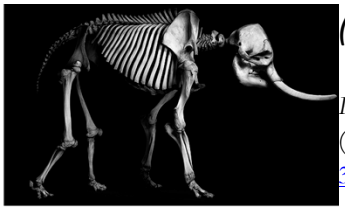
Mechanical Similarity and Bone Shape



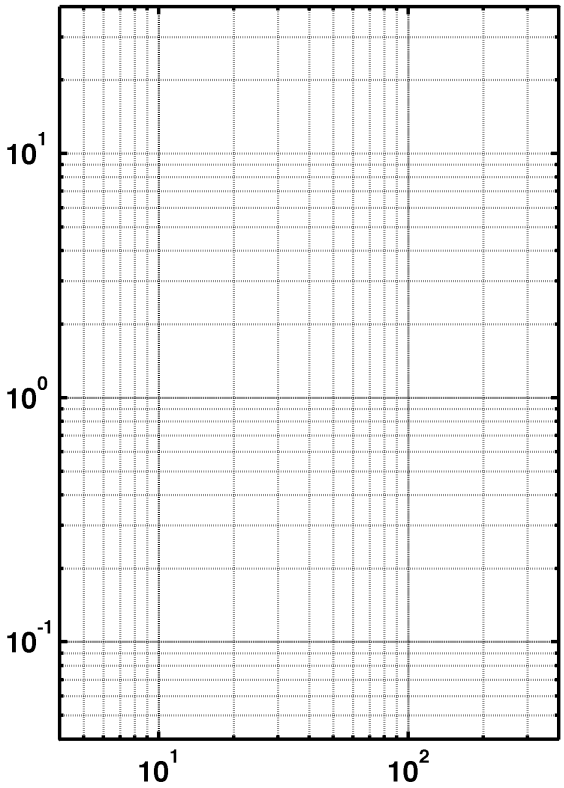
(i.e. Why can't elephants jump?)

Photo: Patrick Gries (http://www.theguardian.com/arts/gallery/2007/oct/26/photography?picture=331083586)

1. We've seen in class the femurs of an elephant and a dog. (Yes, this is awesome.) Note their lengths and diameters, and the factor by which the elephant's measurement is greater than the dog's.

	Length (cm)	**Diameter (cm)**
Dog		
Elephant		
Factor		

2. Plot on the logarithmic graph below Diameter vs. Length for each of these two animals



3. Suppose the dog's bone grew **isometrically**. Draw a line on the graph indicating the diameter vs. length relationship that would result. What slope should your line have? Is the elephant data point on this line?

Impala. (from Wikipedia.)

Bovids. We've seen in class the graph of bone diameter vs. length for the humerus (shoulder-elbow bone) of many species of African bovids, reprinted again at the end of this document. Let's work through what it means...

4. Notice that bone width vs. bone length for a *lot* of different bovids is a straight line on a log-log plot. What is the scaling exponent for bone width as a function of bone length?

5. What exponent would we have for *isometric* scaling?

[Draw a few cylinders with the same length and / different cross-sectional areas]

6. Here's how the strength of a bone (i.e. the force it can support) scales with its size:

7. Suppose an organism *isometrically* doubles its width? By what factor would the gravitational force (pulling it downward) increase?

8. Suppose an organism *isometrically* doubles its width? By what factor would the strength of its bones increase?

9. Based on #7 and #8, but without calculating exact numbers, **what would you conclude needs to "happen" to the width of an animal's weight-bearing bones relative to their length if it is to grow larger?** Answer in words, not numbers. (In addition to words, illustrate this with diagrams of cylinders.)

10. Now for numbers: How should bone diameter (non-isometrically) scale with length so that bone strength scales in the same way as the force of gravity? (I.e. so that both involve length raised to the same exponent?)

10. Why do we say that the bovids in the graph are "mechanically similar?"

11. Is the elephant mechanically similar to the dog? (Draw a line indicating "mechanical similarity" on your graph – is the elephant on it?) [I'll show more animals' measurements in class.]

12. Why can't elephants jump?