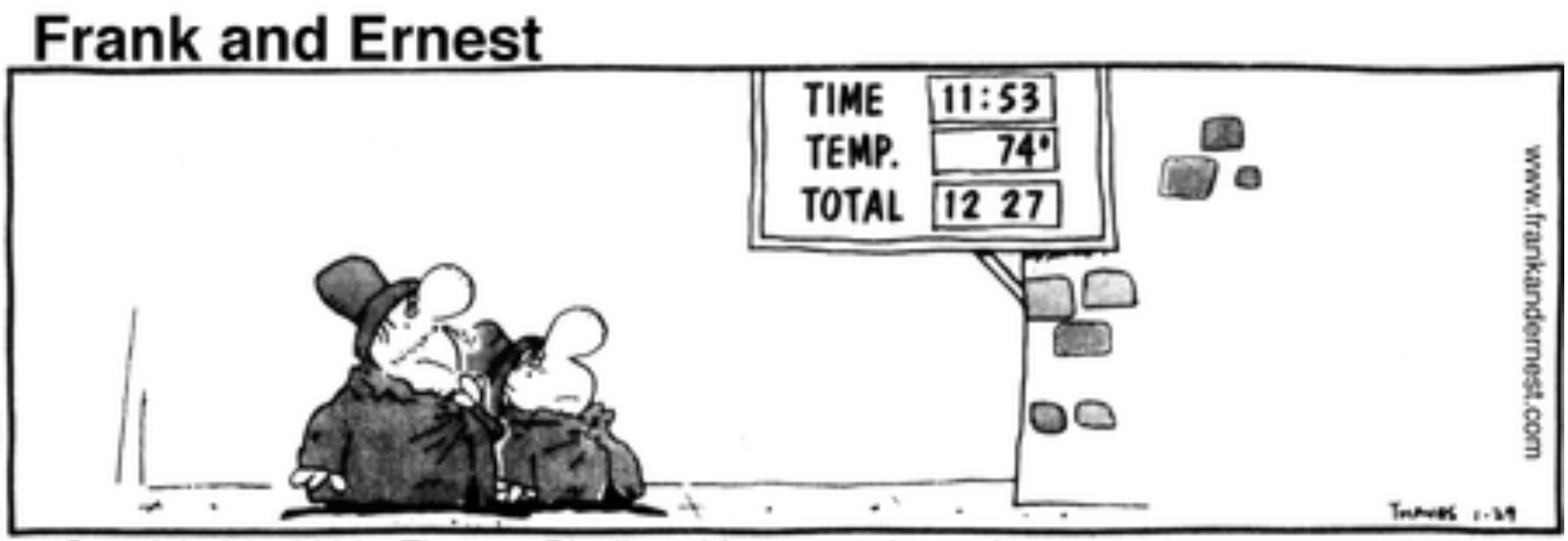
Sept 11, 2015 LB 273, Physics I Prof. Vashti Sawtelle
Prof. Leanne Doughty

- **<u>Topic:</u> Ch1 – Units/Dimensions & Estimation**
- **<u>Cartoon:</u> Bob Thaves**

Frank and Ernest



Foothold ideas: Dimensional and unit analysis

- We label the kinds of measurement that go into assigning a number to a quantity like this:
  - [x] = L means “x is a length”
  - [t] = T means “t is a time”
  - [m] = M means “m is a mass”
  - [v] = L/T means “you get v by dividing a length by a time
- Units specify which particular arbitrary measurement we have chosen.
  - Units should be manipulated like algebraic quantities.
  - Units can be changed by multiplying by appropriate forms of “1” e.g. 1 = (1 inch)/(2.54 cm)

Foothold ideas: Dimensional analysis

- In physics we have different kinds of quantities depending on how measurements were combined to get them. These quantities may change in different ways when you change your measuring units.
- Only quantities of the same type may be equated (or added) otherwise an equality for one person would not hold for another. Equating quantities of different dimensions yields nonsense.
- Dimensional analysis tells us *how* something changes when we either
  - Change our arbitrary scale (passive change)
  - Change the scale of the object itself (active change)

Which equation represents the quantity on the left?

1. The area of a circle.
2. The volume of a sphere.
3. The circumference of a circle.
4. The surface area of a sphere.

A. $2\pi R$

B. $4\pi R^2$

C. $\frac{4}{3}\pi R^3$

D. πR^2

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Which equation could represent the surface area of a cylinder?

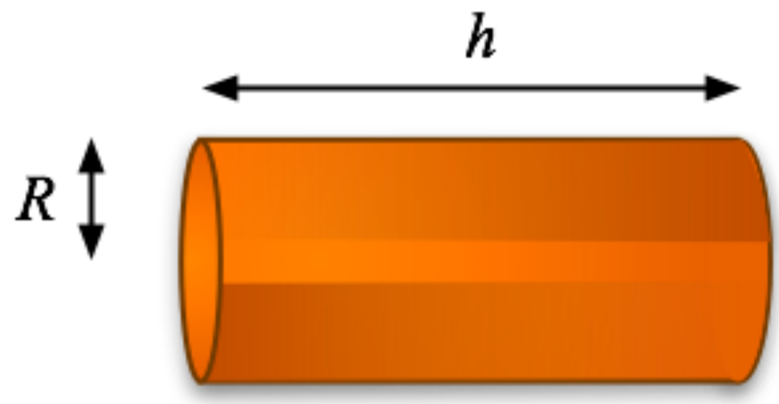
A. $2\pi R + 2\pi Rh$

B. $2\pi R^2 + 2\pi Rh$

C. $2\pi R^2 + 2\pi h$

D. $\pi R^2 h$

E. None of the above



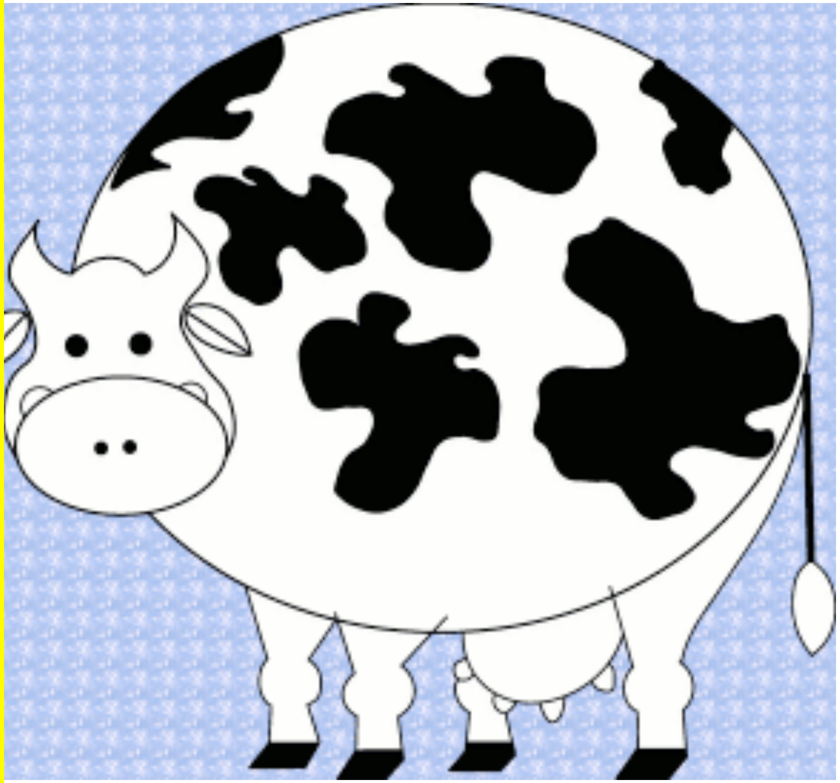
Announcements

- Lon-Capa Ch1 HW due TODAY at midnight!
- On-Paper Ch1 HW due next Friday at start of class! (we'll talk more about this today)
- Reading Questions for Ch2 due on Sunday at midnight!
  - If you need a refresher on adding/subtracting vectors read Ch 1.5
- Interested in an Honor's Option for this class?
  - Send Leanne & I an email by the end of the day!


Scaling

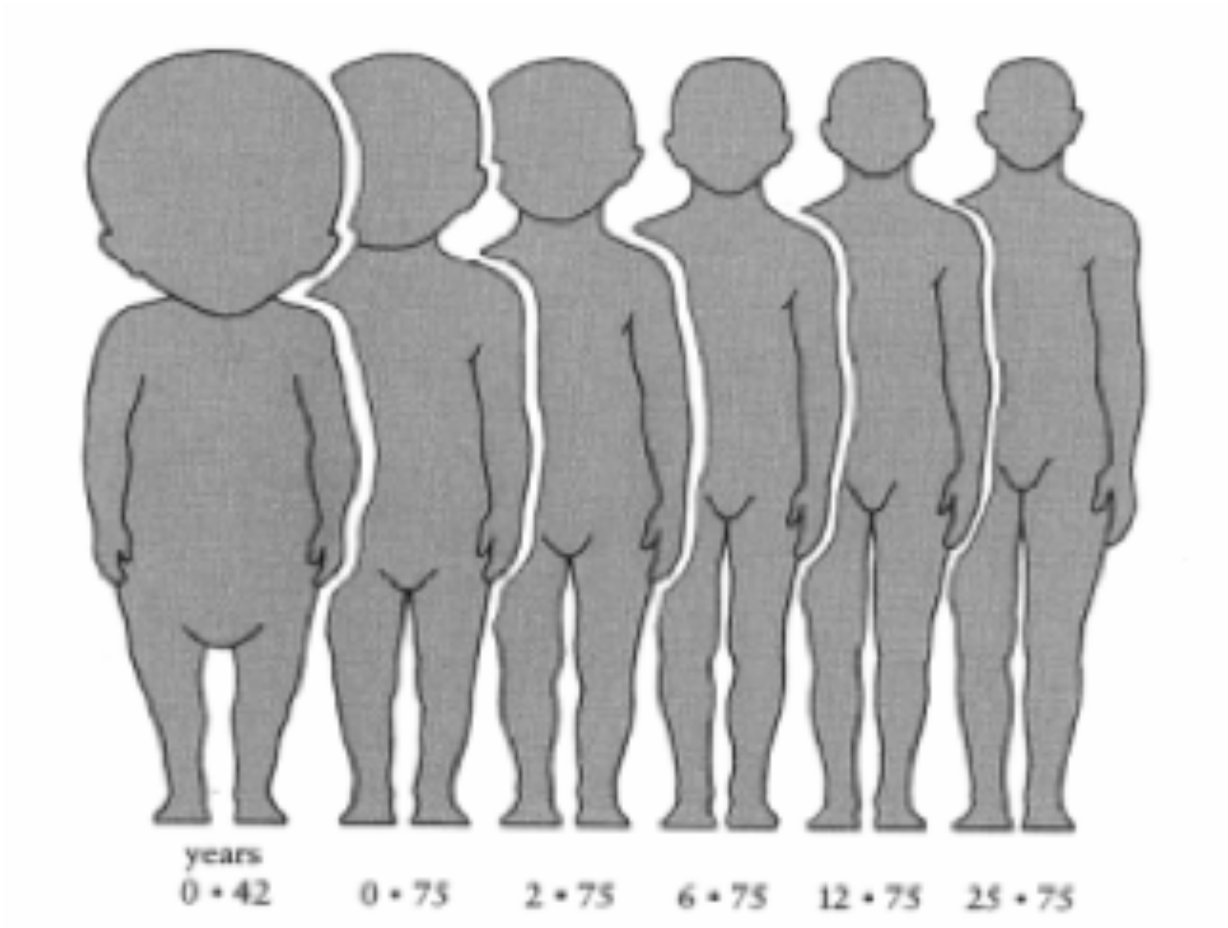
The "Spherical cow approximation," or SCA

After reading this chapter, I would like to further discuss the SCA principle. I am still a little confused with the idea that when something changes size, it stays the same shape, and how the surface area will increase by the size squared and how the volume will increase by the size cubed.



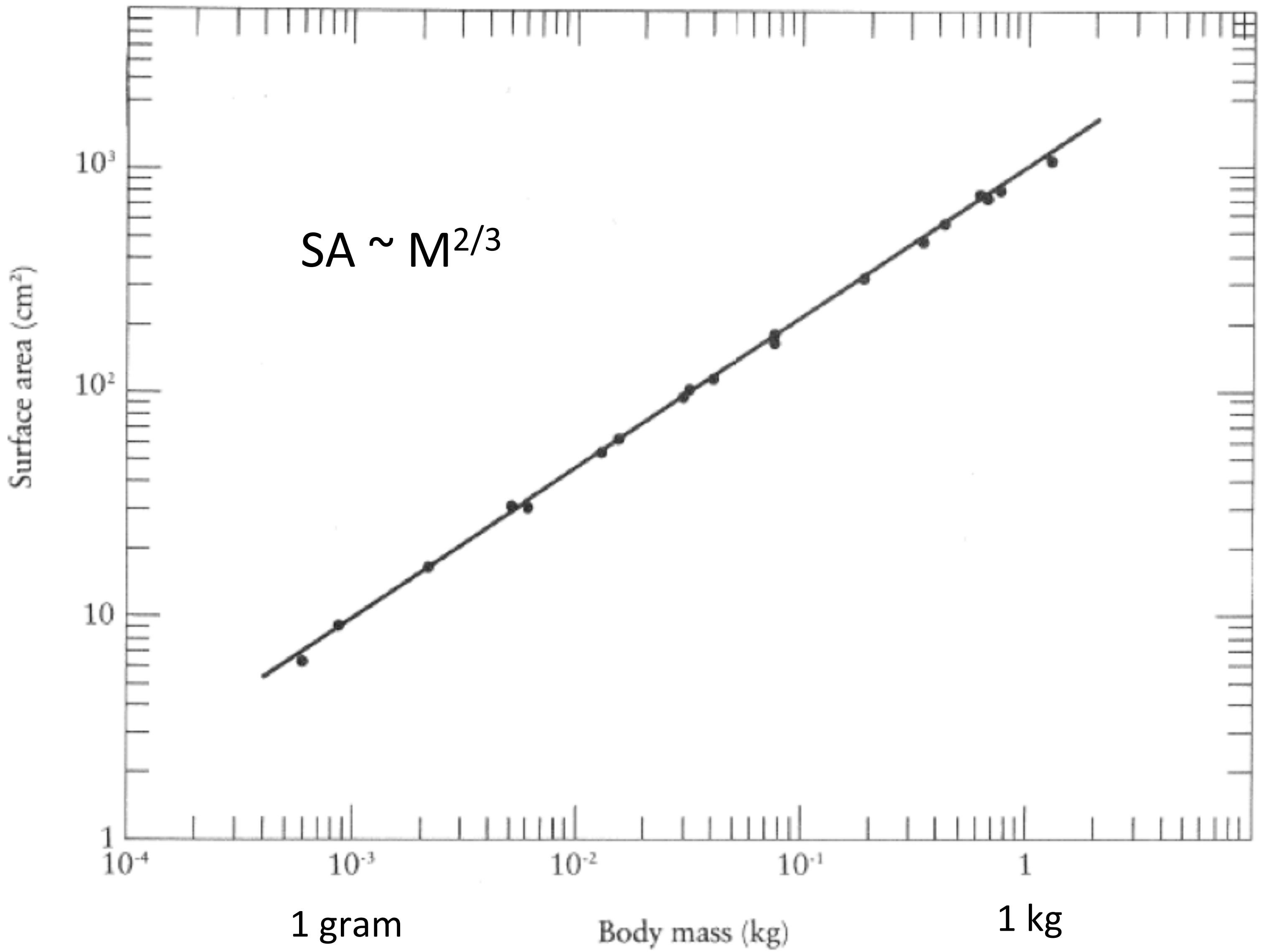
What is another example of describing how an increase in size affects shape other than the SCA?

Humans are not quite isomorphic, but it's not a bad approximation!



from McMahon & Bonner, 1981 - On Size and Life

The dwarf siren salamander



McMahon & Bonner, 1981

Implications?

- Mass grows with volume, or size^3
- Area available to support weight goes as size^2
- Difficulty of supporting your weight ~ Mass/Area or size^3/size^2 = size
- So big organisms have more difficulty supporting their weight!




The earthworm absorbs oxygen directly through its skin. The worm does have a good circulatory system that brings oxygen to all the cells. But the cells are distributed throughout the worm's volume and oxygen can only enter through the skin. This means the surface area to volume ratio plays an important role.

How big can an earthworm get?

You will be finishing this problem for homework, so take good notes!

A typical specimen of the common earthworm (lumbricus terretris) has the following average dimensions:

Mass: 3.7 g   Length: 12 cm   Width: .64 cm

What would be the surface area of the typical earthworm?

A. $3.9\ cm^2$
B. $24\ cm^2$
C. $25\ cm^2$
D. $51\ cm^2$
E. Something else

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Model as a cylinder, but exclude the end caps because they are less than 2% of the surface area from the length.

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B. 3.9 cm^3
C. .32 cm^3
D. 16 cm^3
E. Something else

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Model as a cylinder

The skin of an earthworm can absorb oxygen at a rate
A = .24μmole per square cm per hour

The body of the earthworm uses approximately
B = .98μmole of oxygen per gram of worm per hour.

Which expression describes the amount of oxygen a typical earthworm **absorbs** in one hour?

A. 3.7g*A

B. $3.9cm^3$*A

C. $24cm^2$*A

D. .95 g/cm^3*A

E. Something else

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Absorbs oxygen through it's skin, so the surface area determines how much oxygen it gets. Coherence check: this also means the units will be moles/hr, which makes sense!

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Can a typical earthworm take in enough oxygen to survive?

A. Yes
B. No
C. I have no idea
D. Something else