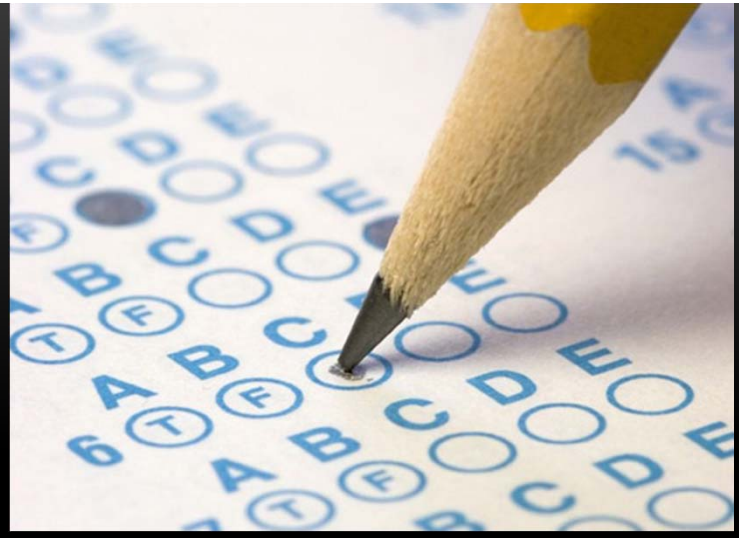
TEST IS COMING



- Test on Friday, 9/22
  - Ch.1 through Ch.5
  - Multiple choice, bring #2 pencil, eraser, & your ACT testing skills
  - No need for calculator
  - No phones
- Work through the practice test posted on the class webpage, end of chapter stuff in Mastering

ORBITS AND ENERGY

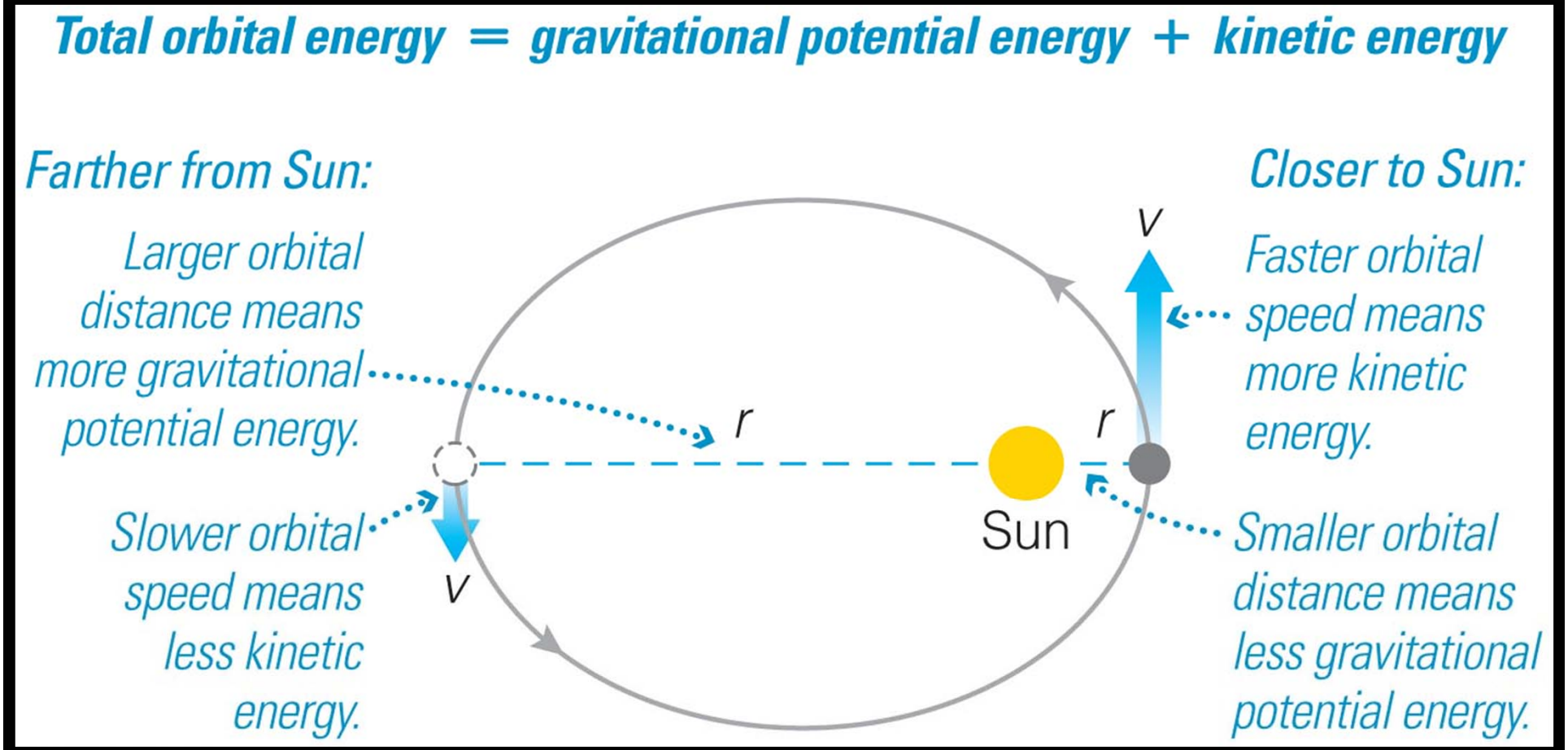
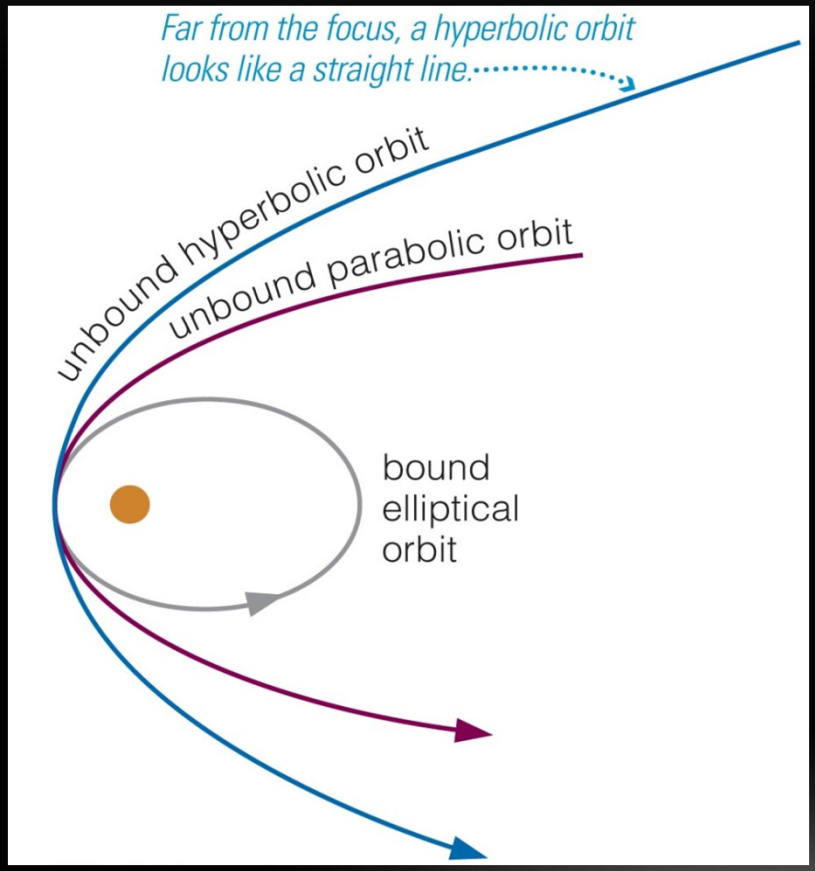


Fig.4.16

ESCAPE VELOCITY

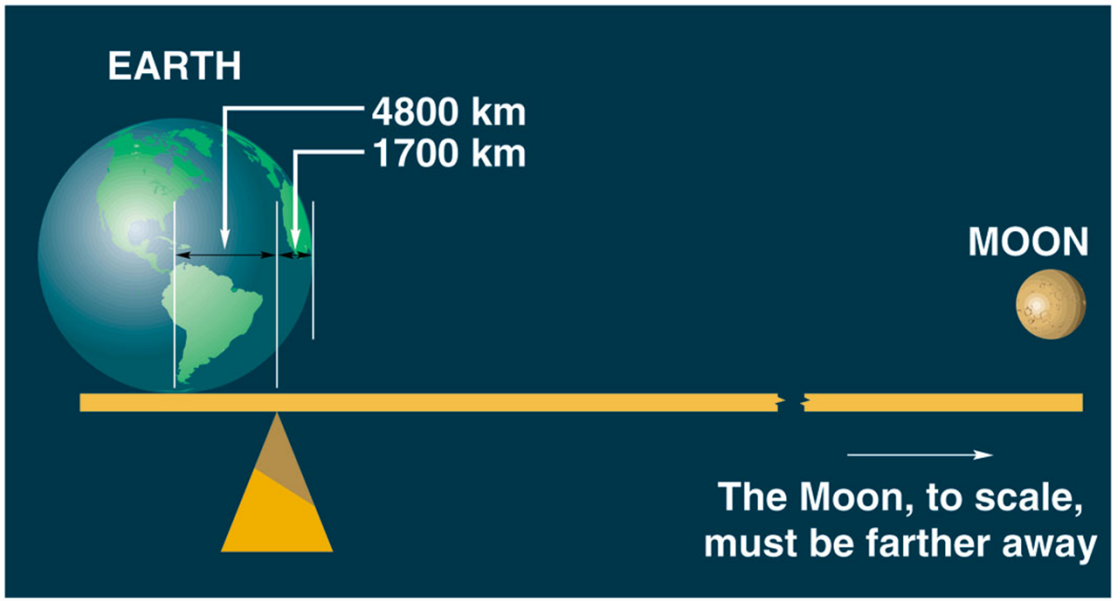


- Add more kinetic energy than there is gravitational potential energy, and things don't orbit: they escape!
- These "unbound" orbits are parabolas or hyperbolas rather than ellipses

PLAY

Fig.4.15

ORBITS AND THE CENTER OF MASS



- If the Earth pulls on the Moon – by the 3rd law, the Moon should also pull on the Earth
  - Earth goes around Moon too!
- A *binary* system like the earth and moon spins about the *center of mass* of the system

ANOTHER PREDICTION FROM NEWTON:

- If all bodies attract one another, shouldn't the planets attract each other too?
  - Newton predicts – yes, but much less than from the much heavier Sun
  - Jupiter should slow down Saturn as Saturn passes
- Newton asks Royal Astronomer John Flamsteed if this happens
  - It had been observed!
  - … and later, this effect was used to discover Neptune

CHANGING ORBITS

- So how do you change an orbit?
  - Add or subtract kinetic energy from the thing in orbit
- Add:
  - burn rocket fuel
  - Steal energy from some other object with gravity
- Subtract:
  - Friction from atmosphere
  - Give energy to some other object with gravity
  - Or burn rockets pointed backwards to slow down

EXAMPLE: BOOSTING TO A NEW ORBIT

- Works both ways: can fire rocket to slow down

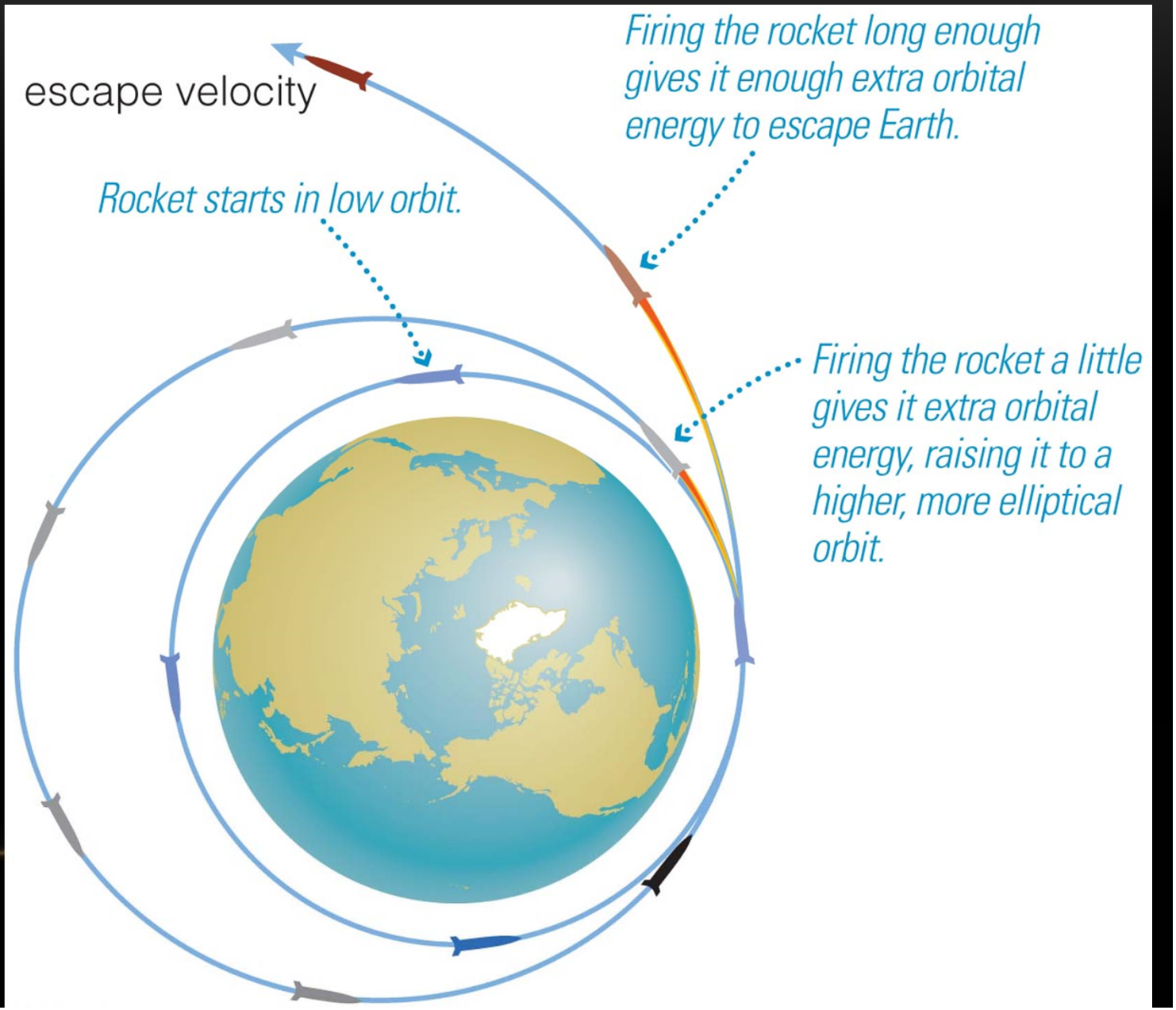


Fig.4.18

CASSINI, TODAY!

- This morning at 6:54am the Cassini spacecraft did a final rocket burn to slow down, and crashed into Saturn
- In Ch.8: all the great Saturn pictures came from this spacecraft over the past 13 years

Follow this link for a very cool 3D Cassini Grand Tour webpage from National Geographic

EXAMPLE: GRAVITATIONAL INTERACTION

- Works both ways: come in ahead of or behind the big thing?

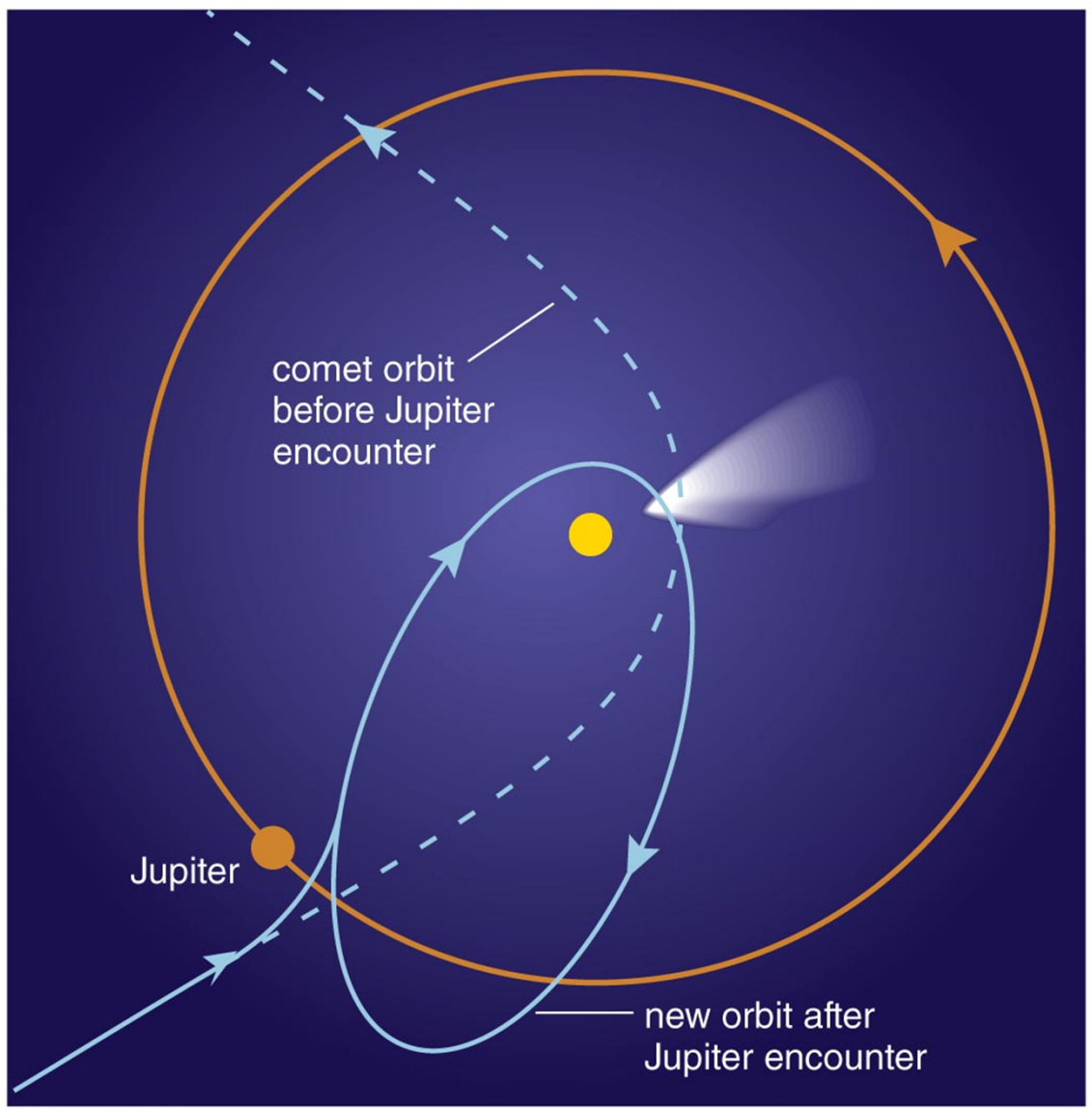
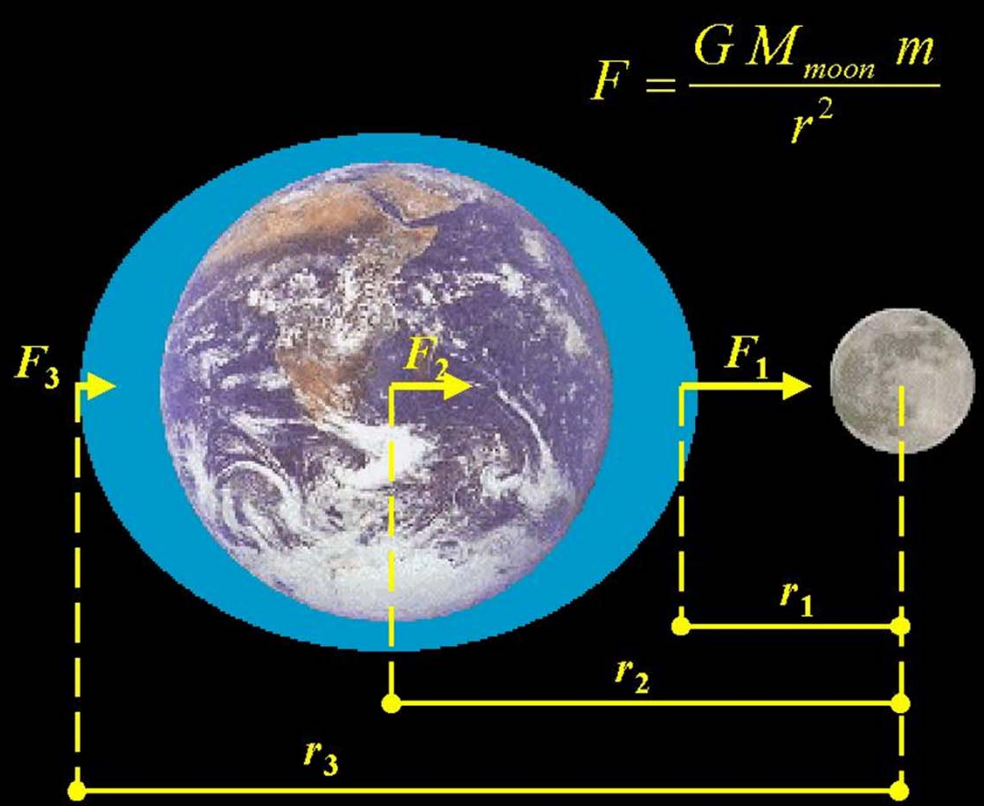


Fig.4.18

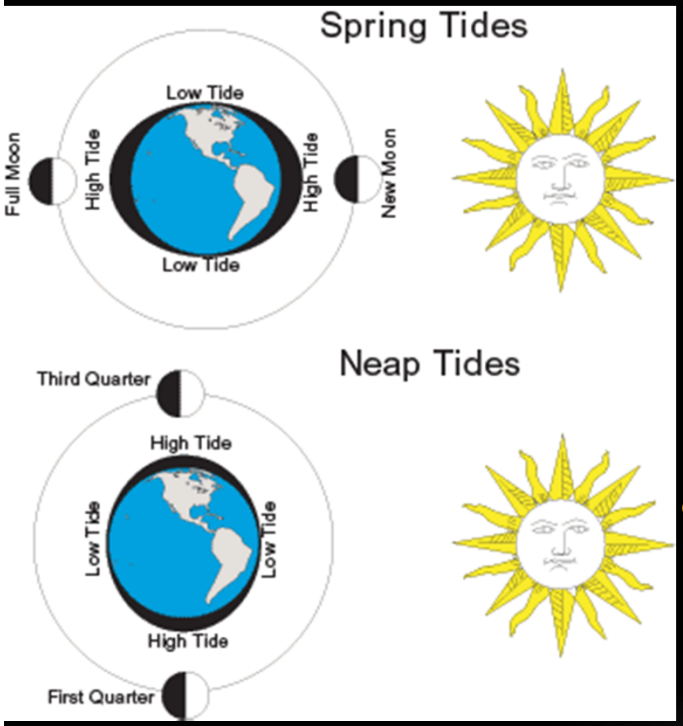
OTHER EFFECTS



- Tides
  - The Moon's pull on the Earth's Ocean is *differential*
    - Stronger near to Moon
    - Weaker far from Moon
  - Oceans bulge out
  - Earth spins under bulge
  - We see Ocean rise and fall twice per day

PLAY

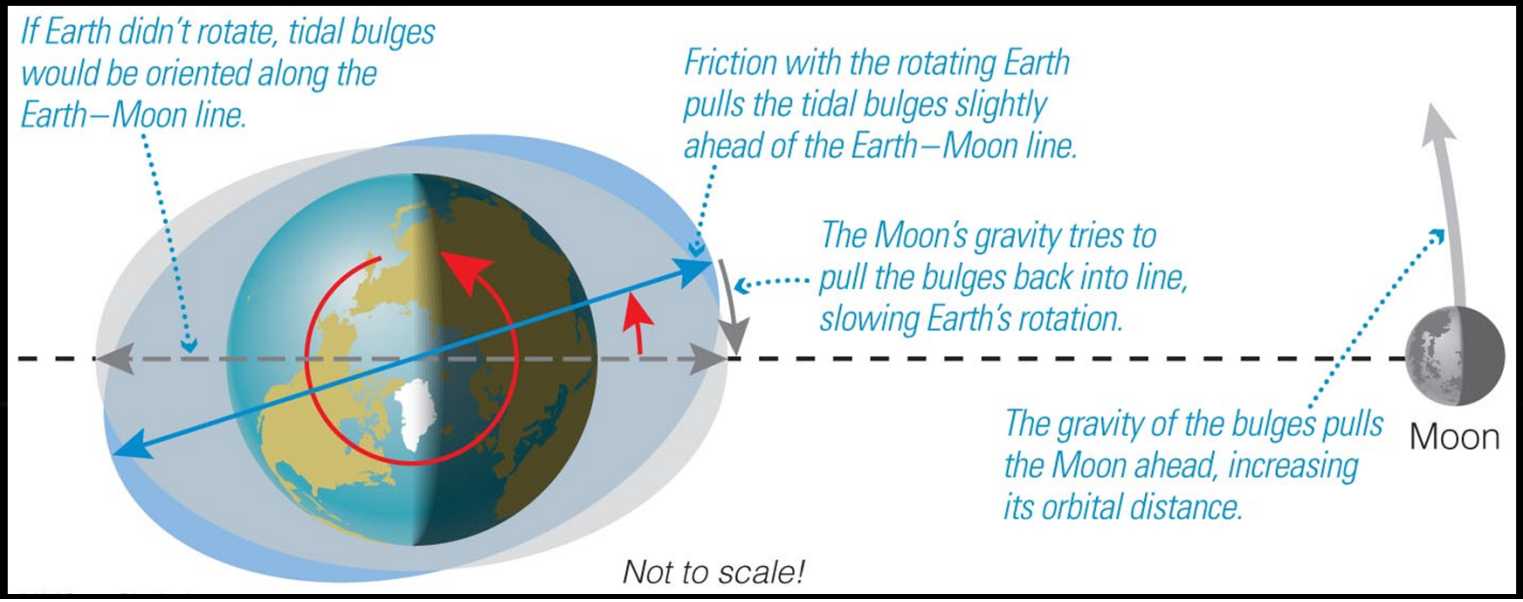
MORE TIDES



- The pull of the Sun also makes tides
  - A smaller effect than the moon, but…
  - if pull of Moon and Sun line up, extra large *spring tides* happen
  - if Moon and Sun are pulling sideways, extra small *neap tides* happen
- The Earth itself stretches tidally too!
  - At most about 9 inches

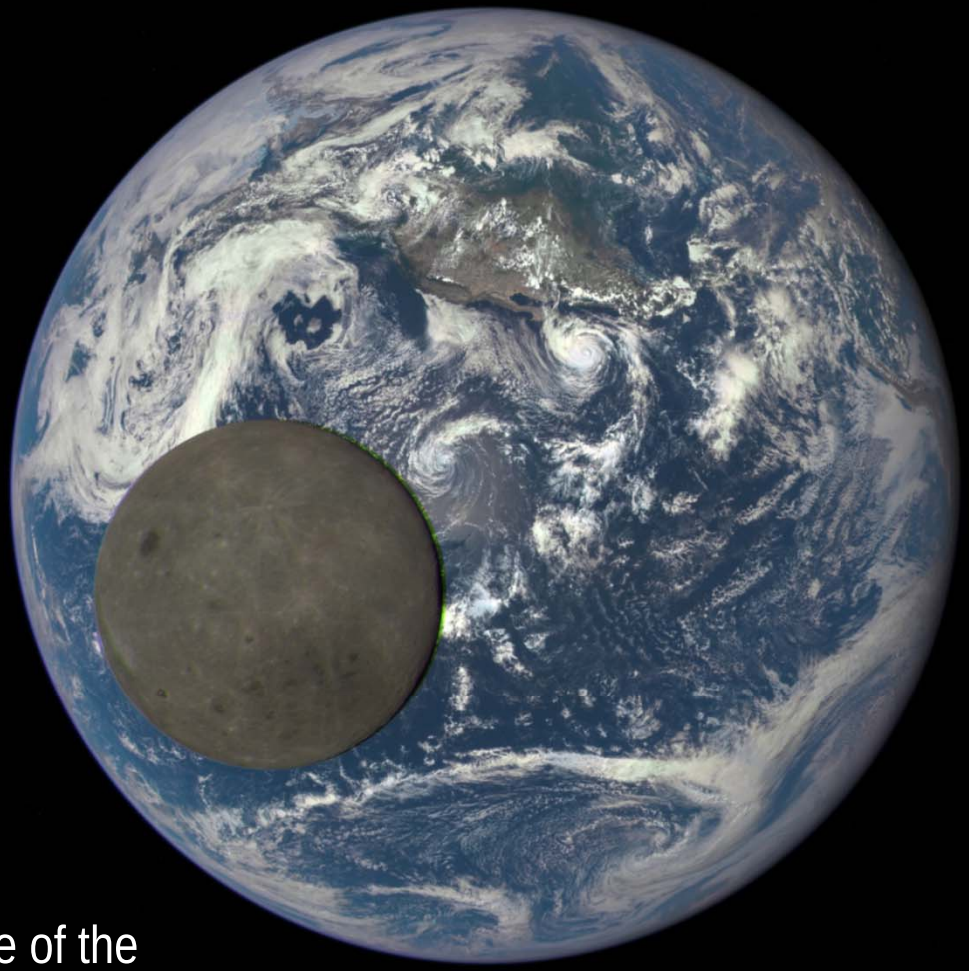
MORE MOON EFFECTS

- All that sloshing about creates tidal friction
  - Slows down rotation of Earth (25 ns/day)
  - Lets moon slip away (1 cm/year)
- On Moon, tide-like action has *tidally locked* one side of the moon (the denser side)
  - The same side of the Moon always points at the Earth
- Precession
  - Moon pulls slightly squashed Earth over, causes axis to precess once each 26,000 yrs (like a top)



SAME SIDE OF THE MOON

- We always see the same side of the moon
  - why?



View back at Earth and the far side of the moon as seen by NASA's DSCOVR spacecraft

THE MOON IS OFF-BALANCE

- Like a Weeble or Punching Bag, the heavier side points “down”

Moon and ISS from Austrailia
by Dylan O’Donnell

LUNAR LIBRATIONS

- Over time, tidal friction slows the wobbles until we barely notice them
  - Still there, we call them “Librations”
  - Lets us see 59% of the moon’s surface

"Lunar libration with phase Oct 2007"
by Tomruen from wikipedia

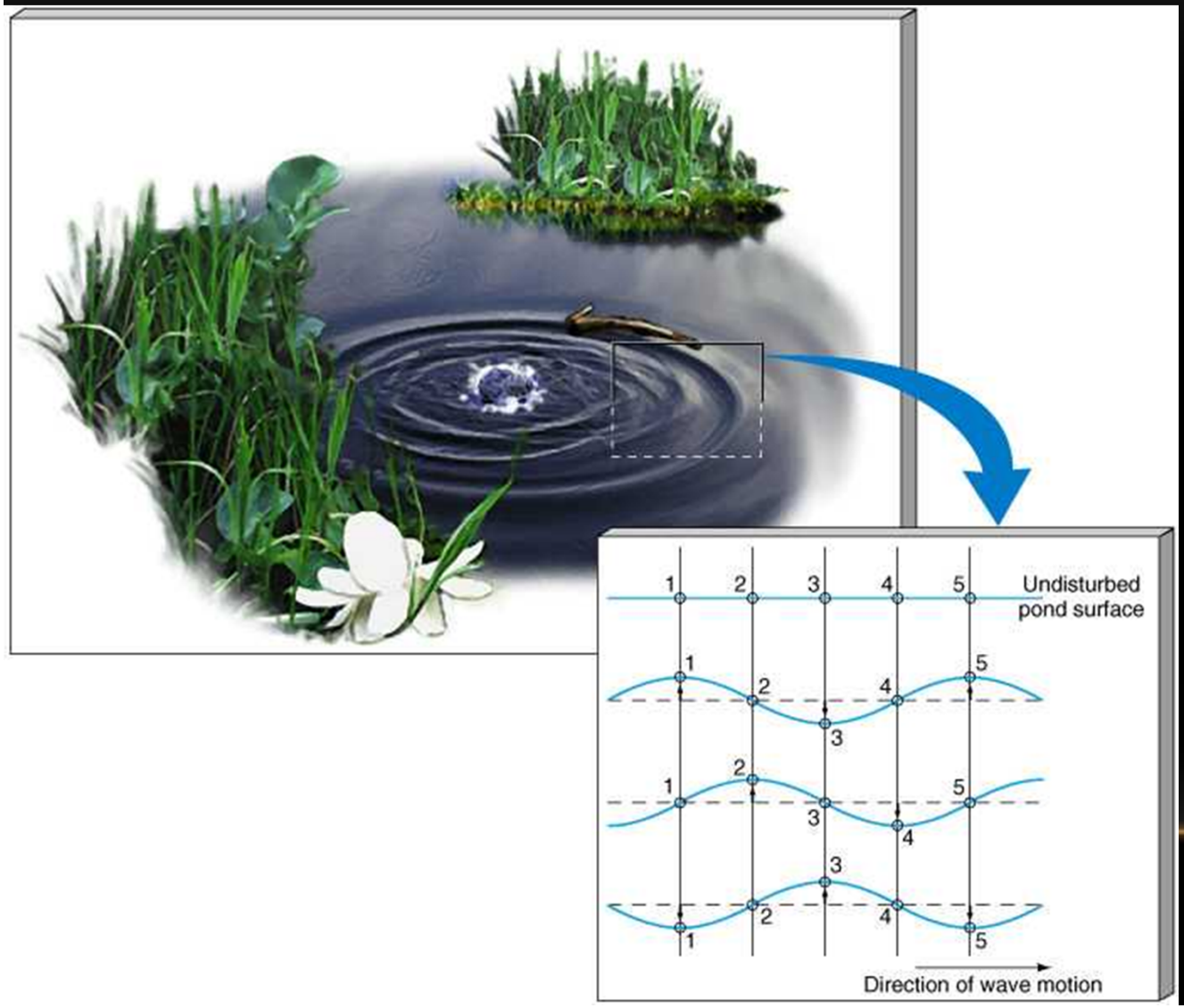
LIGHT AND MATTER

How can we tell what's going on up there?

MODELS AS TOOLS

- So far, we've watched the theory of gravity and planetary motion get assembled
- In Ch.5, we will see many models presented in their current form
  - Use them as tools
  - They also were carefully put together
  - But we'll not follow their story completely
- All have been tested carefully, make accurate predictions, and have convincing theories of "why" backing them up

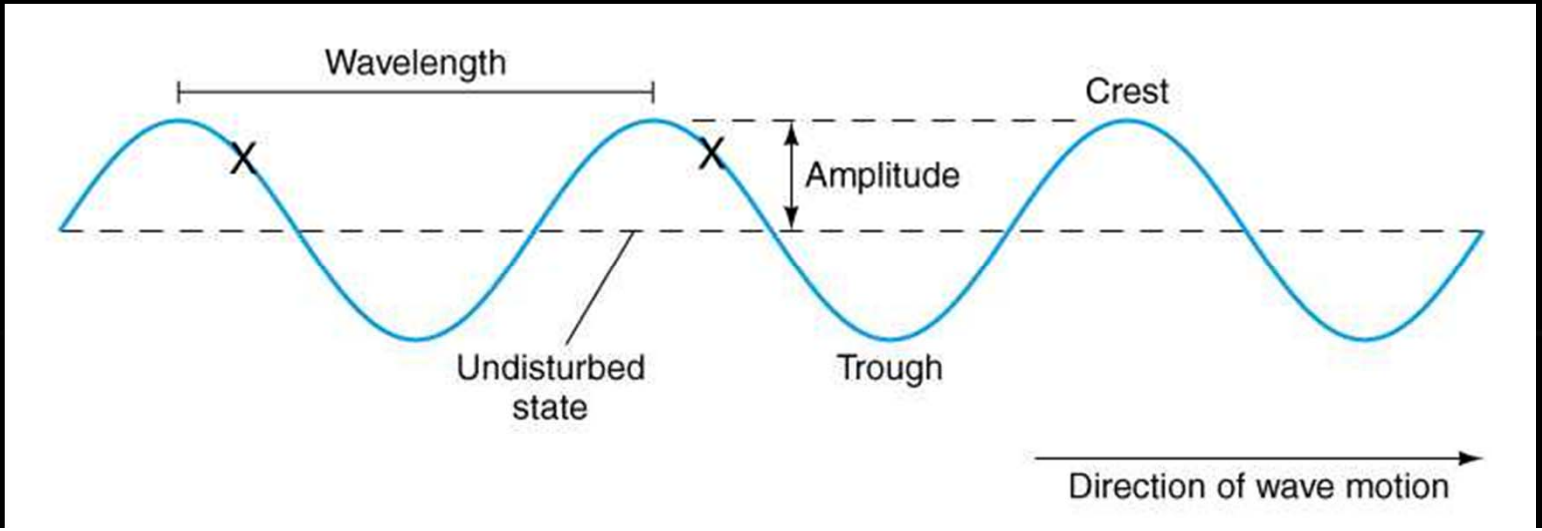
WAVE MOTION

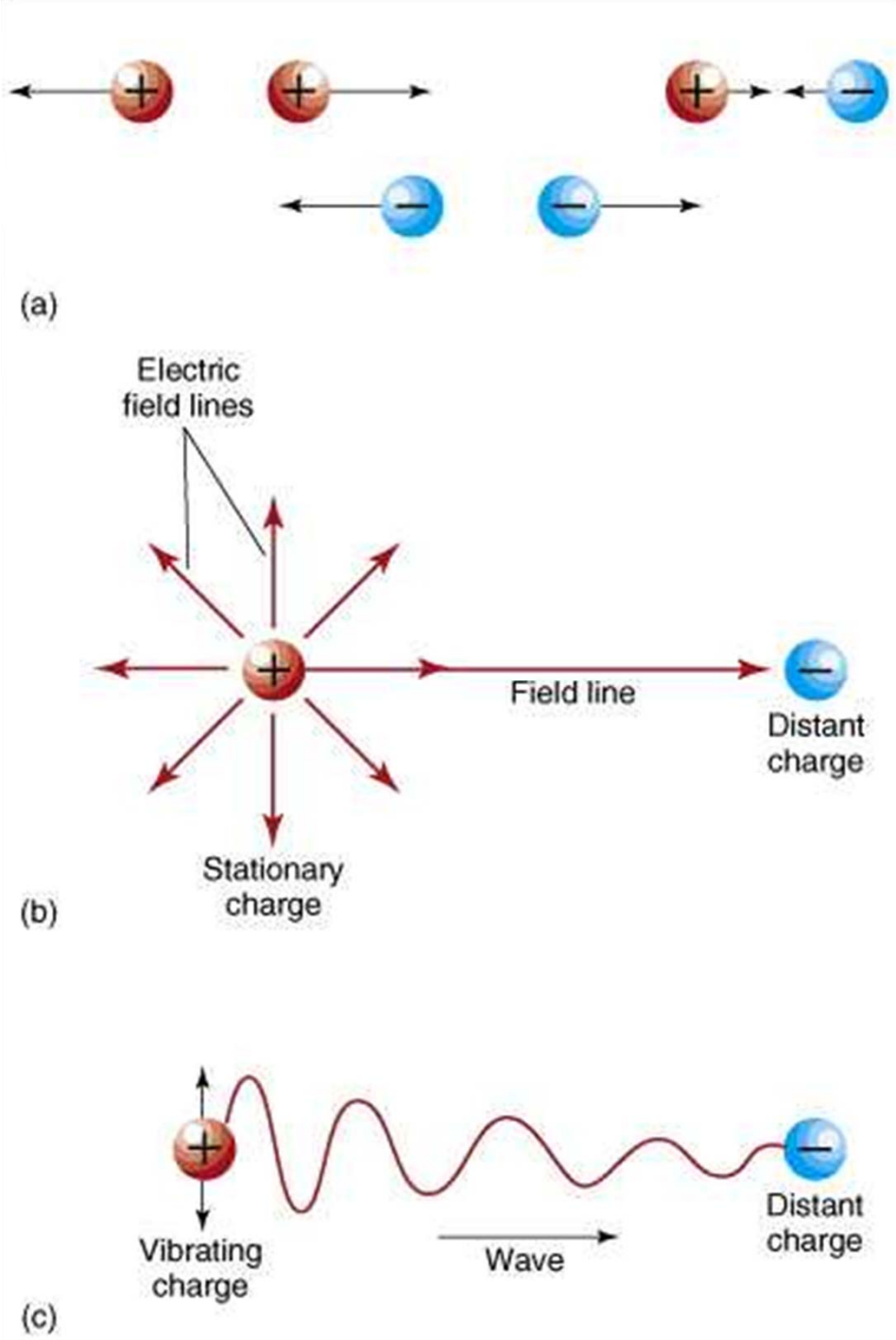


- Waves in water pass by a stick
- The water doesn't travel – the wave does
- Stick bobs up and down

WAVE ANATOMY

- Wavelength – length of wave
- Amplitude – height of wave
- Period
  - how long for one complete wave to pass you
- Frequency
  - How many complete waves pass you per second?

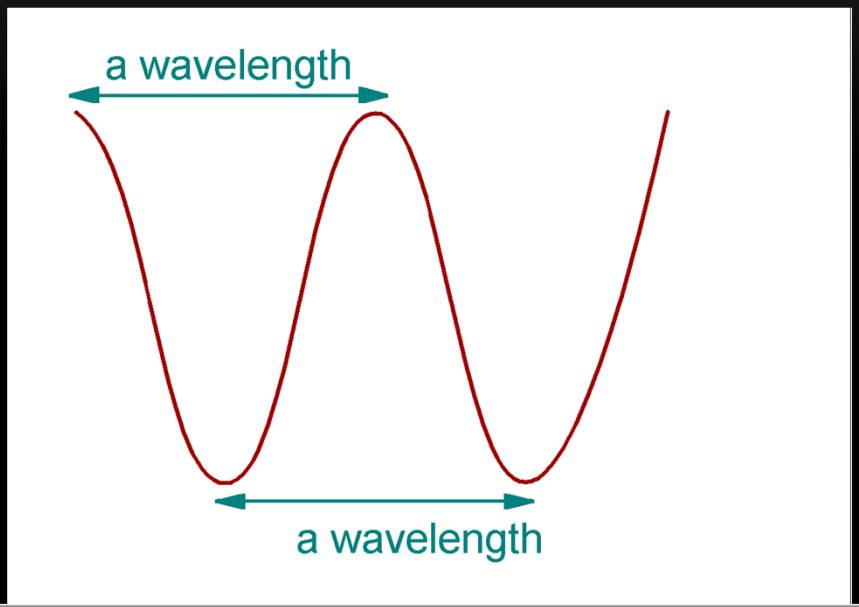


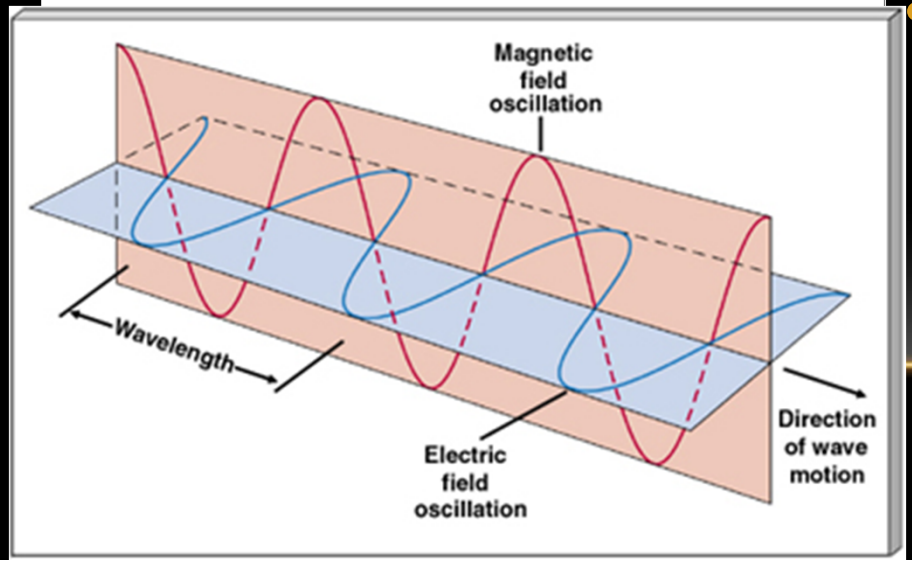


ELECTRIC FIELDS

- Opposite charges attract, like charges repel
- The force which does this can be thought of as lines
- Wiggle a charge – the line wiggles

WHAT IS LIGHT?





- A wave
  - Wiggling Electric and Magnetic fields
  - Has wavelength λ
  - Frequency *f*
  - Travels at c = λ x *f*
  - c constant at 186,000 mi/sec (300,000 km/s)
- Electromagnetic Radiation
  - Visible light is a small part of this
  - Comes in tiny bits called “photons”

SPEED, WAVELENGTH, AND FREQUENCY

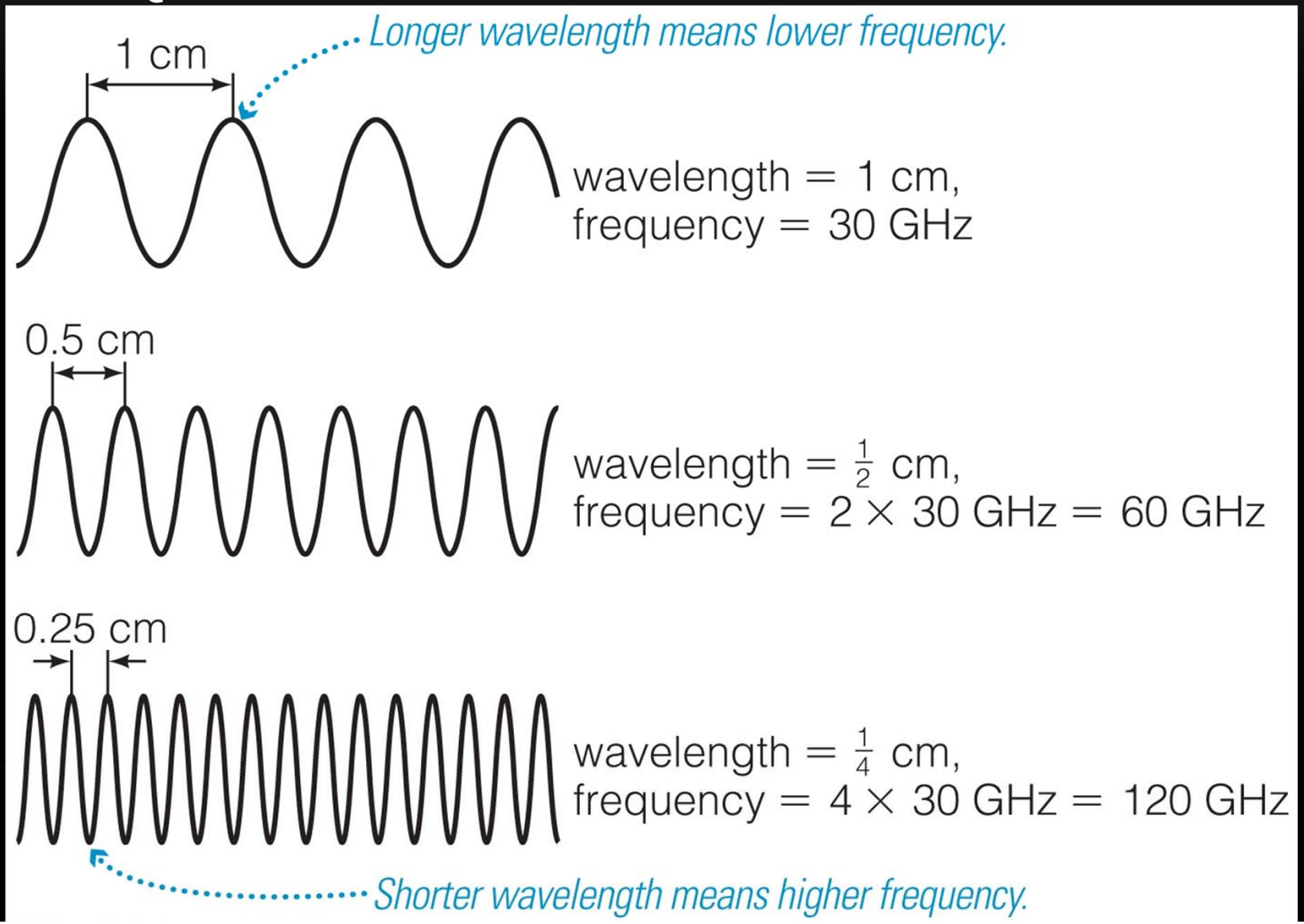


Fig.5.4

WAVELENGTH, FREQUENCY, AND ENERGY

$$\lambda \times f = c$$

λ = wavelength, f = frequency

$c = 3.00 \times 10^{8}$ m/s = speed of light

$$E = h \times f = \text{photon energy}$$

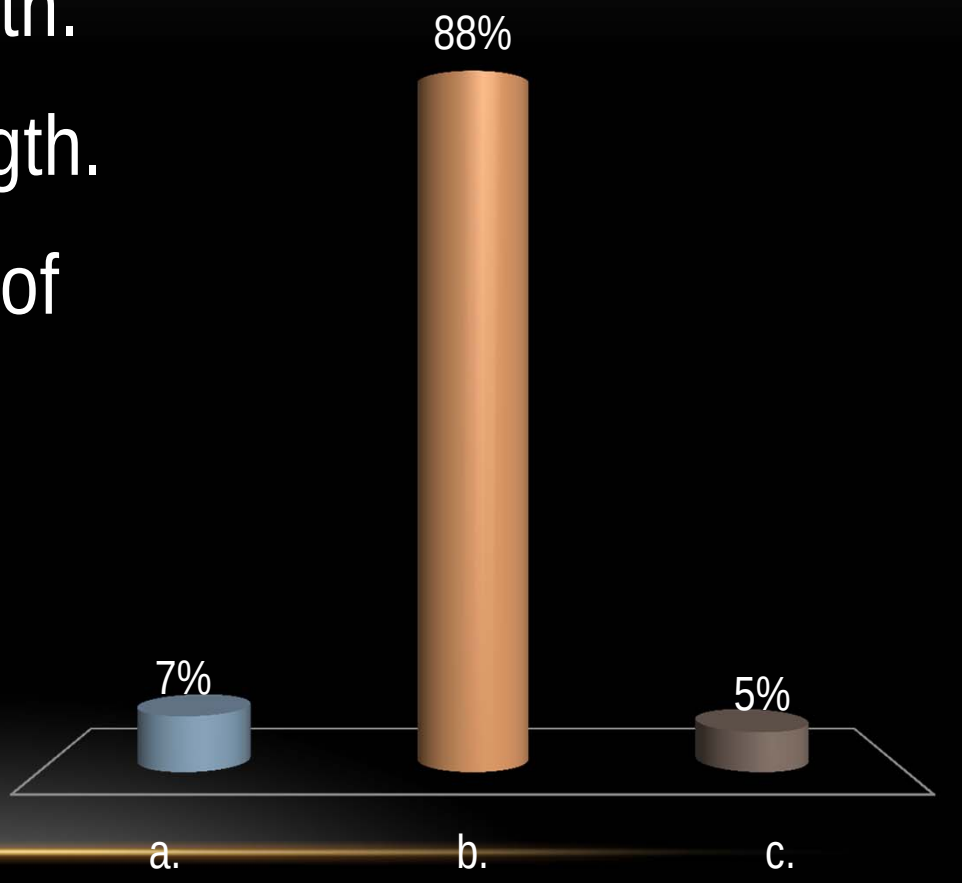
$h = 6.626 \times 10^{-34}$ joule × s

THE HIGHER THE PHOTON ENERGY…

a. the longer its wavelength.

✓ b. the shorter its wavelength.

c. Energy is independent of wavelength.



IMPORTANCE FOR ASTRONOMY

- We can’t go out there to take samples of stuff or run experiments
- Light contains all the information we will ever get from most of the universe
- So, we must understand light, and how it can be used to find out about where it was made and what happened to it on the way here

MATTER

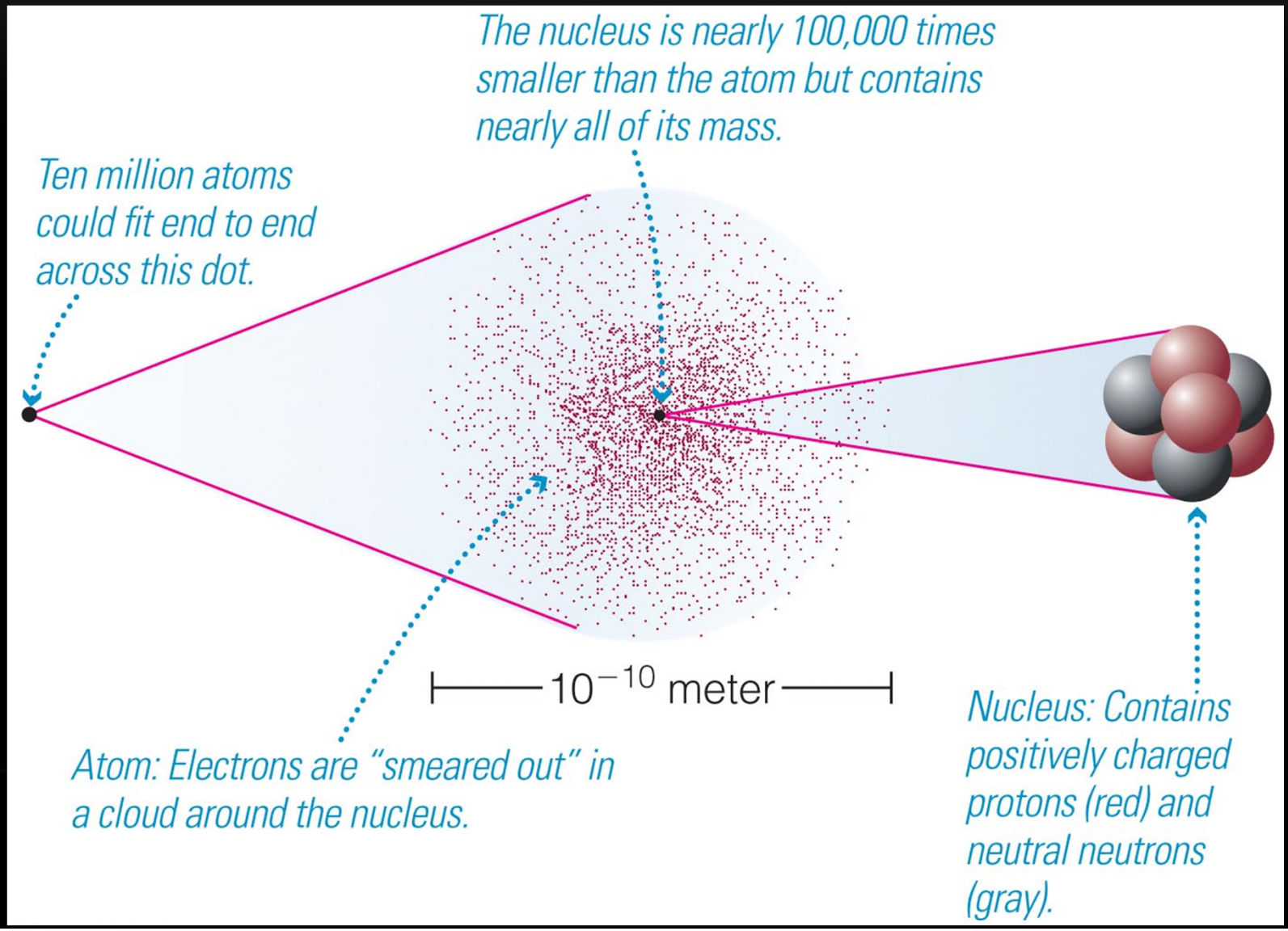


Fig.5.5

ATOMIC TERMINOLOGY

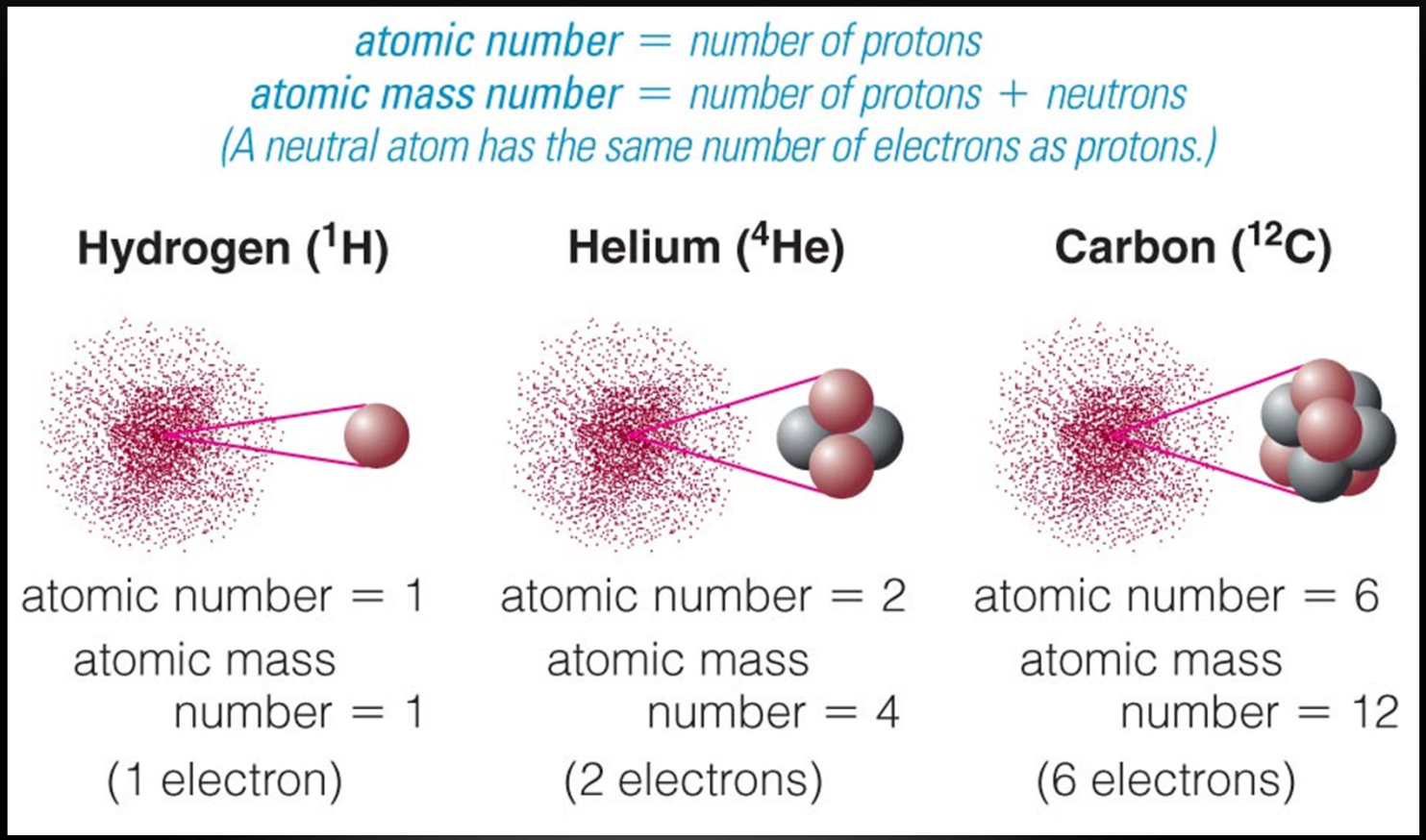


Fig.5.6

MORE TERMINOLOGY

- Isotope: same # of protons but different # of neutrons (^4He, ^3He)
- Molecules: consist of two or more atoms (H_2O, CO_2) stuck together

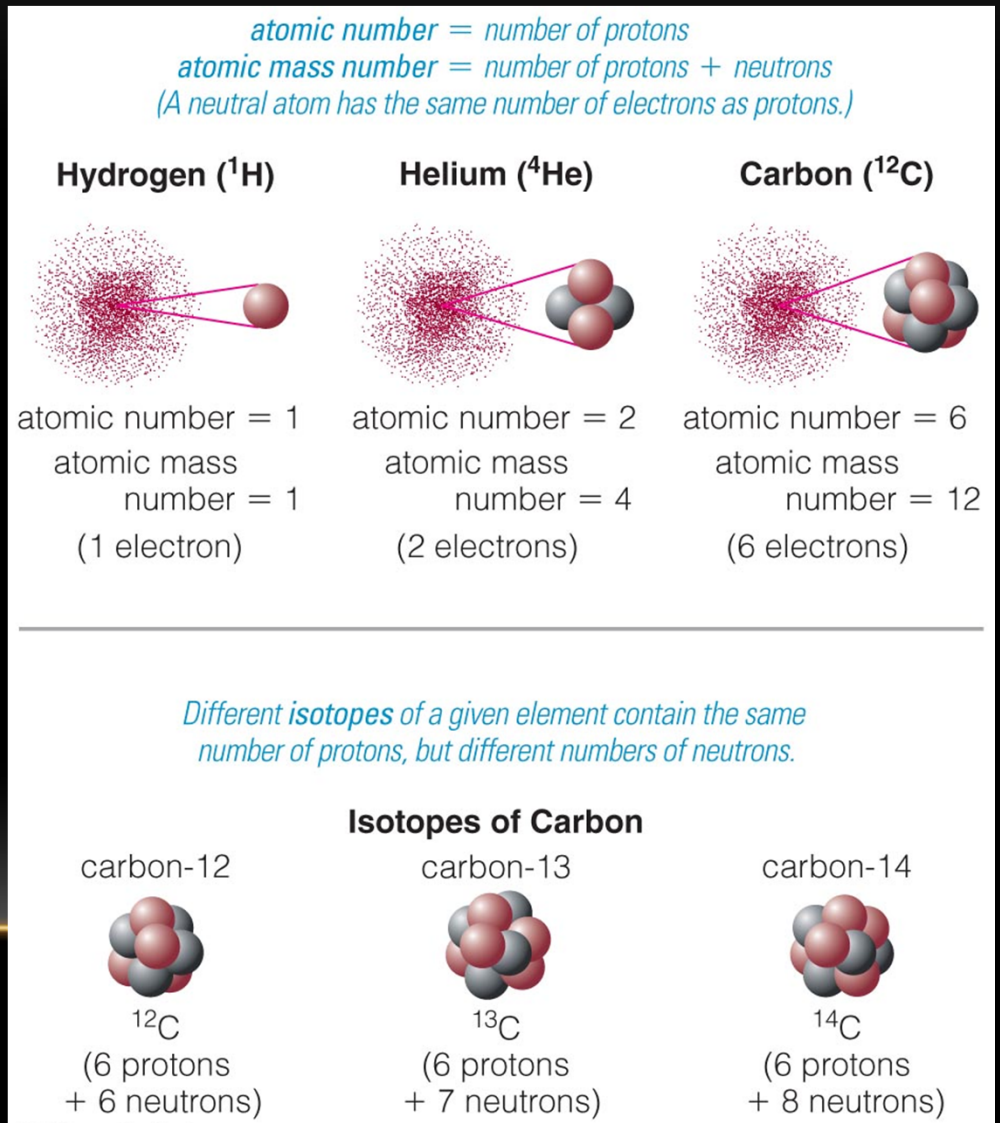


Fig.5.6