Test Results:

Mean: 72.3%
Median: 74%
Stdev: 12%
Exam 2: Thursday, May 13!
Marginocephalians (Chapt 6)
Pachycephalosaurs
Ceratopsians
Ornithopods (Chapt 7)
Basic Saurischian dinos (Part III)
Sauropodomorpha (Chap 8)
Dinosaur Physiology (Chap 12)

RED SCANTRON
Behavior!

2) Bonebeds

Bonebeds found for:
  Dryosaurus
  Iguanodon
  Maiasaura
  Hypacrosaurus

Herds?
Migratory behavior?
Behavior!

3) Reproductive Behavior

“R-selected”

“K-selected”
3) Reproductive Behavior

Hatchlings have well-developed limb bones
Fully formed joint surfaces
Parental care assumed to be minimal
But still groups

= Precocial

Nested in colonies
Usually 17 (30 max) eggs in each nest
Hatchlings have poorly developed limbs; likely needed constant parental care for 8-9 months after birth

= Altricial
Maiasaura Nesting Sites
Maiasaura: 30 ft long
LARGE HERDS: up to 10,000 individuals!

Nests
Eggs packed tightly together, like modern seabirds
Ostrich egg size
Rotten vegetation helped incubate the nests (no sitting)
Hatchlings incapable of walking
Hatchling rate of growth thought to be extremely high: warm-bloodedness?
Hatchlings were ‘cute’: a common feature among altricial young
Enter Saurischia!

Saurischians:

Two major clades:

-Sauropodomorpha
  The Big
- Theropoda
  The Bad

The Ugly
What characterizes Saurischian Dinosaurs?

1. Subnarial foramen
2. Extra articulation on dorsal vertebrae
3. Twisted thumb

Ancestral characteristics:
- ‘Lizard Hip’ three-pronged pelvis structure
Basal, non-sauropoda Saurischians
Small
Bipedal
Fast-moving (how can you tell?)
Carnivorous

Possibly a very early sauropodomorpha: Saturnalia
Sauropodomorpha
1. Prosauropoda
2. Sauropoda

Massospondylus

Diplodocus
Sauropodomorpha

Shared, derived characteristics

- Relatively small skull
- Long neck (10 vertebrae or more!)
- Deflected front end of lower jaw
- Elongate, peg-like teeth
- Added dorsal vertebrae in front of and behind the sacrum
- Enormous thumb
- Elongate femur (upper leg bone)

Plateosaurus
(prosauropod)
Prosauropod

Shared, derived characteristics

Whopping big claw on thumb
Reduced pinky toe
Front limbs shorter than hind limbs

Plateosaurus (prosauropod)
Skull:

- Not meant for chewing
- Jaw joint below tooth row
- Leaf-shaped teeth (few grinding marks)

**NOT CHEWERS**

- Predominantly herbivorous, but some basal forms may have been omnivorous
Gastroliths a-plenty
Likely utilized stomach fermentation
Stomach-contents finds and morphology suggest gymnosperms were likely important
The increase in diversity of prosauropods parallels gymnosperm diversity!
Derived Prosauropoda

Plateosaurus
Quadrupedal / Facultative bipedal

Riojasaurus
Fully quadrupedal

7-9 meters (25-30 feet)

1.8 m (5.9 ft)
Mussaurus
(late Triassic)
Adults probably 10 ft long
Cetiosaurus- first sauropod discovered
Had spongy bone (similar to whales), hence it's name
Thought to be strictly aquatic & related to crocodiles
Later, finds of the leg bone suggested an upright stance, rather than a crocodilian sprawling posture

Edward Drinker Cope
ProsauroPods

Sauropod Skulls

- Shortened head
- Rounded snout
- Lower temporal fenestra below orbit
- No inset cheek teeth
  - not chewers
- Delicate - not built to withstand large forces

Evolutionary trend: nares gradually move to the top of the skulls
Triangulate, spatulate, or pencil-like teeth
In some clades, teeth are limited
Sauropoda-Neosauropoda

12+ cervical vertebrae

Pleurocoels (particularly in neck)

Long tail

Massive, solid limb bones

5 fingers, 5 toes

Figure 11.5. Left lateral view of the skull and skeleton of Apatosaurus.
Uni-Directional Breathing
Air flows in one direction
Pumped by auxiliary air sacs
More O2 can be extracted
Auxiliary airsacs partly housed in cavities within bones (sinuses) ~ pneumatic foramen
Sauropods have these cavities in their backbones... dual purpose
Uni-Directional Breathing

compared to bi-directional breathing
(Mammals, lizards, snakes, crocodiles)
Basal Sauropods

Vulcanodon
Early Jurassic
6.5 m (20 ft) long

Shunosaurus
Middle Jurassic
10 m (32 ft) long
Club Tail

Omeisaurus
Late Jurassic
15.2 m (50 ft) long
4 m (12 ft) high
Omeisaurus
Late Jurassic

Mamenchisaurus
Late Jurassic

19 elongate vertebrae
Camarasauroomorpha
Camarasauroomorpha

Large Nares

Relatively Short Neck

Relatively long forelimbs
Camarasauroomorpha

U-shaped neck vertebrae
To house strong, thick neck ligaments!
Camarasauroomorpha

Diplodocus

Camarasaurus

Shorter snout
Enlarged external nares
Camarasauromorpha

18 m (60 ft) long

Camarasaurus
Brachiosaurids

13 elongate vertebrae
Distinct snout
Vaulted skull
Very long forelimbs
Neck held vertically

16 m (52 feet) tall

Brachiosaurus
Brachiosaurids

**Sauroposeidon**

Late Jurassic
Neck: 37-40 ft long
Vertebrae EXTREMELY ELONGATED
Honeycombed with tiny air cells
Bones very thin
Longest sauropod neck vertebrae on record
Likely able to raise it’s head 6 stories high
Brachiosaurids: an interesting physical problem...
Titanosaurids
Titanosaurids: primarily in the Cretaceous

Alamosaurus

Very small heads

Osteoderms!

Robust lower forelimbs

~9-10 m (30 ft) long
Nemegtosaurus
Pencil-like teeth; similar to Diplodocids
Probably convergent evolution (the rest of body is very different)
Titanosaurids: Saltasaurus

Saltasaurus 10 meters (35 feet).

Saltasaurus egg

Nesting ground; implies herding
One of the only lines of evidence for sauropod reproduction
Titanosaurids: Argentinosaurus

Mid-Cretaceous
21-35 m (72-85 ft) long
Diplodocid traits

>12 vertebrae + bifurcate cervical neural spines

At least 80 caudals

Relatively long skulls with peg-like teeth

Neck joint horizontally oriented

Odd chevrons

Figure 6.8
An adult Diplodocus was a 27-meter-long, lightly built sauropod, characteristic of the diplodocids.

27 m = 90 ft; Blue whale length
Diplodocids

Long sub-rectangular skulls
Fully retracted Nares (on roof of skull)
Late Jurassic
26 m (86 ft) long
Compared to Diplodocus, longer neck and shorter tail
Diplodocids: Supersaurus

Late Jurassic
25-30 m (80-100 ft) long
**Gray whale**  
*Eschrichtius robustus*  
30-40 tons  
Inhabits shallow waters of North American Pacific coast, migrating from Bering Sea in summer to Baja California breeding areas in winter. A small population lives along Asian Pacific coast as well. North Atlantic population is extinct.  
Mottled appearance is due to large numbers of parasitic crustaceans, whale lice and barnacles on its skin.  
Usually travels in groups of 2-3, moving at 3-6 mph. Can stay submerged up to 15 minutes.  
Eats small crustaceans in ocean floor by sifting sediment through its mouth plates.  
Existing population worldwide is 19,000-23,000.

**Blue whale**  
*Balaenoptera musculus*  
100-150 tons  
The largest living animal, and on par with the largest animals that ever lived. Incomplete fossils of several dinosaurs suggest they might have been marginally longer and heavier. The largest blue whale on record was 108 feet long and was estimated to weigh 170 tons.  
Range is worldwide; migrates to warmer waters in winter. Northern hemisphere whales average 75-80 feet; southern whales reach 90-100 feet. Commonly travel in pairs. Cruising speed is 12 mph; can sprint up to 30 mph.  
Eats krill and other small animals by filtering through a series of overlapping plates in its mouth that substitute for teeth. Can consume up to 4 tons a day.  
Pre-whaling population has been estimated at 250,000-350,000. Today there are 5,000-10,000 in southern hemisphere; 3,000-4,000 in north.

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Sources: American Cetacean Society, BBC, Whale and Dolphin Conservation Society, MarineBio.org, Orange Coast College

Phil Loubere, The Register
Diplodocids: Diplodocus

Late Jurassic
54 m (177 ft) long
Compared to Diplodocus, longer neck and shorter tail

Double-beamed chevrons
The largest known sauropod; almost 2x the length of a blue whale
WHY SO BIG? ... a complex question. Ecology & Physiology

Sauropods attained large body size in the latest Triassic / early Jurassic...
i.e. quickly
Very large body size is found among Diplodocids, Titanosaurs,
Brachiosaurids
Benefits include
   Obtain food that is out of reach for other animals
   Greater ability to digest low-nutrient foods
   Higher metabolic efficiency
   Escape from predation
Cope’s Rule: Animals tend to increase in body size over evolutionary time
Diplodocid Tails: strange chevrons...

Camarasaurus chevrons

a = articular surface (where chevron connects to the body of the vertebra)

Recall...

Diplodocus chevrons...
An explanation for odd mid-caudal chevrons?
Tail variations involve and increase in tail vertebrae from 44 - 80 (Apatosaurus & Diplodocus)
Why?
Figure 6. Distal tail tip velocity versus time from one simulation for the reconstructed tail of *Apatosaurus* CM 3018.

Contact between tail and solid object at this velocity $\Rightarrow$ damage!

Speed of sound = 350 m/s

Apatosaurus tail snap simulation
Supersonic Diplodocid tails?

FOR
1. Tail proportions work
2. Extreme thinness and elongation of distal tail vertebrae
3. Unusually long, stiffened vertebrae at the very end of the tail

AGAINST
1. Tail tips highly vulnerable to damage on impact
2. No poppers found in the fossil record!

“It is pleasant to think that the first residents of Earth to break the sound barrier were not humans.”
Accessories
Accessories

a) Hypothesized trunk
b) Classical rendering

c) Modern depiction w/ resonating chamber

d) Indian Elephant

Diplodocus
Accessories

Vertebral spines: *Amargasaurus* (Diplodocid)
Accessories

Keratinous spines?
Sauropod Lifestyles
The Sauropod Hiatus

Box Figure 6.3
The sauropod hiatus lasted 25 million years.
Apatosaurus