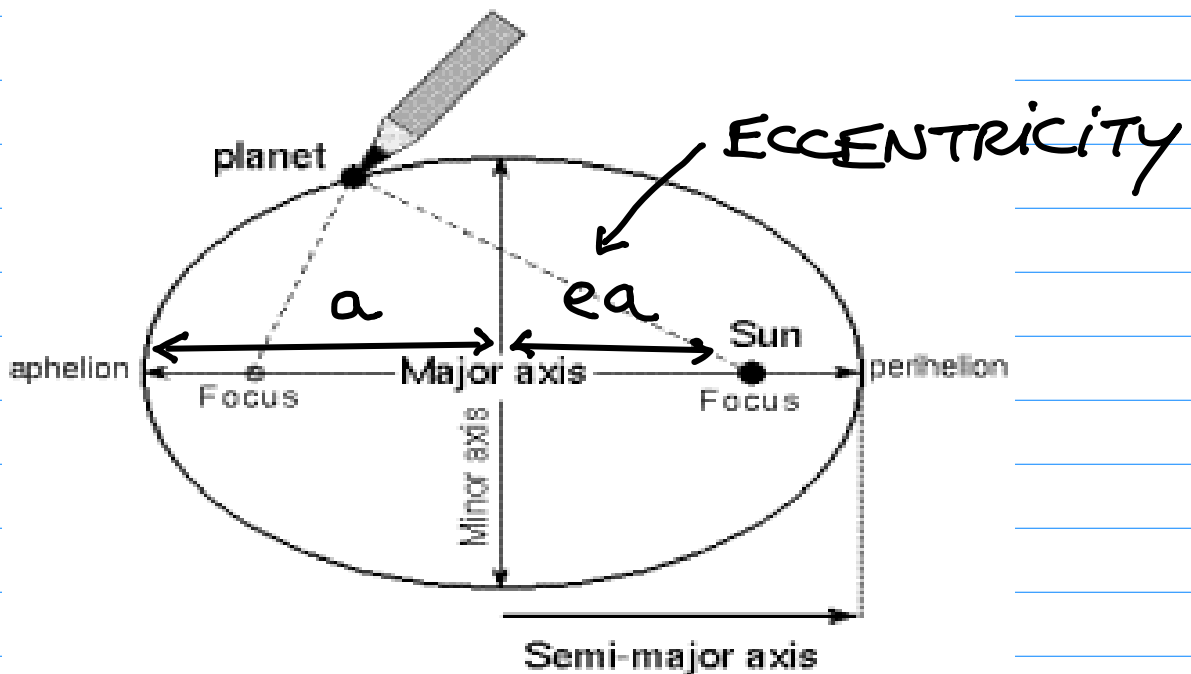


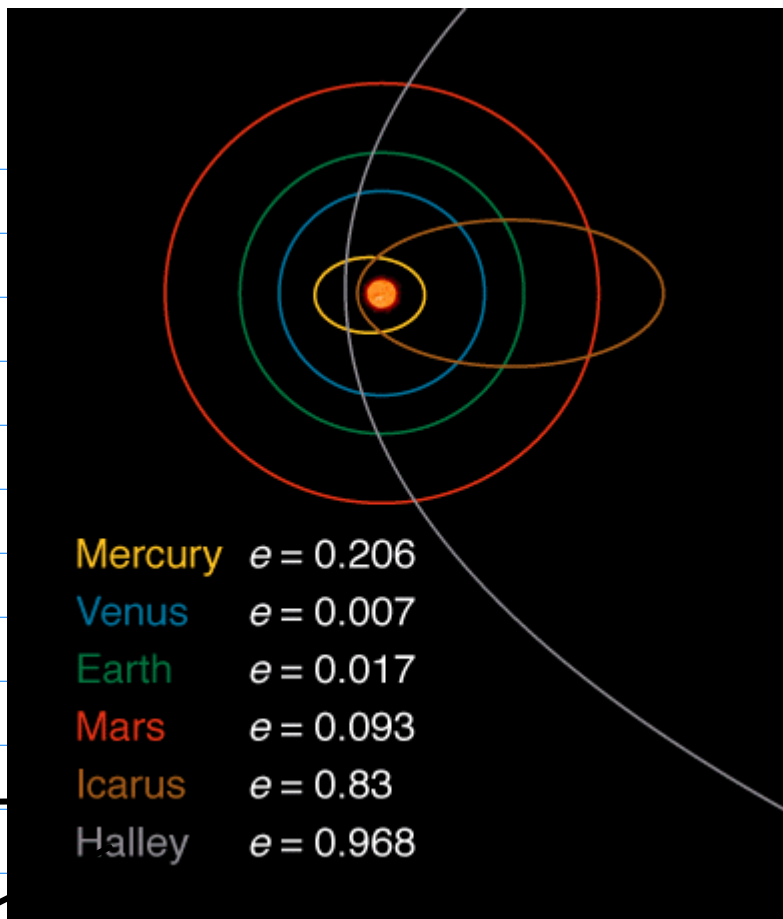
REGULARITIES IN PLANETARY MOTIONS:

1) FIRST KEPLER'S LAW: PLANETS MOVE ALONG ELLIPTICAL ORBITS WITH SUN AT ONE FOCUS



Drawing an ellipse: loop string around thumb tacks at each focus and stretch string tight with a pencil while moving the pencil around the tacks. The Sun is at one focus.

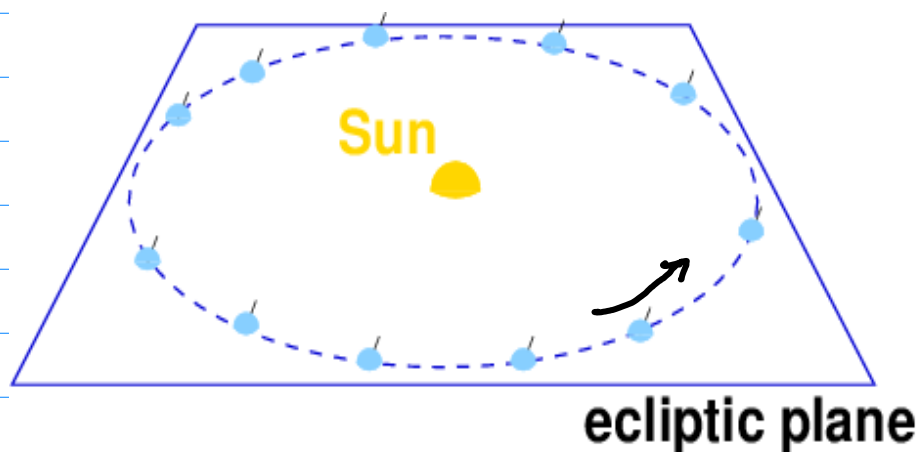
EXCEPT FOR MERCURY ($e = 0.206 \approx 21\%$)
THE ECCENTRICITIES OF PLANETARY
ORBITS ARE LESS THAN 10%

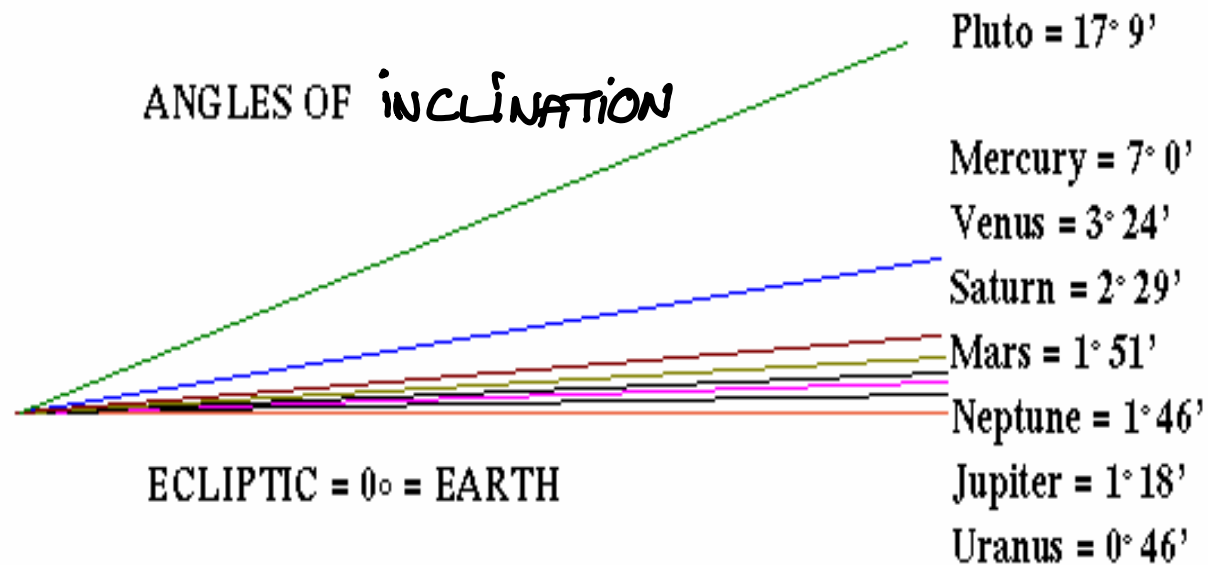


APOLLO
ASTEROID

COMET

2) THE ORBITS OF ALL PLANETS ARE NEARLY IN THE PLANE OF THE ECLIPTIC (THE ORBITAL PLANE OF THE EARTH)





THE INCLINATION ANGLES OF ALL PLANETARY ORBITS ARE LESS THAN 10°. THE SOLAR SYSTEM IS FLAT.

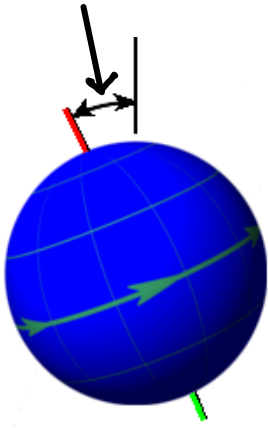
3) ALL PLANETS ORBIT THE SUN COUNTERCLOCKWISE (PROGRADE MOTION) AS ONE WOULD OBSERVE FROM ABOVE THE EARTH'S NORTH POLE.

THE SUN ALSO SPINS COUNTERCLOCKWISE.

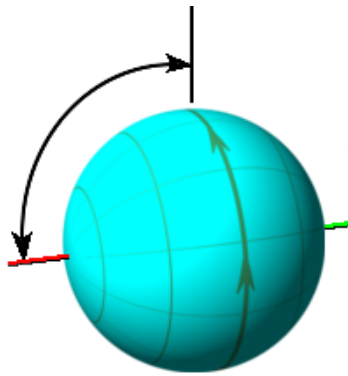
4) NEARLY ALL LARGE SATELLITES ORBIT THEIR PLANETS COUNTERCLOCKWISE.

5) NEARLY ALL PLANETS SPIN COUNTERCLOCKWISE.
THE EXCEPTIONS ARE VENUS AND URANUS:

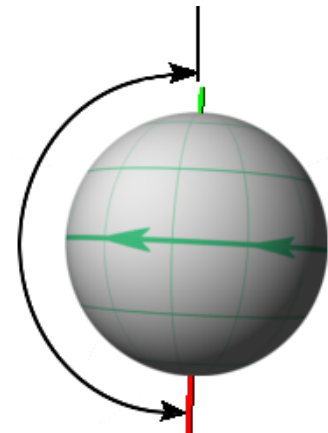
OBLIQUITY = AXIS TILT ANGLE



Earth: 23°



Uranus: 97°



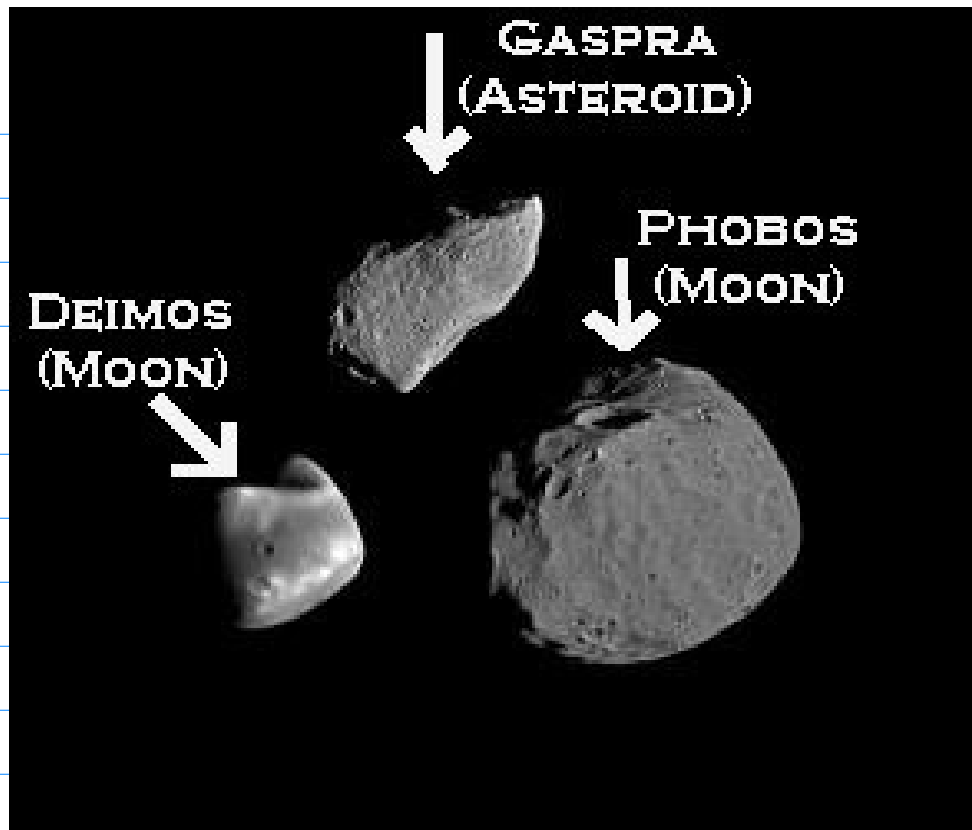
Venus: 177°



6) NEARLY ALL LARGE SATELLITES HAVE
COUNTERCLOCKWISE SPIN.

EXCEPTIONS:

- TWO SATELLITES OF MARS (PHOBOS AND DEIMOS); THEY ARE MOST LIKELY CAPTURED ASTEROIDS



- ALL SATELLITES OF URANUS

FROM 3)-6) ONE CAN INFER THAT THERE IS A DEFINITE COUNTERCLOCKWISE TWIST IN THE SOLAR SYSTEM.

7) THIRD KEPLER'S LAW :

AVERAGE DISTANCE FROM THE SUN IN AU $\rightarrow \frac{a^3}{P^2} = 1$

ORBITAL PERIOD IN YEAR

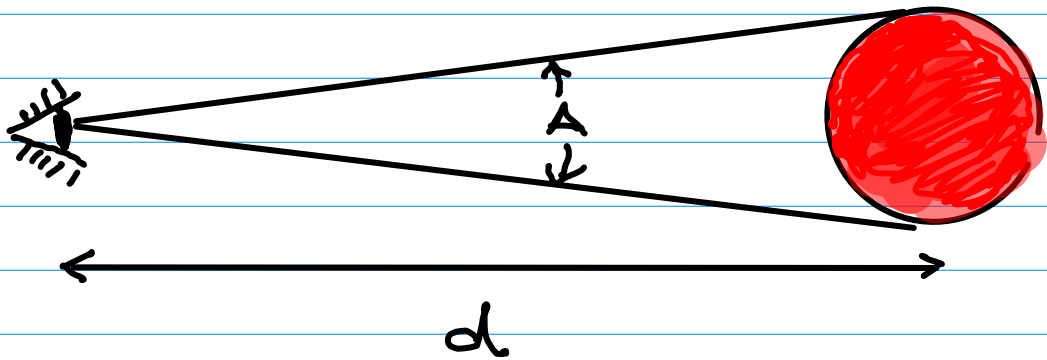
<u>PLANET</u>	<u>a (AU)</u>	<u>P (y)</u>	<u>$\frac{a^3}{P^2}$</u>
MERCURY	0.387	0.241	0.998
VENUS	0.723	0.615	0.999
EARTH	1	1	1
MARS	1.524	1.881	1.000
JUPITER	5.204	11.86	1.002
SATURN	9.539	29.46	1.000
URANUS	19.18	84.01	1.000
NEPTUNE	30.06	164.793	1.000

NOTE: THE THIRD KEPLER'S LAW IMPLIES THAT THE GREATER THE DISTANCE FROM THE SUN (a), THE LONGER IS THE ORBITAL PERIOD (P).

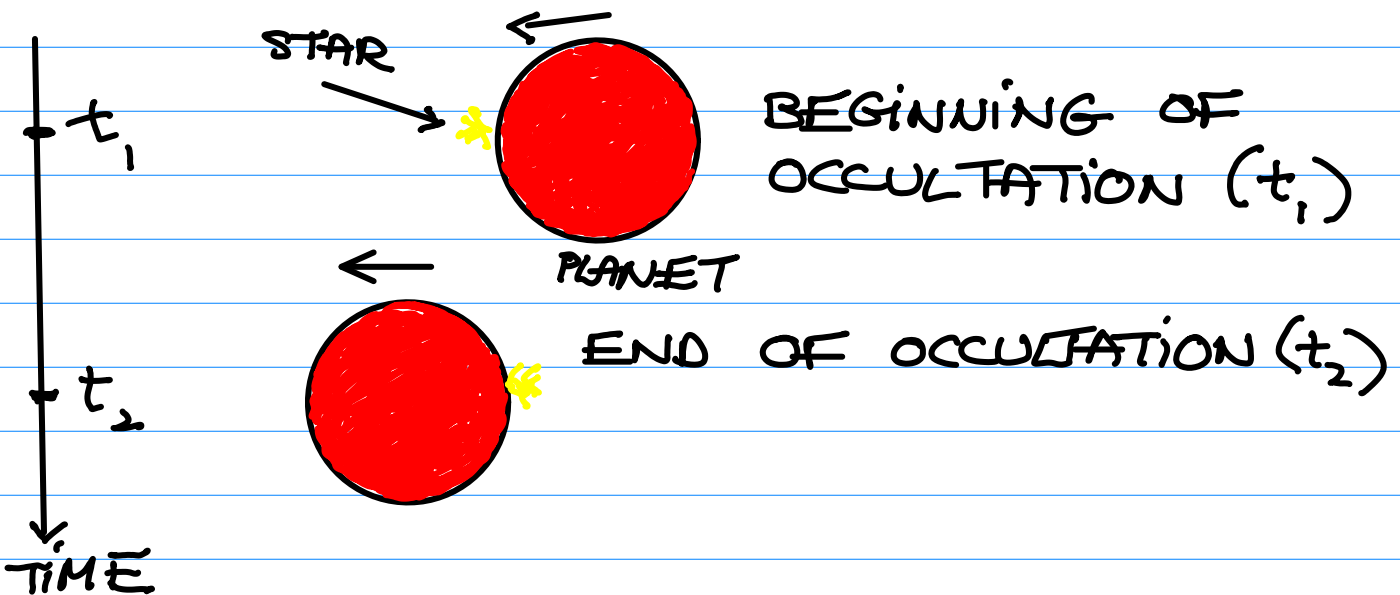
SOME PHYSICAL PROPERTIES OF PLANETS:

DIAMETER D — COULD BE DETERMINED FROM

— ANGULAR SIZE (A) AND DISTANCE d

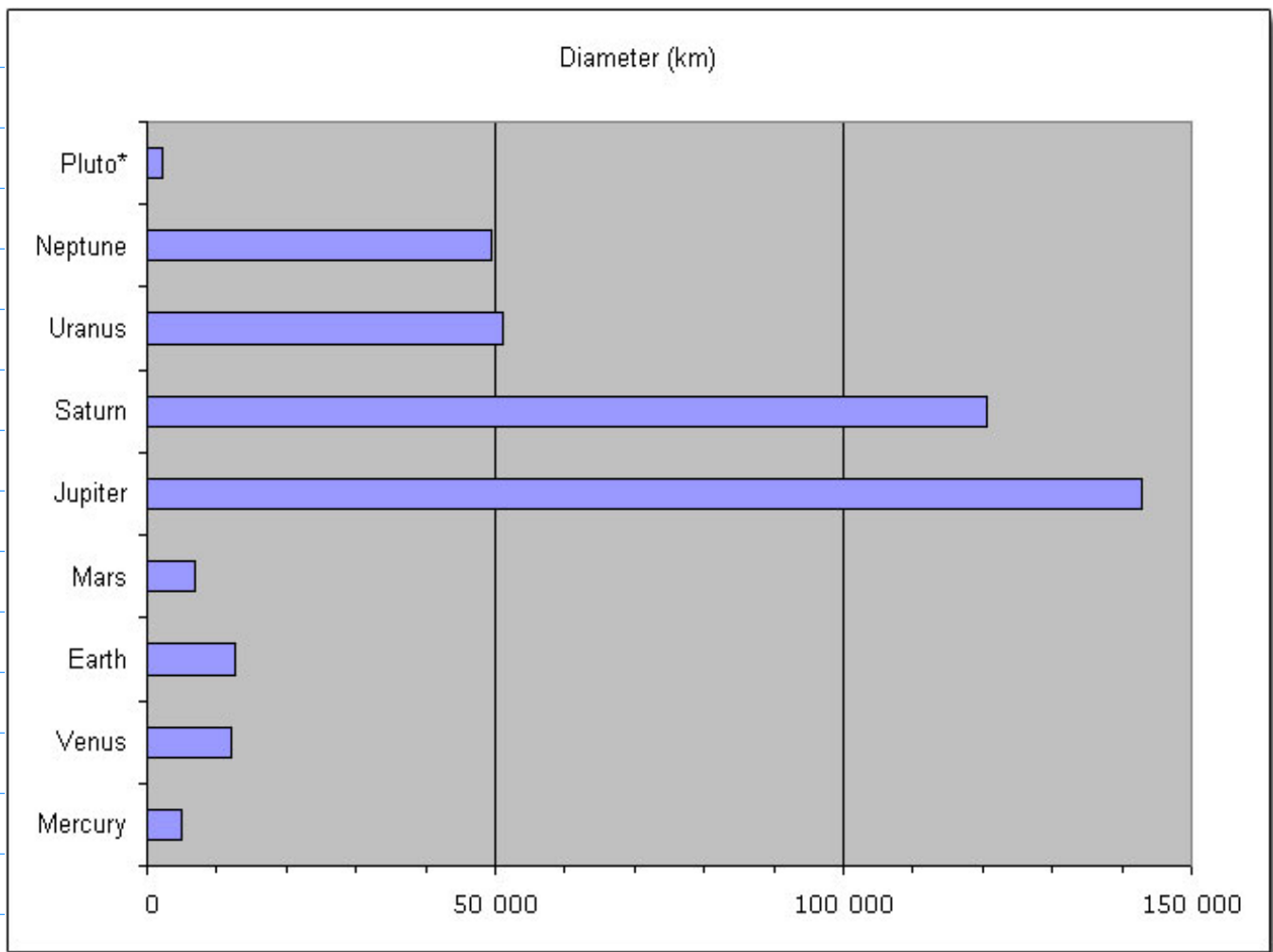


— TIME OF STAR OCCULTATION



$$D = (t_2 - t_1) \cdot \text{THE SPEED OF THE PLANET}$$

↑
FROM α AND P



MASS M - FROM ORBITAL DATA FOR ONE OF ITS SATELLITES USING THE THIRD KEPLER'S LAW AS FORMULATED BY NEWTON

$$\underline{\text{AVERAGE DENSITY}} = \frac{\text{MASS}}{\text{VOLUME}}$$

↖ FROM D

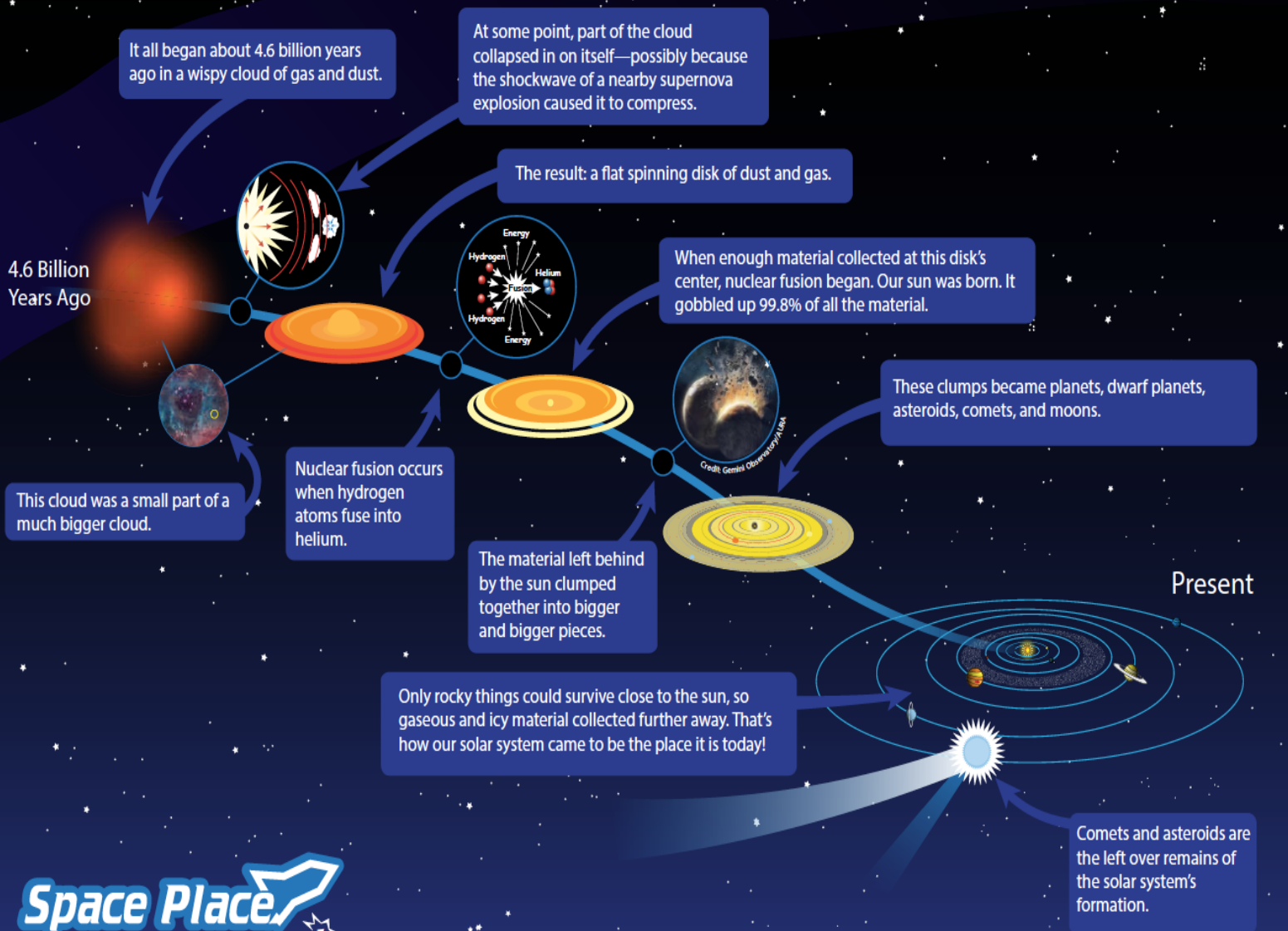
<u>PLANET</u>	<u>MASS (IN UNITS OF EARTH MASS)</u>	<u>DENSITY (IN g/cm³)</u>
MERCURY	0.055	5.43
VENUS	0.815	5.24
EARTH	1 (6×10^{24} kg)	5.52
MARS	0.107	3.92
JUPITER	318	1.32
SATURN	95.1	0.70
URANUS	14.5	1.25
NEPTUNE	17.2	1.76
(SUN	333,000	1.4)

TERRESTRIAL PLANETS - SMALL & DENSE
 JOVIAN PLANETS - LARGE & LOWER DENSITY

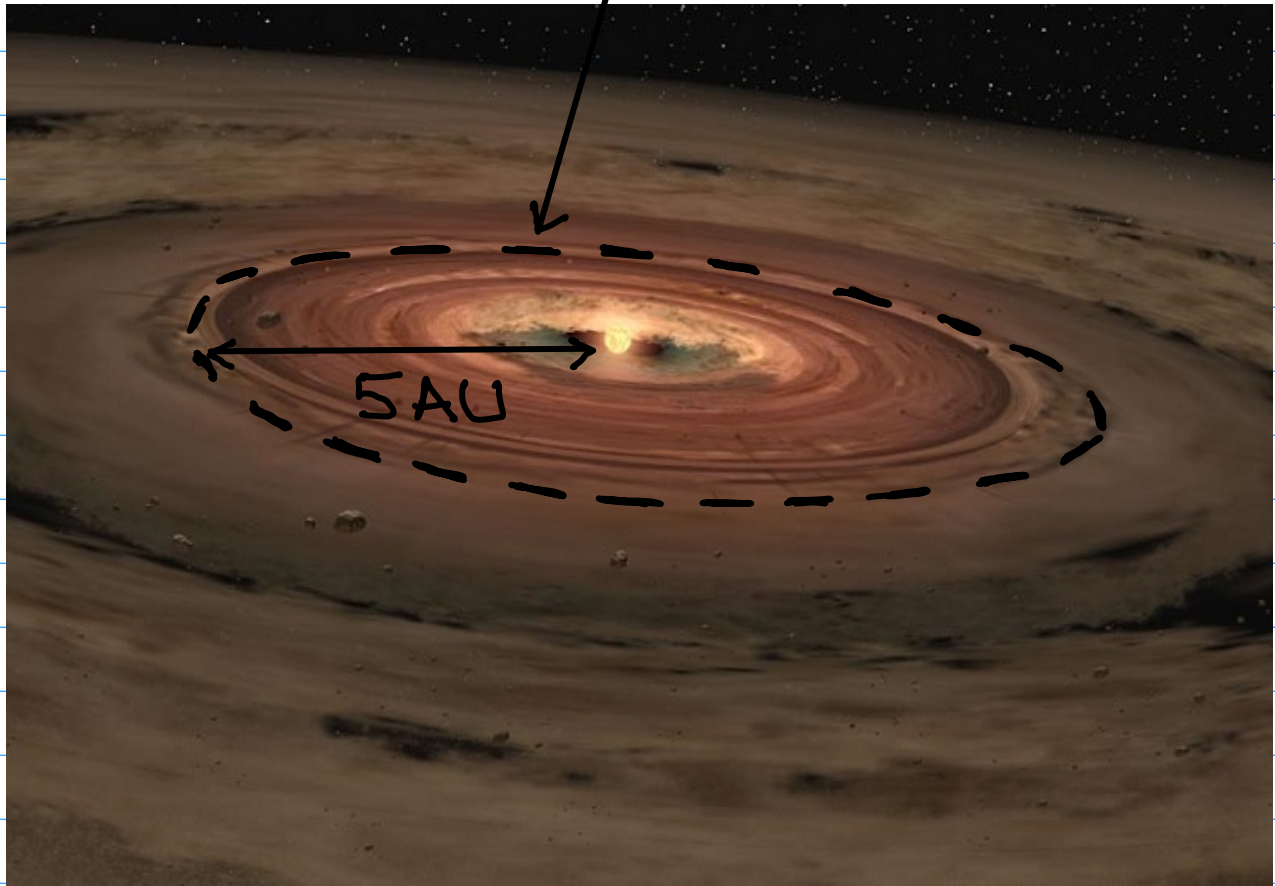
FORMATION OF THE SOLAR SYSTEM :

COLLAPSING NEBULA SCENARIO

How did our solar system come to be?



FROST (OR SNOW, OR ICE) LINE



INSIDE THE FROST LINE : TEMP. $> -120^{\circ}\text{C}$
OUTSIDE THE FROST LINE : TEMP. $< -120^{\circ}\text{C}$

CONDENSATION TEMPERATURE IS THE TEMPERATURE AT WHICH A SUBSTANCE SOLIDIFIES. IT DEPENDS ON PRESSURE - IT INCREASES WITH PRESSURE. IN SPACE THE PRESSURE IS ZERO.

CONDENSATION SEQUENCE:

MATERIAL	RELATIVE ABUNDANCE (BY MASS)	CONDENSATION TEMPERATURE
IRON, NICKEL, ALUMINUM	0.2%	1,000 - 1,600 K
VARIOUS MINERALS	0.4%	500 - 1,300 K
WATER (H_2O) METHANE (CH_4) AMMONIA (NH_3)	1.4%	$< 150 K = -120^\circ C$
HYDROGEN, HELIUM	98%	DO NOT CONDENSE AT ZERO PRESSURE

HENCE, TERRESTRIAL PLANETS ARE COMPOSED OF ROCKS AND METALS AND HAVE HIGH DENSITY; JOVIAN PLANETS ARE COMPOSED MOSTLY OF HYDROGEN AND HELIUM AND HAVE LOW DENSITY.

SMALL SOLID PARTICLES COLLIDED, OCCASIONALLY STICKING TO ONE ANOTHER FORMING LARGER GRAINS (ACCRETION PROCESS).

LARGER BODIES (PLANETESIMALS) RANGING IN SIZE FROM 1 μm TO 100 μm WERE FORMED THROUGH ACCRETION PROCESS (ANALOGY: A ROLLING SNOWBALL).

PLANETESIMALS SWEEP MOST OF THE DUST AND SMALL PARTICLES.

ONCE THE LARGER PLANETESIMALS GREW TO THE POINT THAT THEIR GRAVITY WAS SIGNIFICANT THEY GREW RAPIDLY INTO PROTOPLANETS.

THE POWERFUL SOLAR WIND FROM THE YOUNG SUN (T-TAURI PHASE) CLEARED OUT DUST AND GAS STILL DISPERSED BETWEEN THE PLANETS.

THE ENTIRE PROCESS OF FORMATION OF THE SOLAR SYSTEM MAY HAVE LASTED A FEW HUNDRED MILLION YEARS AND WAS COMPLETED 4.6 BILLION YEARS AGO.