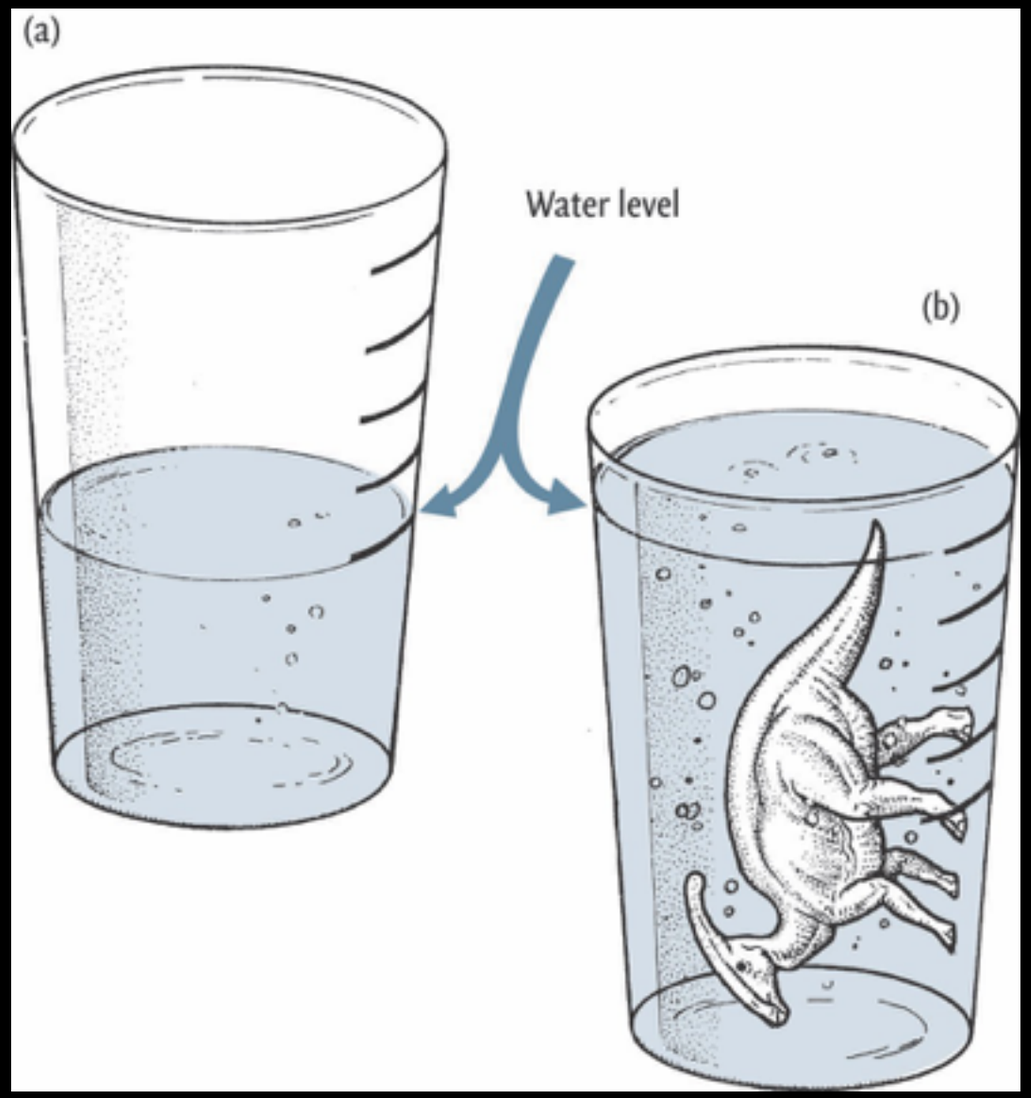
Dinosaurs were unlike modern endotherms or modern ectotherms! Oh great!

1) Dinosaurs seem to be a mixed bag
2) Large ornithopods and theropods were likely homeothermic endotherms as juveniles, and more like homeothermic ectotherms as adults
3) Sauropods were likely gigantotherms ~ their large size retained core heat (small SA:V); homeothermic without the cost of endothermy
4) Small ornithopods and theropods were likely homeothermic endotherms throughout lives
5) Some large slow-moving ornithischians were likely more ectothermic, and perhaps poikilothermic

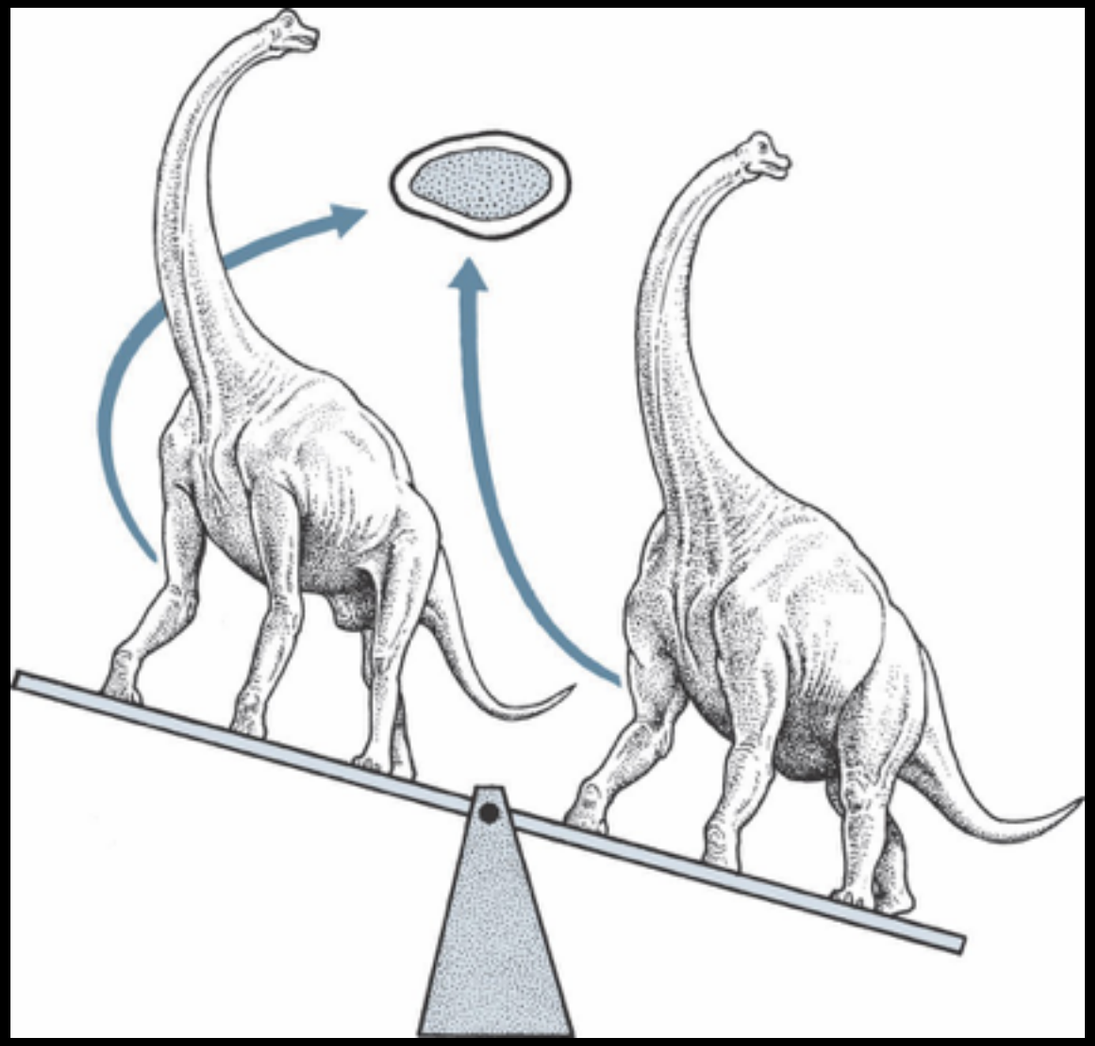
# Dinosaurs and Body size

# Dinosaurs and Body size

## How do we estimate size from fossils?




Volumetric reasoning

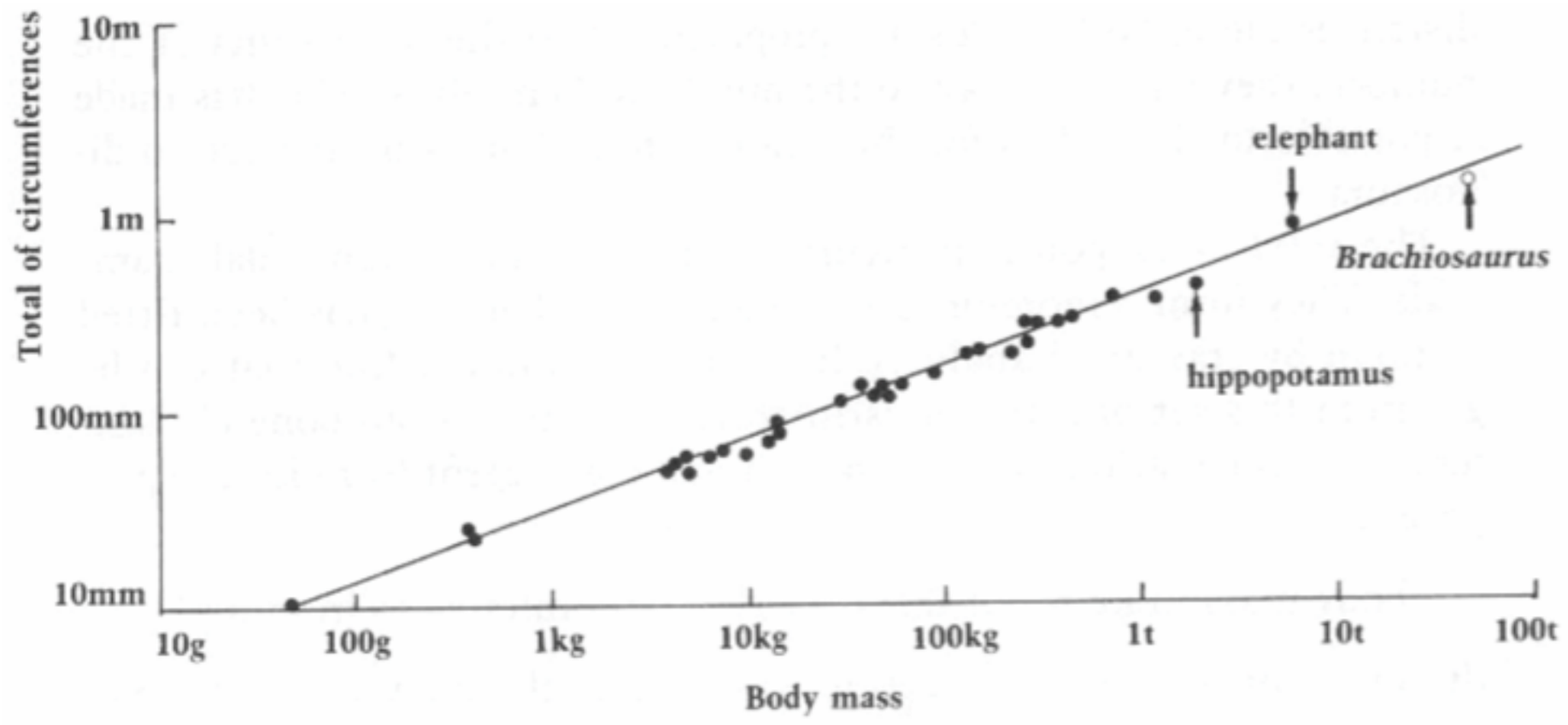


Cross sections of individual bones

# Dinosaurs and Body size

## How do we estimate size from fossils?

### Weighing Dinosaurs with Leg Bone Measurement (cont.)




Log-log plot of data (quadrupedal mammals) obtained by Anderson et al.

# Dinosaurs and Body size

## How do we estimate size from fossils?