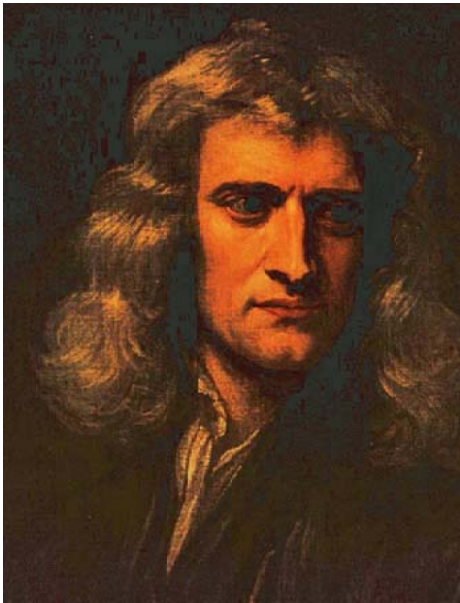


Physics 113 - Sept. 3, 2013



1980's rock star
or
Awesome superstar
of physics ?

What is Science ?

What is science?

A way of looking at and trying to comprehend
the world around us.

Same for religion ...

Same for some art ...

What sets science apart?

Also
Scientific
Method

Science bows to observation

Science is testable and refutable

Science attempts to minimize ambiguity

Religion is irrefutable. It is a matter
of faith and opinion

What is truth ?

Religious truth is whatever the chosen book or prophet says.

Scientific truth does not exist.

we have scientific laws and principles that have withstood many experiments and are generally accepted.

But a single experiment can overthrow or show need for modifying the theory.

The scientific method says nothing about Truth

How does the mission of science lead to the nature of science ?

What is

The Human Experience

in terms of time
DISTANCE
MASS

Roughly

Time 10^{-3} s - 100 s of yrs

Distance 10^{-9} m - 25000 m.

Mass 10^{-6} g - 100 TONS

How does the scales of the human experience
compare to what we can see in our universe?

Length:

| Distance | Length (m) |
|----------------------------|----------------------|
| Radius of visible universe | 1×10^{26} |
| To Andromeda Galaxy | 2×10^{22} |
| To nearest star | 4×10^{16} |
| Earth to Sun | 1.5×10^{11} |
| Radius of Earth | 6.4×10^6 |
| Sears Tower | 4.5×10^2 |
| Football field | 1.0×10^2 |
| Tall person | 2×10^0 |
| Thickness of paper | 1×10^{-4} |
| Wavelength of blue light | 4×10^{-7} |
| Diameter of hydrogen atom | 1×10^{-10} |
| Diameter of proton | 1×10^{-15} |

Time:

| Interval | Time (s) |
|---------------------------------|---------------------|
| Age of universe | 5×10^{17} |
| Age of Grand Canyon | 3×10^{14} |
| 32 years | 1×10^9 |
| One year | 3.2×10^7 |
| One hour | 3.6×10^3 |
| Light travel from Earth to Moon | 1.3×10^0 |
| One cycle of guitar A string | 2×10^{-3} |
| One cycle of FM radio wave | 6×10^{-8} |
| Lifetime of neutral pi meson | 1×10^{-16} |
| Lifetime of top quark | 4×10^{-25} |

Mass:

| Object | Mass (kg) |
|------------------|---------------------|
| Milky Way Galaxy | 4×10^{41} |
| Sun | 2×10^{30} |
| Earth | 6×10^{24} |
| Boeing 747 | 4×10^5 |
| Car | 1×10^3 |
| Student | 7×10^1 |
| Dust particle | 1×10^{-9} |
| Top quark | 3×10^{-25} |
| Proton | 2×10^{-27} |
| Electron | 9×10^{-31} |
| Neutrino | 1×10^{-38} |

The human experience encompasses only a
tiny fraction of the
Time/Length/Mass Scales in the
universe

We have likely evolved with biases (physical
and mental) that work well for the
Scales we experience

Eye resolution vs. body height
 (y) (x)

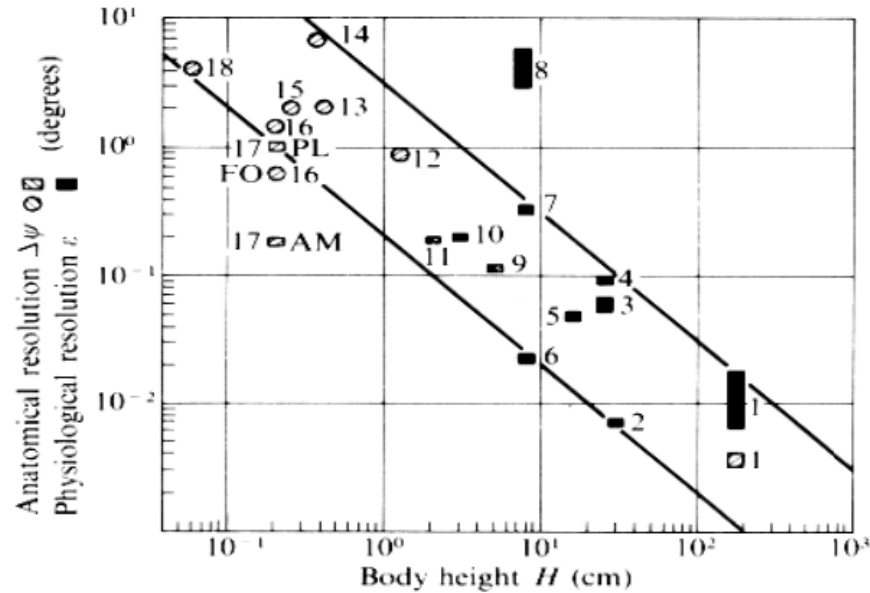


Fig. 2.9. Resolution of the eyes of various animals measured physiologically and deduced from anatomical criteria compared to body height: (1) man; (2) peregrine falcon; (3) hen; (4) cat; (5) pigeon; (6) chaffinch; (7) rat; (8) bat (*Myotis*); (9) frog; (10) lizard; (11) minnow; (12) dragonfly (*Aeschna*); (13) bee (*Apis*); (14) *Chlorophanus*; (15) housefly (*Musca*); (16) hover fly (*Syrrita*), frontal region FO; (17) jumping spider (*Methaphidippus*), anteromedian eye AM, postero-lateral eye PL; (18) fruit fly, *Drosophila*. (From Kirschfeld 1976.)

Example of place
 where evolution
 supplies a bias
 that fits
 the scale of
 the species
 need/experience

Beware of the "human bias"

You have faulty intuition

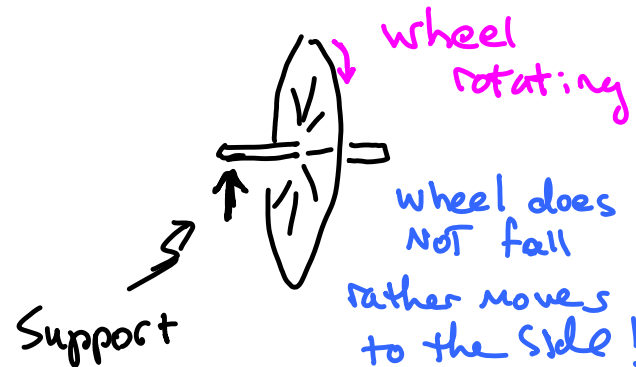
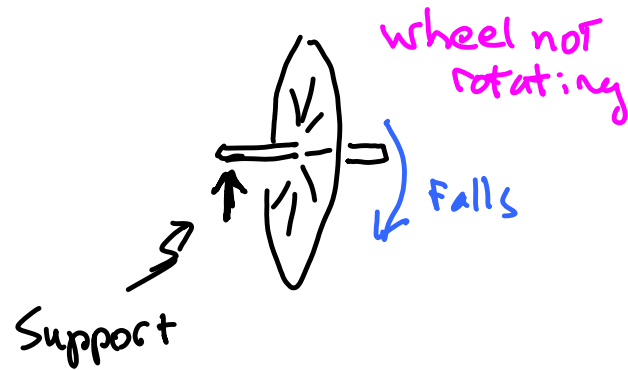
you have built in bias that may lead you to expect something that is not, after all, how nature operates

Physics has much of this:

- light is both a wave and a particle
- At large velocities the nature of space and time are not at all what we think intuitively
- ⋮

If you do careful observations... even at "human" scales nature has some surprises

bicycle wheel demo

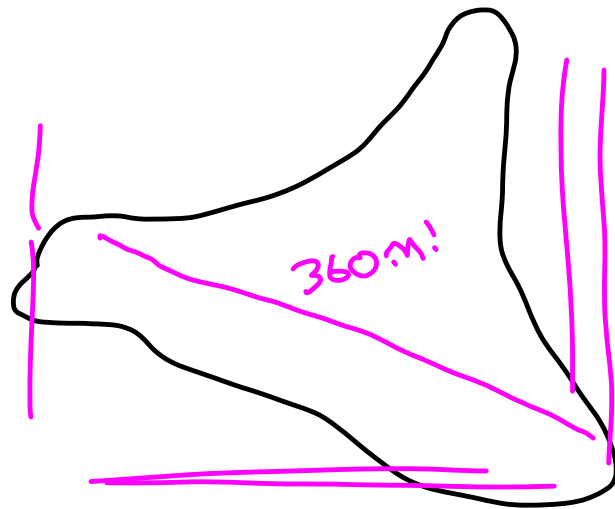


Even at everyday scales physical effects can surprise you. Physics uses mathematical formalism to avoid such pitfalls. It may seem tedious at times ... but is necessary

Surprise!

How many birds are in NY State?

10 birds / football field



$$\frac{1}{2} 360 \text{mi}^2$$
$$\hookrightarrow 64800 \text{mi}^2$$

$$1 \text{ yard} \times 3 \frac{\text{ft}}{\text{yd}} \times \frac{1 \text{ Mi}}{5280 \text{ ft}} = .0006 \text{ Mi.}$$

$$100 \text{ yd} \times 50 \text{ yds} \rightarrow .0016 \text{ Mi}^2$$

$$\frac{10 \text{ birds}}{.0016 \text{ Mi}^2} = \frac{x \text{ birds}}{64800 \text{ Mi}^2}$$

405 Million birds