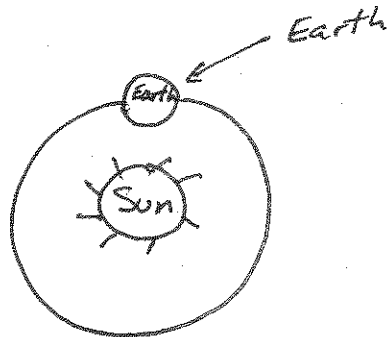
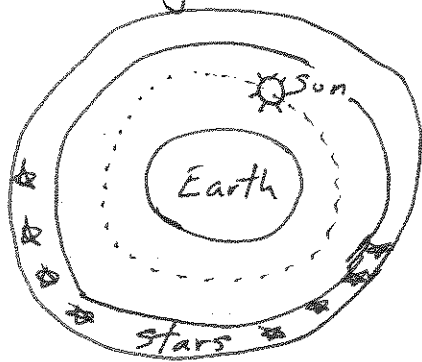


Cosmology and the Birth of Earth

Ch. 1

Explanations of stars/planets configuration

Geocentric Model vs Heliocentric Model



- Earth @ center
- Surrounded by:
 - air
 - fire
 - other planets
- All contained within globe of stars

- Most believed the geocentric model, as theorized by Egyptian mathematician, Ptolemy
- Church leaders adopted Ptolemy's geocentric model as dogma, because it selfishly shows ~~to~~ us (Earth) being central and most important place in the universe

Nobody dared to disagree! you could be killed.

Copernicus / Galileo Galilei
(1473-1543) (1564-1642)

Earth and Planets orbit the Sun

But couldn't explain it.

Neptune
Uranus
Saturn
Jupiter
Asteroid belt
Mars
Earth
Venus
Mercury
Sun
Mercury
V
E
Mars
A.B.
J
S
U
N

Isaac Newton
(1643-1727)

Explained gravity
↑

"One object exerts a force on another"

Newton's theory of gravity opened up possible explanations to heliocentric model

Studies with Telescopes

- We found other planets
- " " moons orbit most planets

Earth travels 150 Million Km per year (completing one orbit)

Solar System

Sun - Planets - moons - other small objects
HELD TOGETHER BY "GLUE" of gravitational attraction

That means → 107,300 Km/h
or 67,000 mph

Total Mass of Solar System
Sun - 99.8%
all else - 0.2%

- Planets, defined -
- ① an object that orbits a star
 - ② is spherical
 - ③ Pulls in all particles of matter in it's orbit.

Our Solar System includes 8 planets

Just outside Neptune

→ Pluto does not fit the modern description of a planet

What Defines a Moon?
 A sizeable body locked in orbit around a planet

Did you know?

All BUT ~~THE~~ PLANETS HAVE MOONS.

EARTH'S ^{MOON} IS LARGE & SPHERICAL

MOST ARE IRREGULARLY SHAPED & SMALL

EXTRA-SOLAR PLANETS -
 PLANETS WHICH DON'T ORBIT EARTH'S SUN, INSTEAD ~~THEY~~ THEY ORBIT A DIFFERENT STAR

OUR SOLAR SYSTEM OF PLANETS

ASTEROIDS

CHUNKS OF ROCKS AND/OR METAL
 FORM A BELT BETWEEN MARS & JUPITER
 < 1cm → 930KM (IN DIAMETER)

INNER PLANETS (CLOSER TO SUN)

- MERCURY
- VENUS
- EARTH
- MOON MARS

- SMALL
- KNOWN AS TERRESTRIAL PLANETS
- CONSIST OF A SHELL OF ROCK SURROUNDING A BALL OF METALLIC IRON ALLOY

OUTER PLANETS

- 318x EARTH JUPITER
- SATURN
- URANUS
- NEPTUNE

- MOST OF MASS CONSISTS OF GAS & ICE
- HUGE
- KNOWN AS GAS GIANT PLANETS

NOT JUST WATER VAPOR. ENCLOSED TERRESTRIAL THAT ARE GASEOUS AT SURFACES THAT

ALSO, ICE BELTS, OR CLOUDS BEYOND NEPTUNE
 Trillions includes PLUTO 2,000 KM IN DIAMETER
 ANY CALL THEM ICE BELTS

CLASS TO READ

Box 1.2 9. 18-19

(A) NEWTON (FORCES)

- MECHANICAL FORCE
- ONE MASS COMES IN CONTACT WITH ANOTHER
- NONCONTACT FORCE, OR FIELD FORCE
- EX Gravity & Magnetism

ABOUT "DWARF PLANETS"

(B) DISCOVERING PLANETS 4

PLANETS SEEN w/ Naked Eye
Earth Mercury Venus Mars
Jupiter Saturn

w/ Telescopes ... Uranus

Uranus' path is altered by Neptune's gravitational force
Pluto alters Neptune's in same way

Kuiper belt -
100 objects, like Pluto, outside of Neptune's orbit (up to 10x Neptune's radial orbit)

THE GRAVITATIONAL PULL OF THE MAIN PLANETS ON DWARF PLANETS RESULTS IN ICY OBJECTS TAKING PATHS TOWARD INNER PART OF SOLAR SYSTEM, WHERE THEY BEGIN TO EVAPORATE AND FORM LONG TAILS. THESE ARE CALLED COMETS

p.20

DEFINITION OF A STAR

IMMENSE BALLS OF INCANDESCENT GAS IN WHICH NUCLEAR FUSION REACTIONS PRODUCE INTENSE HEAT AND LIGHT.

EX: OUR SUN IS A MEDIUM SIZED STAR

GRAVITY HOLDS STARS TOGETHER, CALLED GALAXIES

SUN + 300 Billion stars form Milky Way GALAXY

OVER 100 Billion galaxies in the UNIVERSE

OUR SOLAR SYSTEM IS CURRENTLY AT THE OUTER EDGE OF THE GALAXY

- ROTATES TO CENTER EVERY 250 million years

EARTH MOVES THROUGH SPACE @ $\frac{200 \text{ km}}{\text{SEC}}$

10K RUN = 6.2 miles

100K = 62 miles

200K = 124 miles → every second!

ESTIMATING THE EARTH'S SIZE

(276-194 B.C.E)

GREEK ASTRONOMER ERATOSTHENES

IN SYENE, SOUTHERN EGYPT, SUN LIT A DEEP VERTICAL WELL ON 1ST DAY OF SUMMER (NOON).

SUN'S RAYS ARE EXACTLY PERPENDICULAR TO EARTH SURFACE.

IF EARTH WERE ROUND, SUN COULD NOT BE PERPENDICULAR @ other parts of earth at same time. ex: Not @ Alexandria, 800km north of Syene

HE MEASURED THE ^{SHADOW} ANGLE FROM A TOWER AT NOON IN ALEXANDRIA ON 1ST DAY OF SUMMER

$$\frac{7.2^\circ}{800\text{km}} = \frac{360^\circ}{n \text{ km}}$$

$$n = 39,300 \text{ km} \quad \text{-OR-} \quad 24,421 \text{ mi}$$

TODAY'S ACCEPTED VALUE = 24,865 mi

DISTANCE FROM EARTH TO MOON

200 B.C.E. GREEK MATHEMATICIANS FIGURED ^{DISTANCE TO} A MOON IS 30X EARTH'S CIRCUMFERENCE

17th CENTURY

MEAN DISTANCE BETWEEN EARTH & SUN IS 149,600,000 KM
-OR- 93,000,000 mi

BUT THEY COULD NOT MEASURE DISTANCE FROM EARTH TO STARS. FIGURED THEY MUST BE MUCH FARTHER.

1838

NEAREST STAR TO EARTH, α CENTAURI IS 40.85 TRILLION ^{KM} ~~MILES~~ AWAY!

IF SUN WERE THE SIZE OF AN ORANGE

THEN EARTH WOULD BE THE SIZE OF A SESAME SEED

THEIR DISTANCE WOULD BE 15 m

α -CENTAURI WOULD BE 2,000 km (1,243 mi)
from the orange

FACTS

Light travels @ a speed of 186,000 miles/sec

So...

- Light from earth to moon = 1.3 sec
- Distance moon \rightarrow Earth = 1.3 Light sec
- " Sun \rightarrow Earth = 8.3 Light ~~sec~~ ^{minutes}

1 Light year = 9.5 Trillion km (6 Trillion Miles)

When you look at α -Centauri that is 4.3 Light ^{YEARS} AWAY...

... You see the light that started it's journey to earth about 4.3 ^{light} years ago.

MILKY WAY = 100,000 Light YEARS across

ANDROMEDA = 2.2 million LIGHT YEARS AWAY

EDGE OF VISIBLE UNIVERSE = OVER 13 Billion Light years away

THIS MEANS THAT LIGHT TRAVELING TO EARTH FROM THIS LOCATION BEGAN ITS JOURNEY ABOUT 9 Billion years BEFORE EARTH'S EXISTENCE

DIMENSIONS OF THE UNIVERSE ARE STAGGERING

So, THE BIG INITIAL EXPLOSION ...

BIG BANG

Fig 1.6

FROM A UNIVERSE AS AN INFINITELY SMALL POINT TO AN EXPLOSION ~ 13.7 Billion years ago

@ explosion, initially so hot that universe consisted of just atoms & smallest subatomic particles that make up atoms.

ENERGY ... NOT WHAT IS X'd out above

after a few seconds ... Temperatures cooled enough for Hydrogen atoms to form

@ ~ 3 minutes, temperatures dropped to below 1 Billion degrees (35 million miles)

- Universe diameter 53 million km
- Hydrogen atoms fused to make Helium atoms

(Big Bang Nucleosynthesis - formation of new nuclei)

Took less than 5 minutes for all BBN to occur \rightarrow Atom # 's \rightarrow < 5

Then ... molecules formed by chemical bonding of atoms.

ex:



With cooling of ~~un~~ universe, molecules slowed down and formed Nebulae, patchy clouds.

74% Hydrogen, 24% Helium

Box 1.4

BIRTH OF FIRST STARS

@ 200 million years ...

Universe looked like swirls of dark nebulae, separated by vast voids of empty space.

Gravity, now, began to shape the universe further

NEWTON - ALL MATTER EXERCISES GRAVITATIONAL PULL

So...

MORE MASSIVE REGIONS OF NEBULAE COULD ATTRACT OTHER PARTICLES (gas).

↳ MASS

↳ DENSITY

... ↳ SWIRLING MOVEMENTS led TO ROTATION AROUND AN AXIS

ILLUSTRATIONS
P. 30-31

AS GAS MOVED INWARD, ROTATIONS BECAME FASTER, FORMING DISK SHAPED NEBULAE

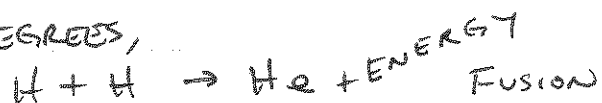
Gravity collapses inner portions of disks into a dense ball

gas compressing into smaller space
↳ temperature

making central ball of disk to glow.
Called a PROTOSTAR

WHEN A PROTOSTAR'S ρ IN TEMP REACHES

10 MILLION DEGREES,



IN THE 1ST PROTOSTAR, INITIAL FUSION REACTIONS
RESULTED IN IGNITION, AND A STAR IS BORN
(\sim 800 Million years after Big Bang)

THIS HAPPENED MANY TIMES, FORMING
1ST GENERATION STARS.

1ST GENERATION STARS WERE LIKELY 100X SUN'S MASS

BIGGER STARS ARE BRIGHTER & BURN OUT FASTER.

AFTER 3-10 MILLION YEARS, IT EXPLODES
INTO A SUPERNOVA

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P.27

WHERE DID ELEMENTS COME FROM? 92 Elements

ONLY 1-5 existed until now

Carbon, Sulphur, Silicon, Iron, Gold, Uranium, etc.

• THEY FORMED DURING THE LIFECYCLE OF STARS
CALLED

STELLAR NUCLEOSYNTHESIS

STARS ARE "ELEMENT FACTORIES"

- SOME ATOMS MOVE FAST ENOUGH TO SPIN OFF AND
OVERCOME THE GRAVITATIONAL PULL BACK TO THE STAR

THE "STREAMING" OF ATOMS FROM A STAR IS A
STELLAR WIND

- SOME ATOMS ONLY ESCAPE WHEN STAR DIES.
- Higher atomic #'d atoms require much more violent
CIRCUMSTANCES (Iron and Larger), LIKE A
SUPERNOVA EXPLOSION

2ND GENERATION OF STARS AND PLANETS FORMED FROM MORE DIVERSE NEBULAE, ALLOWING FOR ~~HIGHER~~ ^{HIGHER} ~~ATOMS~~ HEAVIER ELEMENTS TO FORM.

^{KEY POINT} SO, THE ELEMENTS THAT MAKE UP YOUR BODY ONCE RESIDED IN A STAR

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NEBULAR THEORY (origin of planets, moons, asteroids, & comets)

ALL THESE PLANETS FORMED FROM THE MATERIAL THAT WAS ^{SWIRLING} IN THE NEBULA

WHEN WE DISCUSSED THE CENTER OF A DISK DROPPING OUT, THE OUTER PORTIONS, PROTOPLANETARY DISKS, BECAME THE SOURCE FOR PLANET FORMATIONS

OF THE 92 elements formed, 2 types of materials ~~for~~ were originated

Volatile materials
H, He, CH₄, NH₄, H₂O, CO₂

These materials exist as a gas @ earth's surface

Refractory materials

These melt only at high temperatures, & condense to form solid ~~in~~ soot-sized particles of "dust" in the coldness of space.

Note:

Originally, the DISKS were homogenous, but the protosun was a source of tremendous heat @ center, causing a separation of materials, Volatile outside, and refractory inside. ^{to} "DUST"

@ formation of planets, first clumpings were very small. Then, small clumps collide... and if slowly, they would stick (inelastic collision). After several of these collisions, they were called planetesimals (1 km diameter). Now, they were large enough to have gravitational influence and pull in other objects nearby. When larger, they became protoplanets. After collecting all particles around it, a planet is formed.

(Time frame from "DUST" to ^{large planetesimals} ~~planet~~ = hundreds of thousands of years,

(planetesimals to planets = 10-200 Million years)

There are some "Dust" materials @ center of gas-giant planets b/c some got pushed out after protostar ignition *

As for the "icy" materials @ outer disk, larger protoplanets also grew, and evolved into the gas-giant planets. Those fragments that were NOT incorporated into the gas-giant planets remain today as asteroids and comets.

The solar system formed about 9 Billion years after the Big Bang, which is about $\frac{1}{3}$ as old as the universe.

So How Did The Moon Form?

IN EARLY EARTH DAYS, A PLANET THE SIZE OF MARS, COLLIDED INTO EARTH, CREATING FRAGMENTS OF THE COLLIDER AND PART OF EARTH'S MANTLE. DEBRIS JOINED THE FRAGMENTED MANTLE, TO FORM THE MOON.

WHY IS THE EARTH ROUND?

PLANETS ARE MORE SPHERICAL B/C
gravity impacts IT'S SHAPE (HAS TO BE BIG ENOUGH).

EX. Block of cheese warming in oven.
As it gets warmer (softer), gravity
causes it to spread out like a
pancake.

Small planetesimals are cooler @ interior
and not fluid-like.

Larger planetesimals (>1,000 km in diameter)
are of warmer interiors and are
soft enough to flow in response to gravity.

So...

protrusions are pulled inward
toward center, & planetesimal
re-forms into a special shape
that allows force of gravity to be
nearly the same at all points on
it's surface.

As a sphere, it is evenly
distributed around the center.

END OF UNIT 1, Chapter 1. Next, Unit 1, Chapter 2