Physics Open Course

JOY OF STAR WATCHING

BOOKS FOR STUDY : 1. The Great Universe- G.K.Sasidharan- S.Chand
2. Joy of star watching – BimanBasu- National Book Trust , India.

REFERENCE **:** Jyothishavum Jyothisasthravum- K. Pappootty- K.S.S.P.

Open(Physics) Course -Theory

5D01PHY: B. Joy of star watching

Semester-V, Credit-2, Contact hours -36, Max. Ext. Marks- 20,Max. Int. marks-5

Module 1: Astrophysics

The study of the Universe - Problems and prospects. The Universe - its origin-_Galaxies__Milkyway. A star is born. The death of a star. The comets–The pole star
(Book 1) (14 Hrs)(Marks: Minimum 7)

Module 2: The constellations

Orion- Canis major-Taurus—Leo-(Book 2) (2 Hrs)
(Marks: Minimum 2)

Module 3: Stars in kerala culture

The origin and expansion of Astrology -Stars and constellations in Kerala culture- (12 Hrs)
(Marks: Minimum 6)

Module 4: Star watching

How to experience star watching — For a better view (Book 2) (8 Hrs) (Marks: Minimum: 5)

Book for study:

1. The Great Universe- G.K.Sasidharan- S.Chand

2. Joy of star watching – BimanBasu- National Book Trust , India.

Book for reference:

1.Jyothishavum Jyothisasthravum- K. Pappootty-K.S.S.P.

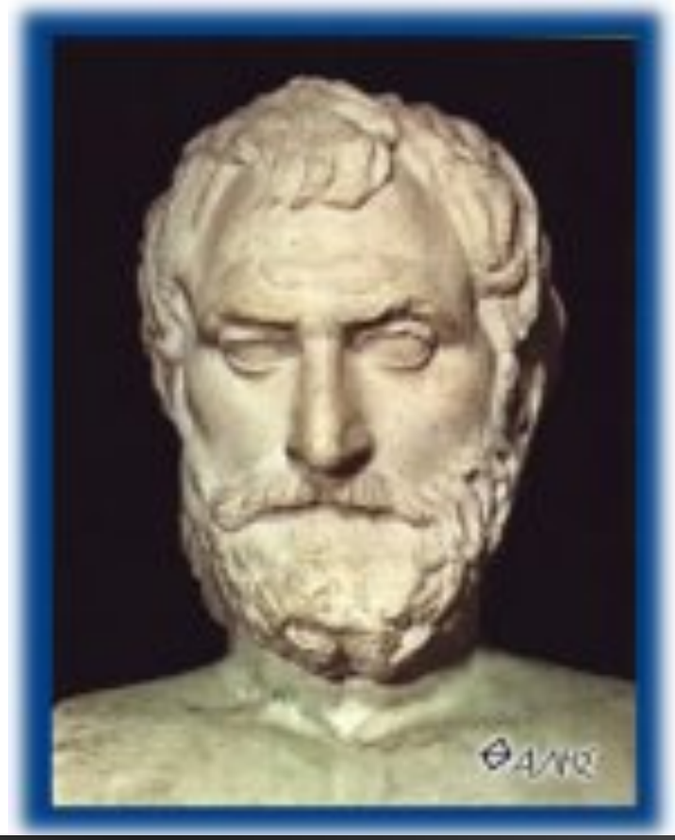
Origin of the Universe

Why are we here ?

Where did we come from ?

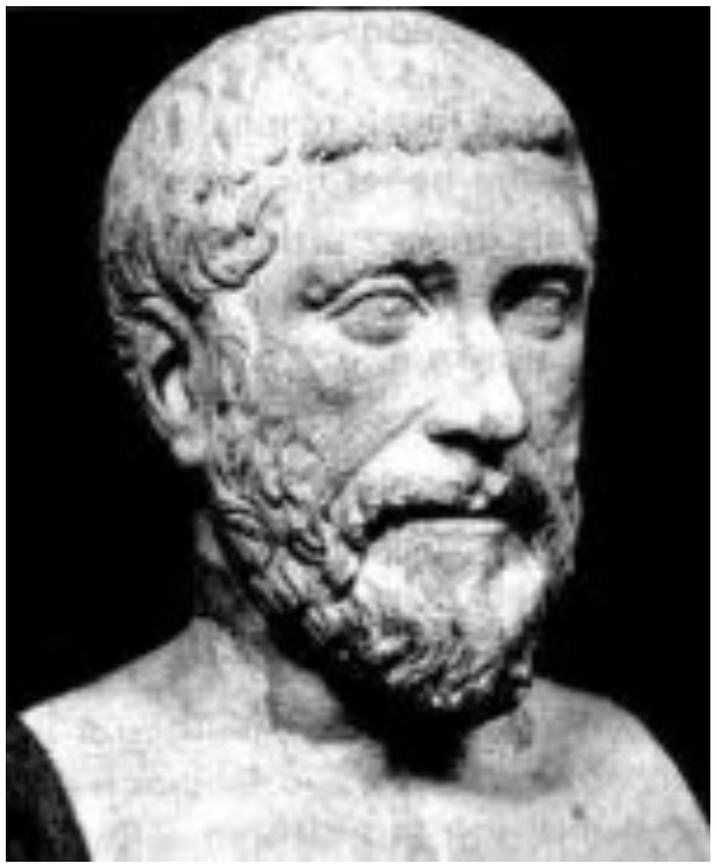
What did we know about the universe and when did we know it ?

Central Africa in the area that is now known as Democratic Republic of the Congo



Thales (624-547 B.C., Ionian) was a Greek philosopher who traveled widely in Mesopotamia and Egypt, and brought astronomical records from these cultures back to Greece. He believed that the Earth is a disk floating on an endless ocean. Legend has it that he correctly predicted a solar eclipse in the year 585 B.C.

Anaximander (611-547 B.C., Ionian) was a Greek philosopher who made the first detailed maps of the Earth and the sky. He knew that the Earth was round, and believed that it was free-floating and unsupported. He measured its circumference, and was the first to put forward the idea that celestial bodies make full circles in their orbits. One of his greatest contributions was the fact that he was the first to conceptualize space as having depth.



Pythagoras (569-475 B.C., Ionian) was a mathematician who put forward the idea that the universe is made of crystal spheres that encircle the Earth. According to him, the Sun, the Moon, the planets, and the stars travel in separate spheres. When the spheres touch each other, a 'music of the spheres' can be heard.

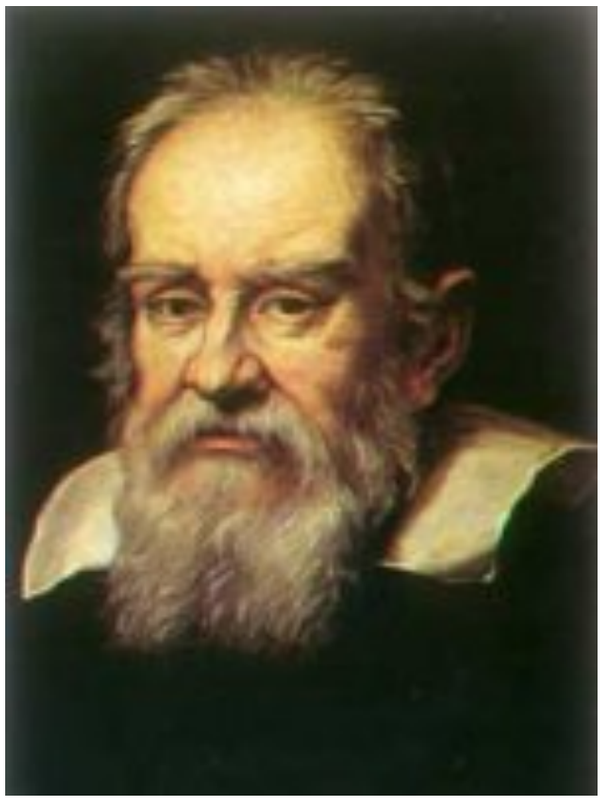
Aristotle (384-322 B.C., Greek), the great philosopher, proved that the Earth is spherical, and believed that it was at the center of the universe. His reason for believing this was actually quite scientific: he knew that if the Earth revolved around the Sun, then we should see the stars shift position throughout the year. Since he did not have the technology to detect this shift, as we do today, he concluded that Earth must rest at the center of the universe. According to him, the Sun, planets, and stars were located in spheres that revolved around the Earth.

Aristarchus (310-230 B.C., Greek) was the first to put forward the idea that the Sun was actually in the center of the universe. His theory was considered far too radical. Unfortunately, history tends to forget that he came to this conclusion about 1,750 years before Copernicus did! He also attempted to measure the relative distances between the Earth and the Sun and the Earth and the Moon. Even though he used a reasonable method, his results were not very accurate, because he lacked the technological equipment to make a precise measurement.

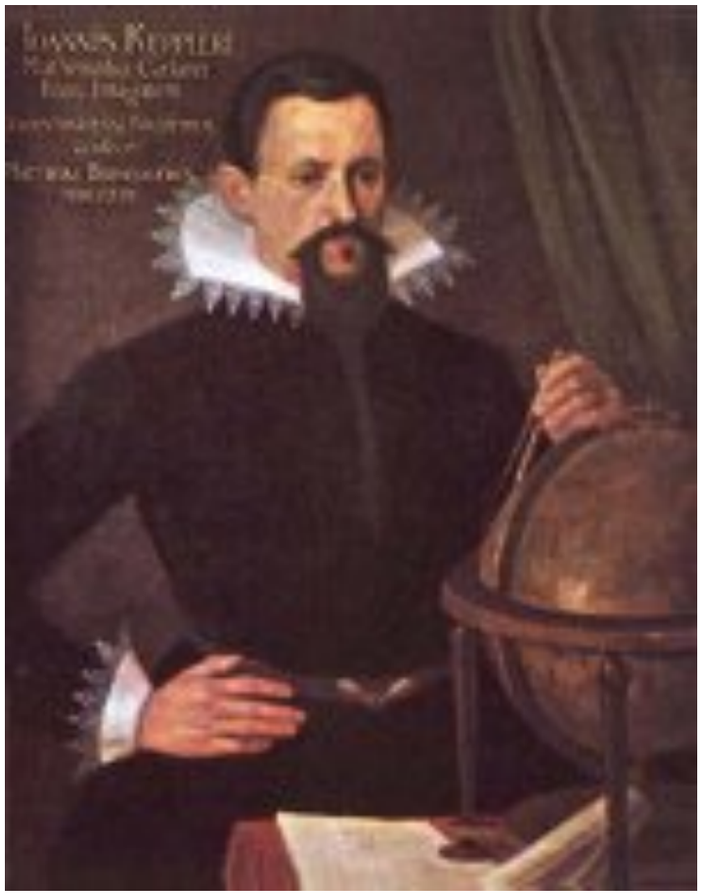
Hipparchus (190-120 B.C., Greek) is widely considered to be the greatest astronomer of ancient times. He compiled the first known star catalog to organize astronomical objects, and also came up with a scale to define the brightnesses of stars. A version of this magnitude system is still used today. He measured the distance from the Earth to the Moon to be 29.5 Earth diameters (we know today that the real value is 30 Earth diameters). Perhaps his greatest discovery was the precession, or wobble, of the Earth's axis, which is caused by the gravitational pull of the Sun and Moon.

Claudius Ptolemy (85-165 A.D., Greek) was an astronomer who used Hipparchus' extensive observations to develop a model that predicted the movements of the Sun, Moon, planets, and stars. His model, called the Ptolemaic system, visualized an Earth-centered universe and assumed that all astronomical objects move at constant speeds in circular orbits. The circle was considered by the ancients to be the perfect shape, and regardless of the evidence against circular orbits, Ptolemy built his model to fit this idea. The Ptolemaic model is one of the longest upheld scientific theories in history: it was the cornerstone of astronomy for 1,500 years.

Nicolaus Copernicus (1473-1543, Polish) began a new era of astronomy when he concluded that the Sun was the center of the universe instead of the Earth. Copernicus felt that the Ptolemaic system was contrived, but in his revisions of that model, he kept the orbits circular. The revolutionary idea was not popular with the Church, but several other astronomers such as Brahe and Galileo helped to eventually prove that this model of the universe more accurately portrayed reality.



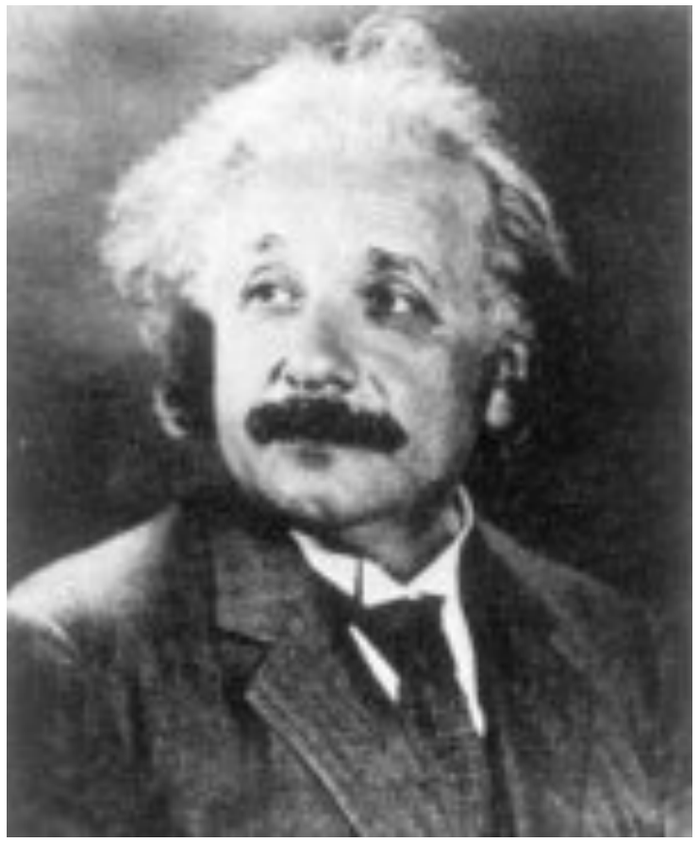
Galileo Galilei (1564-1642, Italian) is the father of observational astronomy. In 1609, he heard about the Dutch invention of the telescope, and built one for himself. Even though his telescope was not very powerful compared to the amateur equipment available today, he was able to make a number of stunning discoveries which changed the face of astronomy. He saw the craters, mountains, and valleys of the Moon, noticed the huge number of stars making up the Milky Way, kept precise records of sunspot activity and the phases of Venus, and discovered four moons orbiting Jupiter. These moons are still called the Galilean Moons today, in honor of the earth-shattering scientific effects of the discovery. During a time when the Earth was still considered to be at the center of the universe, he publicized the fact that other astronomical bodies, such as Jupiter's moons, were clearly revolving around something other than the Earth. Galileo's support of the Copernican model of the universe frightened the Church, which put Galileo on trial in 1633. He was forced to renounce his Copernican views and was held under house arrest for the rest of his life.



Johannes Kepler (1571-1630, German) was Tycho Brahe's assistant and student. He inherited his teacher's extensive collection of astronomical records, and used them to develop three laws of planetary motion. He believed in the Copernican model of the universe, although he found it difficult to fit Tycho's observations of Mars into the model with a circular orbit. He therefore used the idea of elliptical orbits to describe the motions of the planets, which became known as Kepler's first law. His second law states that a line from the Sun to a planet sweeps out equal areas in equal amounts of time. The third law was a masterpiece of simplicity: the square of the number of years of a planet's orbital period is equal to the cube of that planet's average distance from the Sun.

Giovanni Cassini (1625-1712, Italian) was the astronomer who first discovered the division in the rings of Saturn, today known as the Cassini division. He also found four moons orbiting Saturn, and measured the periods of rotation of Mars and Jupiter. The Cassini space mission currently on its way to Saturn was named after him.

Isaac Newton (1643-1727, British) was a mathematician who developed extensive mathematics to describe the astronomical models of Copernicus and Kepler. His Theory of Universal Gravitation was the foundation of Kepler's laws of planetary motion, but it also went further: Newton showed that the laws governing astronomical bodies were the same laws governing motion on the surface of the Earth. Newton's scientific ideas are so complete that they still offer an accurate description of physics today, except for certain cases in which 20th century physics must be used.



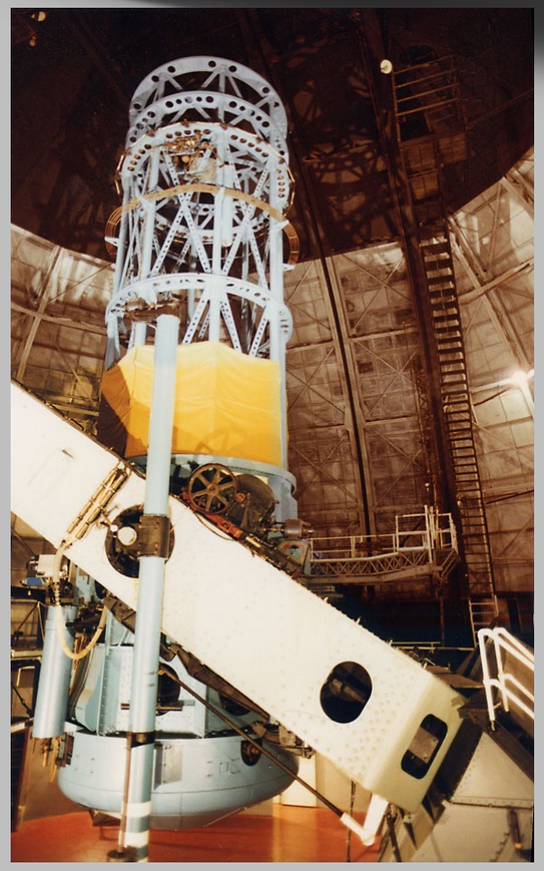
Albert Einstein (1879-1955, German) was probably the greatest mind of the twentieth century. His Special Theory of Relativity, proposed in 1905, extended Newtonian Mechanics to very large speeds close to the speed of light. It describes the changes in measurements of physical phenomena when viewed by observers who are in motion relative to the phenomena. In 1915, Einstein extended this further in the General Theory of Relativity, which includes the effects of gravitation. According to this theory, mass and energy determine the geometry of spacetime, and curvatures of spacetime manifest themselves in gravitational forces.

Alexander Friedmann (June 16, 1888 – September 16, 1925**)**
was a Russian and Soviet physicist and mathematician.
He is best known for his pioneering theory that the universe was expanding, governed by a set of equations he developed now known as the Friedmann equations.

Georges Lemaître, (17 July 1894 – 20 June 1966)
was a Belgian Catholic priest, astronomer and professor of physics at the Catholic University of Leuven. He proposed on theoretical grounds that the universe is expanding, which was observationally confirmed soon afterwards by Edwin Hubble.He was the first to derive what is now known as Hubble's law and made the first estimation of what is now called the Hubble constant, which he published in 1927, two years before Hubble's article. Lemaître also proposed what became known as the "Big Bang theory" of the origin of the universe, which he called his "hypothesis of the primeval atom" or the "Cosmic Egg

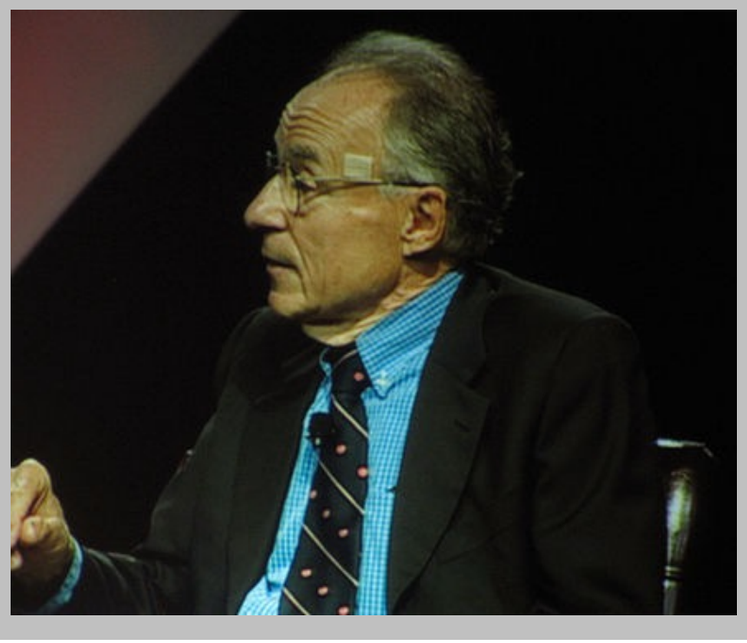
George Gamow (March 4, 1904- August 19, 1968),
was a Russian-American theoretical physicist and cosmologist.
He was an early advocate and developer of Lemaître's
Big Bang theory.

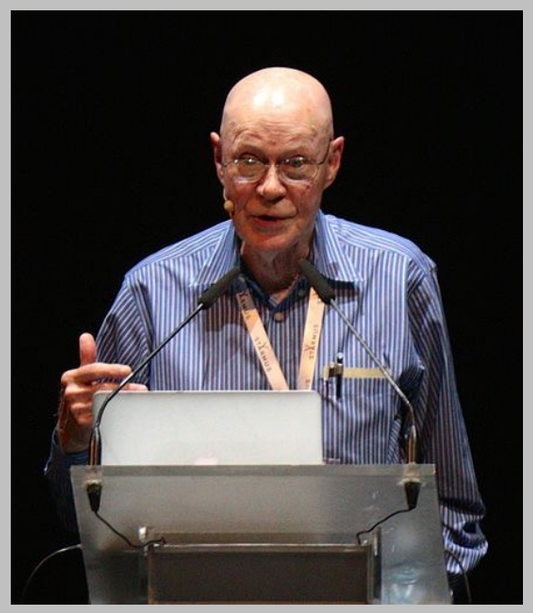
Edwin Powell Hubble (November 20, 1889 – September 28, 1953) was an American astronomer. He played a crucial role in establishing the fields of extragalactic astronomy and observational cosmology and is regarded as one of the most important astronomers of all time. Hubble discovered that many objects previously thought to be clouds of dust and gas and classified as "nebulae" were actually galaxies beyond the Milky Way.



The 100-inch Hooker telescope at Mount Wilson Observatory that Hubble used to measure galaxy distances and a value for the rate of expansion of the universe.

Sir Fred Hoyle (24 June 1915 – 20 August 2001) was a British astronomer who formulated the theory of stellar nucleosynthesis. He also held controversial stances on his rejection of the "Big Bang" theory





Arno Allan Penzias (26 April 1933) is an American physicist, radio astronomer and Nobel laureate in physics who is co-discoverer of the cosmic microwave background radiation along with Robert Woodrow Wilson, which helped establish the Big Bang theory of cosmology.

Bigbang Theory

13.772 billion years
old Universe !!!

The universe had a definite beginning.

The ‘best’ explanation for the existence of the universe is currently the Big Bang Theory.

The Big Bang is thought to be an explosion from a SINGULARITY
(a single point of density – where all known space was compressed)

This happened 13.8 bn years ago

They don’t really know what the singularity was or ‘how long’ it had been there.

Evidence Supporting the Big Bang Theory

Hubble's Law: the speed of the galaxies moving away from each other causes a change in the light spectrum, 'red shift'.

Background radiation: We can still detect radiation from an explosion of this size – the radiation is the same everywhere on earth (TV static, etc).

Composition of Older Galaxies: Analysis of light from galaxies towards the 'outside' of the universe confirm theories about the early universe. They are made up of approx 93% H, 7% He.

History of the Universe

Inflation Generates Two Types of Waves

Gravitational Waves

Density Waves

Waves Imprint Characteristic Polarization Signals

Free Electrons Scatter Light

Earliest Time Visible with Light

Radius of the Visible Universe

Quantum Fluctuations

Big Bang

Inflation

Protons Formed

Nuclear Fusion Begins

Nuclear Fusion Ends

Cosmic Microwave Background

Neutral Hydrogen Forms

Modern Universe

0

10^{-32} s

1 μs

0.01 s

3 min

380,000 yrs

13.8 Billion yrs

Age of the Universe

TIME AFTER THE BIG BANG

- 10^{-35} Sec — THE BIG BANG
- 10^{-6} Sec — Universe Shaped
- 3 Sec — Basic Elements Form
- 10,000 Yrs — Radiation Era
- 300,000 Yrs — Matter Domination Era
- 300 Million — Stars & Galaxies Form

YEARS BEFORE THE PRESENT

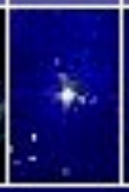
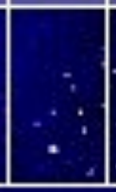
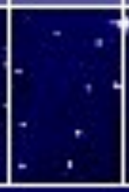
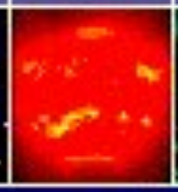
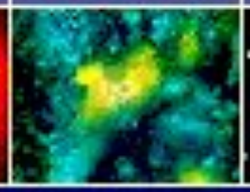
- 5 Billion — Birth of the Sun
- 3.8 Billion — Earliest Life Forms
- 700 Million — Primitive Animals Appear
- 200 Million — Mammals Evolve
- 65 Million — Dinosaurs Are Extinct
- 600,000 — Homo Sapiens Evolve
- 170,000 — Supernova 1987A Explodes

AD

- 1054 — Crab Supernova Appears
- 1609 — Galileo Builds First Telescope
- 1665 — Newton Describes Gravity
- 1905 — Einstein Publishes Relativity
- 1929 — Hubble Discovers Universe Expansion
- 1960 — Quasars Discovered
- 1964 — Microwave Radiation Discovered
- 1967 — Pulsars Discovered
- 1987 — Super Nova 1987A Reaches Earth
- 1990 — Hubble Telescope Launched
- 1990 — Big Bang Confirmed
- 1993 — Hubble Telescope Repaired

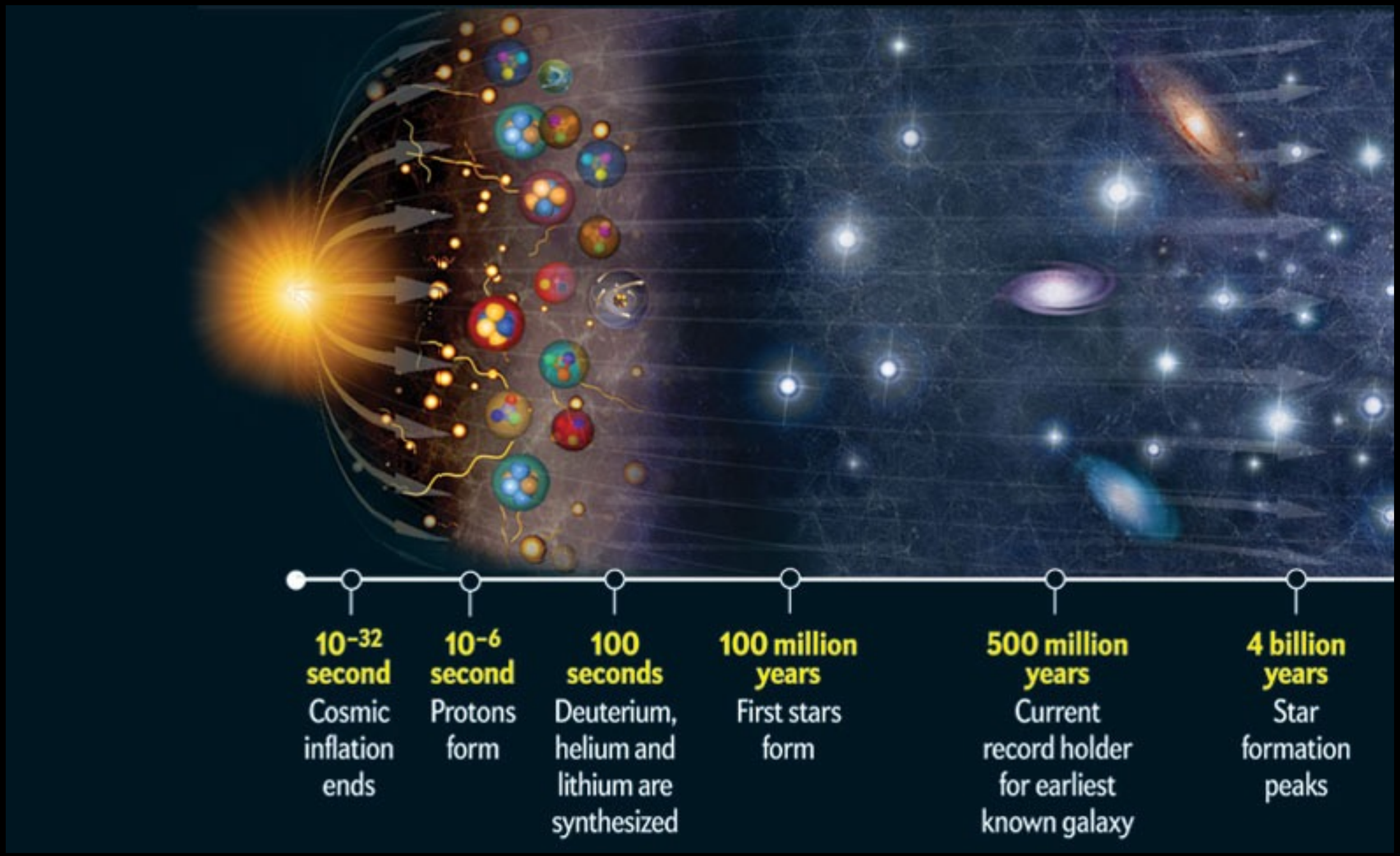
YEARS IN THE FUTURE

- 100 Trillion — Stellar Era Ends
- 10^{37} — Degenerate Era Ends
- 10^{38} To 10^{100} — Black Hole Era Begins
- 10^{100} — Dark Era Begins

January	February	March	April	May	June	July	August	September	October	November
										
New Year's Day: The Big Bang		Mily Way forms					Sun and planets form	Oldest known life.(single celled).		First multi-celluar organisms

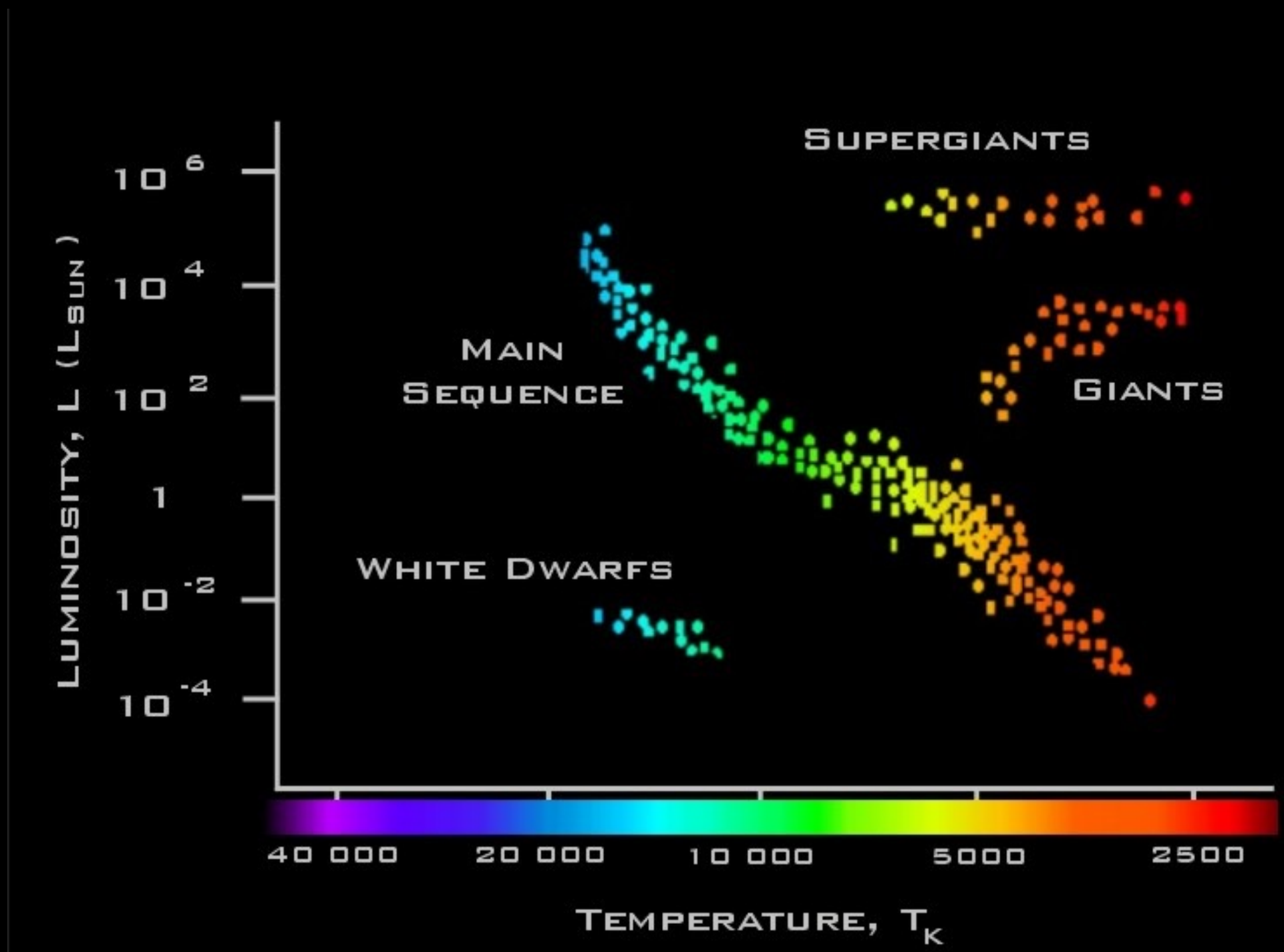
December

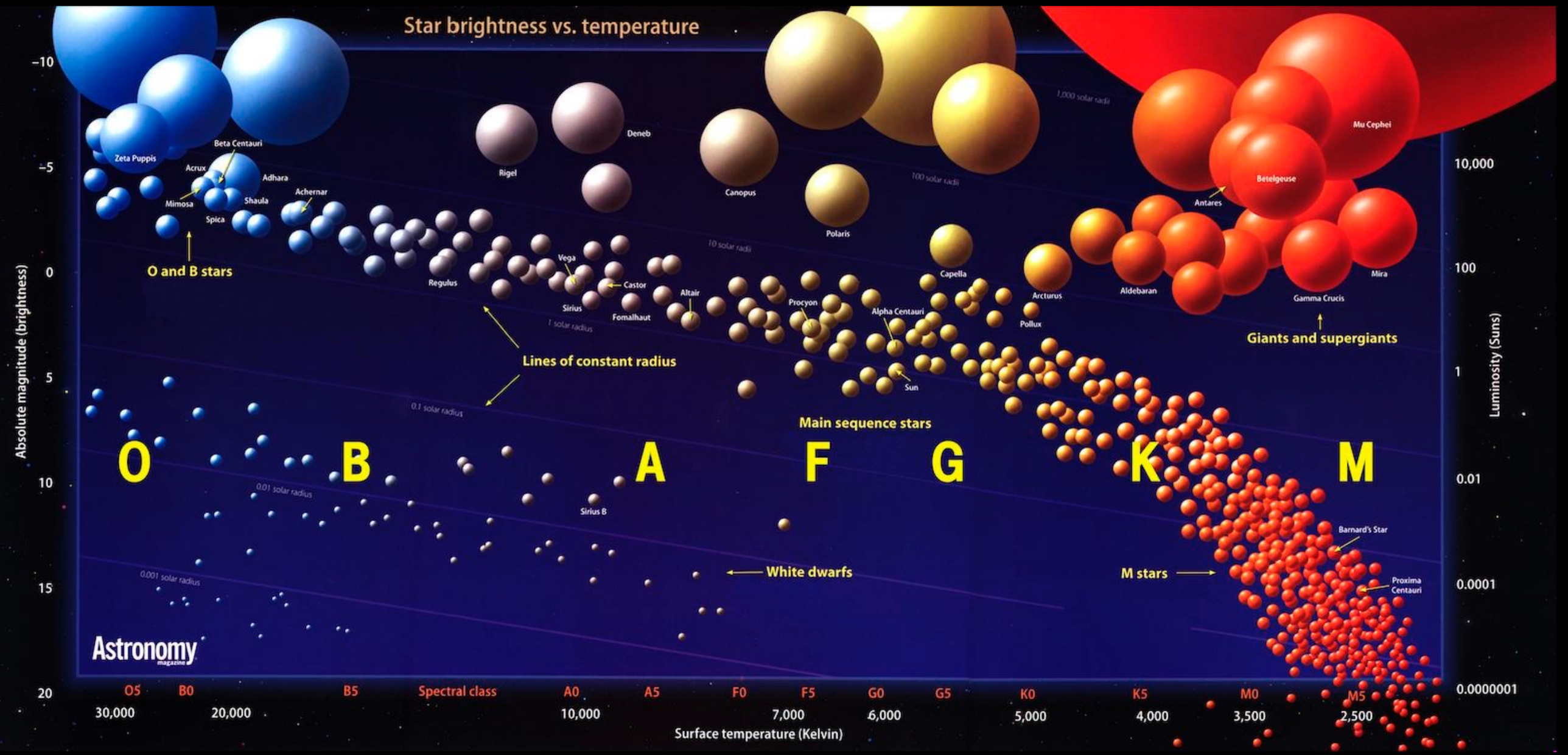
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15 Cambrian Explosion (burst of new life forms)	16	17 Emergence of first vertebrates	 18 Early land plants	19	 20 First four-limbed animals	 21 Variety of insects begin to flourish
22	23	 24 First dinosaurs appear	 25 First mammalian ancestors appear	26	 27 First known birds	28
 29 Dinosaurs wiped out by asteroid or comet	30	31 10:15am Apes appear 9:24pm First human ancestors to walk upright 10:48pm Homo erectus appears 11:54pm Anatomically modern humans appear 11:59:45pm Invention of writing 11:59:50pm Pyramids built in Egypt 1 second before midnight: Voyage of Christopher Columbus				


10⁻³² second
Cosmic inflation ends
10⁻⁶ second
Protons form
100 seconds
Deuterium, helium and lithium are synthesized
100 million years
First stars form
500 million years
Current record holder for earliest known galaxy
4 billion years
Star formation peaks

Stellar Evolution

H R Diagram (Hertzsprung-Russell Diagram)




Star brightness vs. temperature
Absolute magnitude (brightness)
Luminosity (Suns)
−10
−5
0
5
10
15
20
10,000
100
1
0.01
0.0001
0.0000001
1,000 solar radii
100 solar radii
10 solar radii
1 solar radius
0.1 solar radius
0.01 solar radius
0.001 solar radius
Zeta Puppis
Beta Centauri
Acrux
Adhara
Mimosa
Shaula
Spica
Achernar
O and B stars
Rigel
Deneb
Canopus
Polaris
Regulus
Vega
Castor
Sirius
Fomalhaut
Altair
Procyon
Capella
Arcturus
Pollux
Alpha Centauri
Sun
Mu Cephei
Betelgeuse
Antares
Aldebaran
Mira
Gamma Crucis
Giants and supergiants
Lines of constant radius
Main sequence stars
O
B
A
F
G
K
M
Sirius B
White dwarfs
M stars
Barnard's Star
Proxima Centauri
Astronomy magazine
O5
B0
B5
Spectral class
A0
A5
F0
F5
G0
G5
K0
K5
M0
M5
30,000
20,000
10,000
7,000
6,000
5,000
4,000
3,500
2,500
Surface temperature (Kelvin)

Main sequence stars
Active

Small Star

Gravitational contraction
Fusion reaction

Mass < 8 Ms

Cloud of cold gas +Tiny grained dust - Nebula
Gravitational contraction - T increases
PROTOSTARS

Red Giant

Fuel begins to run out
core shrinks
He —> C
Outer layer puff out —> cooling

Planetary Nebula

Shell of hot gas with shrieked
and exposed core

Core continues to shrink

White Dwarf

Mass > 1.4 Ms (Chandrasekhar limit)

Neutron
Star

Core mass < 15 Ms

Supernova

Red Supergiant

Large Star
Mass > 8 Ms

Stellar Cloud
with
Protostars

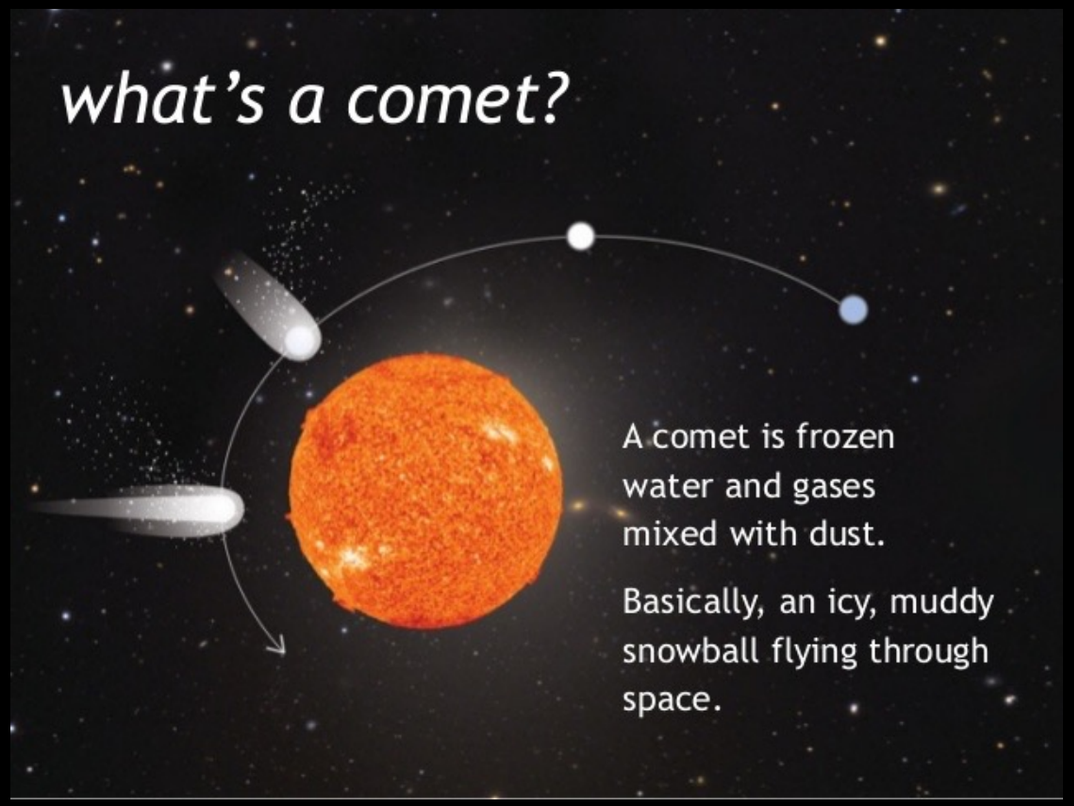
Rapid H fusion and at the end
Fe nuclei are formed.
100 times diameter of sun

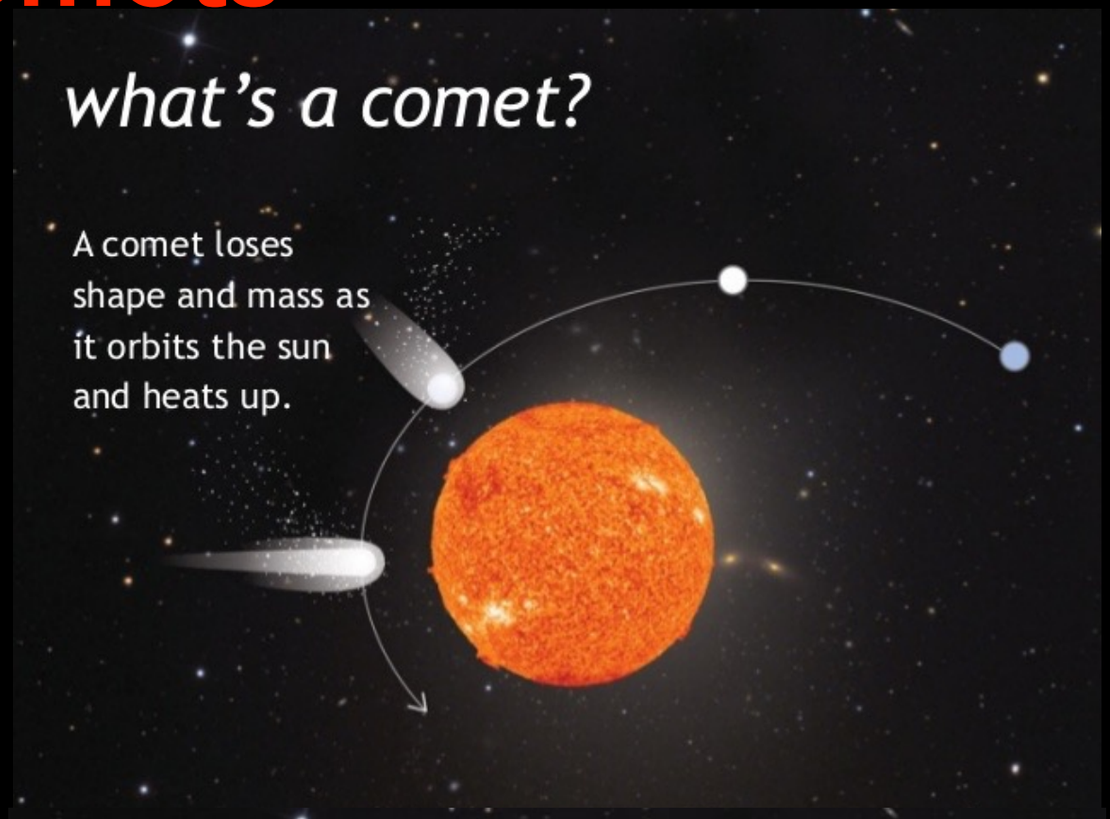
Fe nuclei absorb energy
Core collapse
Explodes into brilliant burst of light

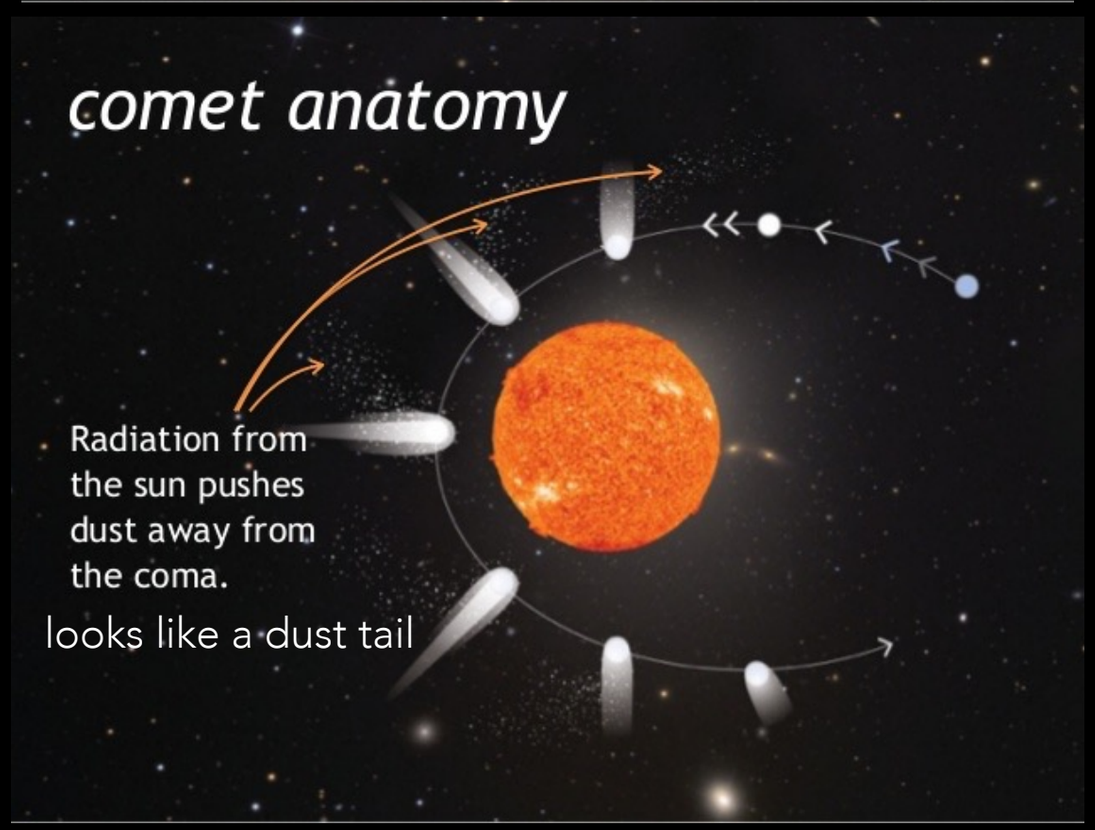
Core mass > 15 Ms

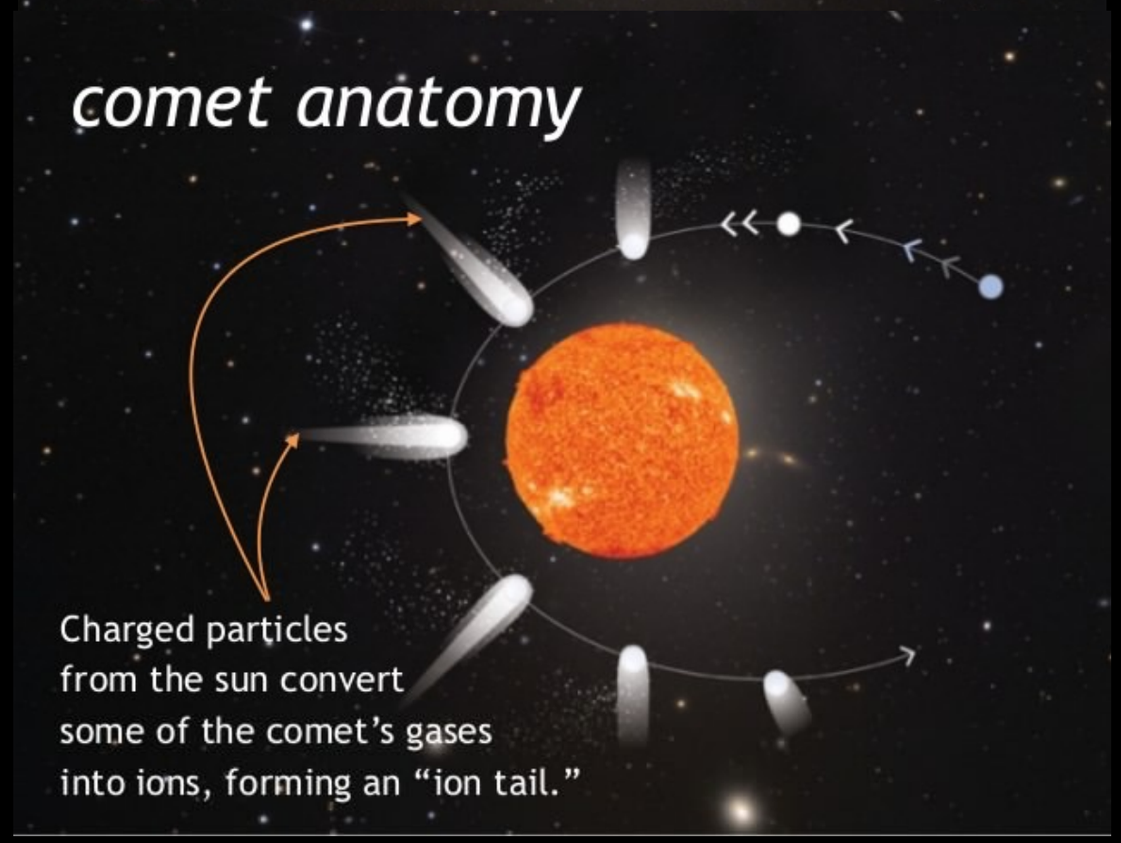
Black
Hole

The Comets


what's a comet?
A comet is frozen water and gases mixed with dust.
Basically, an icy, muddy snowball flying through space.


what's a comet?
A comet loses shape and mass as it orbits the sun and heats up.


comet anatomy
Radiation from the sun pushes dust away from the coma.
looks like a dust tail


comet anatomy
Charged particles from the sun convert some of the comet's gases into ions, forming an "ion tail."

A comet is an icy body that releases gas or dust. Comets contain dust, ice, carbon dioxide, ammonia, methane and more. Astronomers think comets are leftovers from the gas, dust, ice and rocks that initially formed the solar system about 4.6 billion years ago.Some researchers think comets might have originally brought some of the water and organic molecules to Earth that now make up life here. To research this hypothesis, the Rosetta mission, which landed a probe on a comet on Nov. 12, 2014, is studying its nucleus and environment, observing how it changes as it approaches the sun. Comets orbit the sun, but most are believed to inhabit in an area known as the Oort Cloud, far beyond the orbit of Pluto. Occasionally a comet streaks through the inner solar system; some do so regularly, some only once every few centuries.

Halley's Comet is likely the most famous comet in the world. It becomes visible to the naked eye every 76 years when it nears the sun. When Halley's Comet zoomed near Earth in 1986, five spacecraft flew past it and gathered unprecedented details, coming close enough to study its nucleus. The comet **Shoemaker-Levy 9** collided spectacularly with Jupiter in 1994, with the giant planet's gravitational pull ripping the comet apart for at least 21 visible impacts. The largest collision created a fireball that rose about 1,800 miles (3,000 km) above the Jovian cloud tops as well as a giant dark spot more than 7,460 miles (12,000 km) across - about the size of the Earth.

A recent, highly visible comet was **Hale-Bopp**, which came within 122 million miles (197 million km) of Earth in 1997. Its unusually large nucleus gave off a great deal of dust and gas — estimated at roughly 18 to 25 miles (30 to 40 km) across — appeared bright to the naked eye.

Comet **ISON** was expected to give a spectacular show in 2013. However, the sun-grazer did not survive its close encounter with the sun and was destroyed in December.

The Pole Stars

A pole star is a visible star, preferably a prominent one, that is approximately aligned with the Earth's axis of rotation; that is, a star whose apparent position is close to one of the celestial poles, and which lies approximately directly overhead when viewed from the Earth's North Pole or South Pole.

Polaris is the North Pole Star

Sigma Octantis, which is sometimes called the South Star.

The Constellations

88 constellations are there

Zodiac constellations are constellations that lie along the plane of the ecliptic

The 12 constellations in the zodiac family can all be seen along the ecliptic.
Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricornus, Aquarius and Pisces.

പാശ്ചാത്യർ ഉപയോഗിക്കുന്ന പേർ	മലയാള നാമം
Aries	മേടം
Taurus	ഇടവം
Gemini	മിഥുനം
Cancer	കർക്കിടകം
Leo	ചിങ്ങം
Virgo	കന്നി
Libra	തുലാം
Scorpio	വൃശ്ചികം
Sagittarius	ധനു
Capricorn	മകരം
Acquarius	കുംഭം
Pisces	മീനം

Nakshatra	Malayalam
Ashwini *Horse like woman*	അശ്വതി
Bharani *The bearer*	ഭരണി
Krittika *The Cutter*	കാർത്തിക
Rohini *Red faced One*	രോഹിണി
Mrigashirsha *the deer's head*	മകയിരം
Ardra *Moist One*	തിരുവാതിര
Punarvasu *Restoring goods*	പുണർതം
Pushya *Nourishing*	പൂയം
Ashlesha *The embracer*	ആയില്യം
Magha *The wealthy one*	മകം
Purva Phalguni *Earlier reddish one*	പൂരം
Uttara Phalguni *Latter reddish one*	ഉത്രം
Hasta *The hand*	അത്തം
Chitra *The bright one*	ചിത്തിര
Swati *Sword or Independence*	ചോതി
Vishaka *Forked (having branches)*	വിശാഖം
Anuradha *Disciple of divine spark*	അനിഴം
Jyeshta *The eldest*	തൃക്കേട്ട
Moola *The root*	മൂലം
Purva Ashadha *Previous invincible one*	പൂരാടം
Uttara Ashada *Latter invincible one*	ഉത്രാടം
Shravana *The audible*	തിരുവോണം
Dhanistha *The richest one*	അവിട്ടം
Shatabhisaa *Hundred healers*	ചതയം
Purva Bhadrapada *Former blessed feet*	പൂരുരുട്ടാതി
Uttara Bhadrapada *Latter blessed feet*	ഉത്രട്ടാതി
Revati *The wealthy*	രേവതി

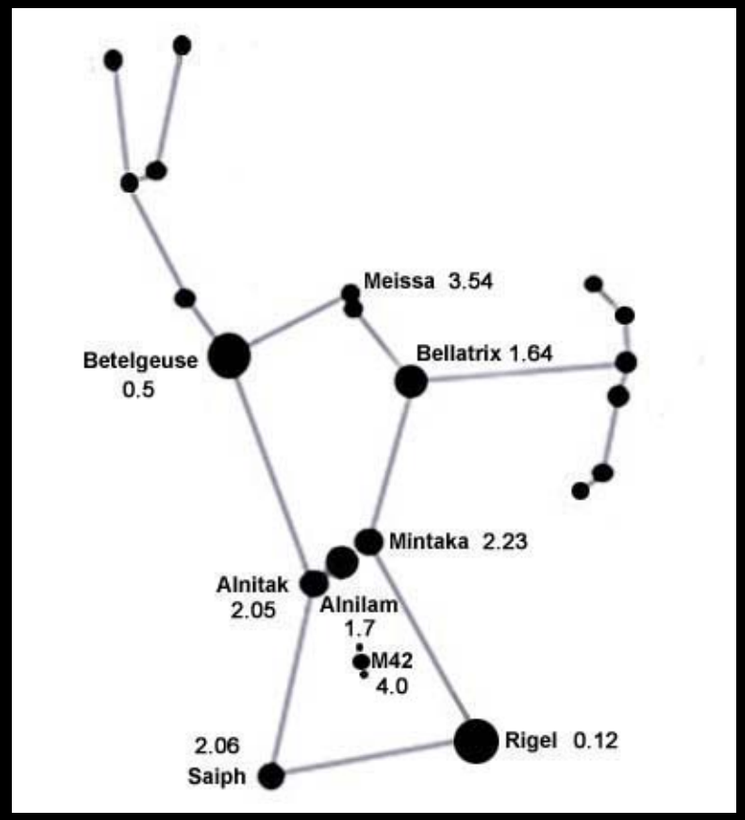
1592 1603 1613 1692 1763

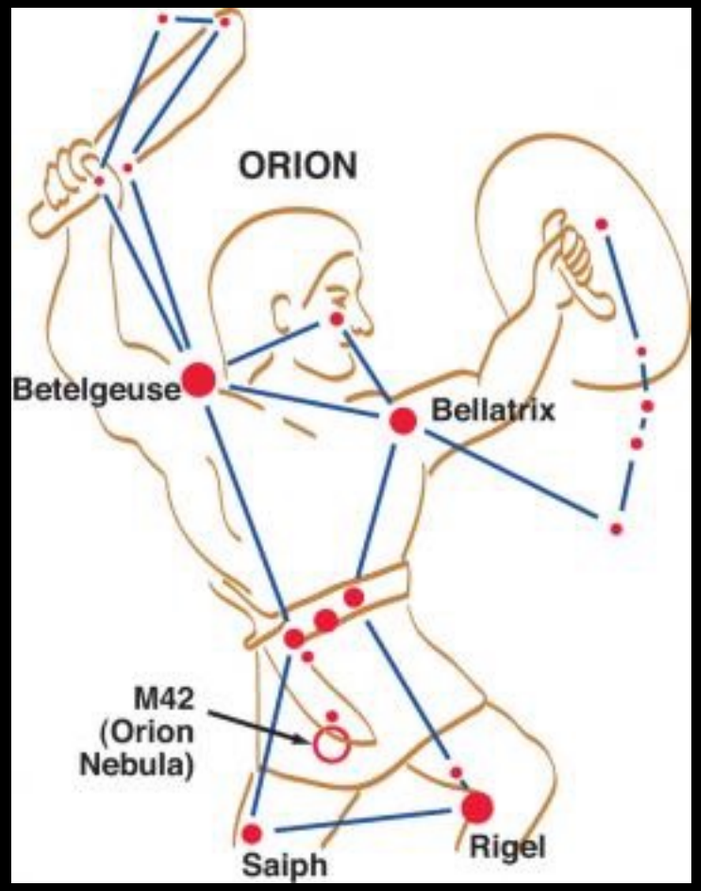
Cepheus
Ursa Minor
Draco
Camelopardalis
Cepheus
Cassiopeia
Ursa Major
Lynx
Lacerta
Cygnus
Boötes
Canes Venatici
Auriga
Perseus
Andromeda
Lyra
Corona Borealis
Leo Minor
Triangulum
Vulpecula
Hercules
Coma Berenices
Gemini
Taurus
Aries
Pegasus
Sagitta
Cancer
Leo ♌
♋
♊
♉
♈
Pisces ♓
Serpens (Caput)
Delphinus
Orion
Equuleus
Canis Minor
Virgo ♍
Aquila
Serpens (Cauda)
Sextans
Monoceros
Cetus
ECLIPTIC
Scutum
Libra
Crater
Aquarius ♒
Capricornus ♑
Ophiuchus ♎
Corvus
Hydra
Canis Major
Lepus
Eridanus
Sagittarius ♐
Pyxis
MILKY WAY
Piscis Austrinus
Scorpius ♏
Antlia
Fornax
Sculptor
Columba
Corona Austrina
Puppis
Microscopium
Lupus
Vela
Caelum
Phoenix
Grus
Centaurus
Pictor
Telescopium
Norma
Horologium
Indus
Ara
Circinus
Crux
Carina
Reticulum
Tucana
Triangulum Australe
Dorado
Tucana
Pavo
Musca
Volans
Hydrus
Apus
Chamaeleon
Mensa
Octans

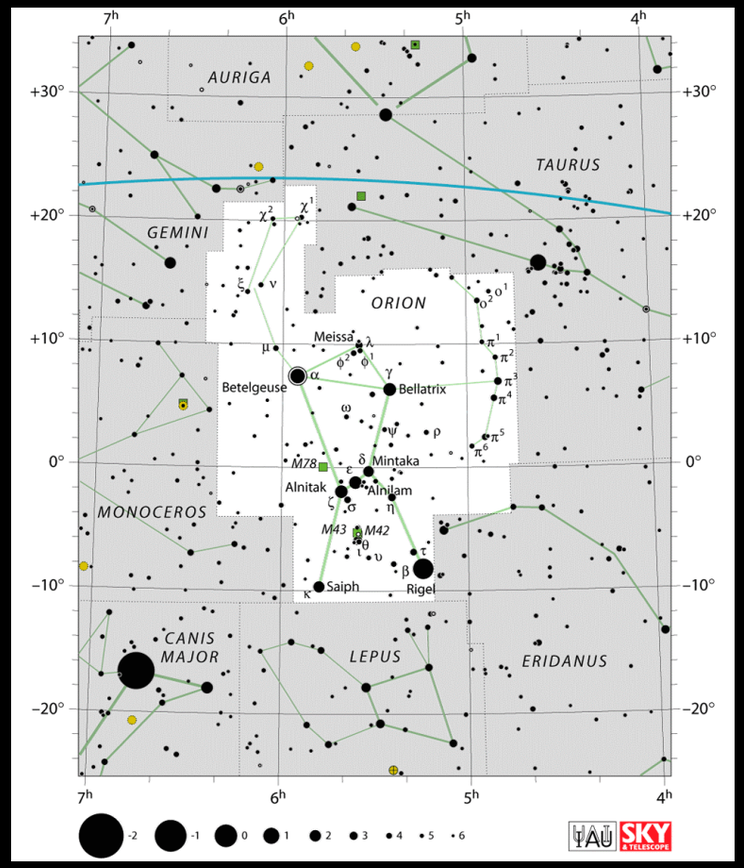
Orion Constellation

Lies on the celestial equator.

Also known as the Hunter, as it is associated with one in Greek mythology.
It represents the mythical hunter Orion.



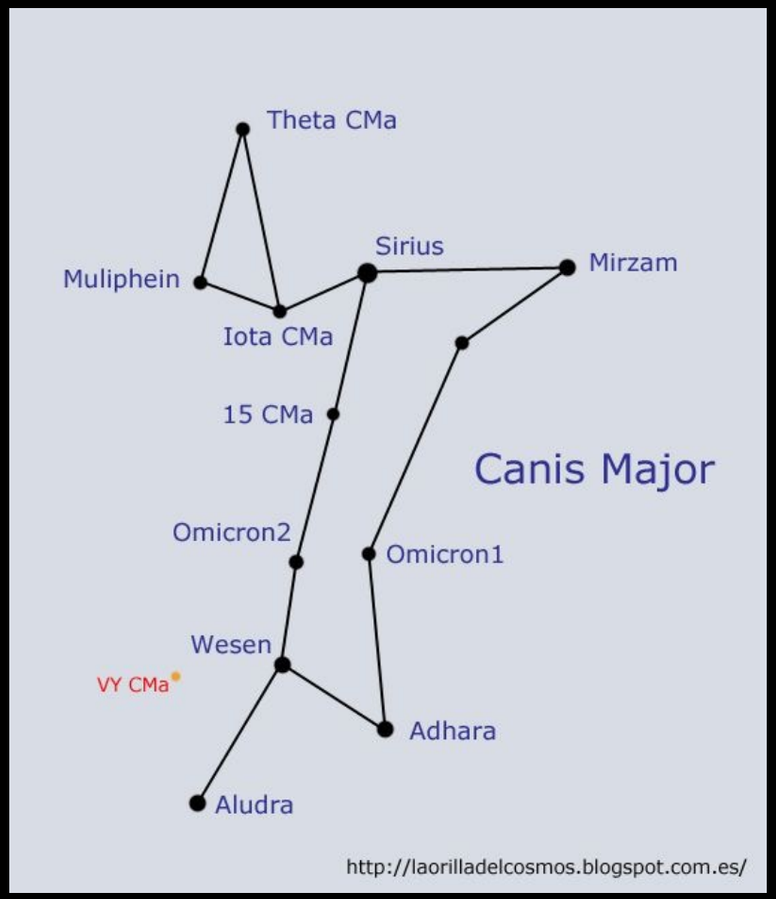


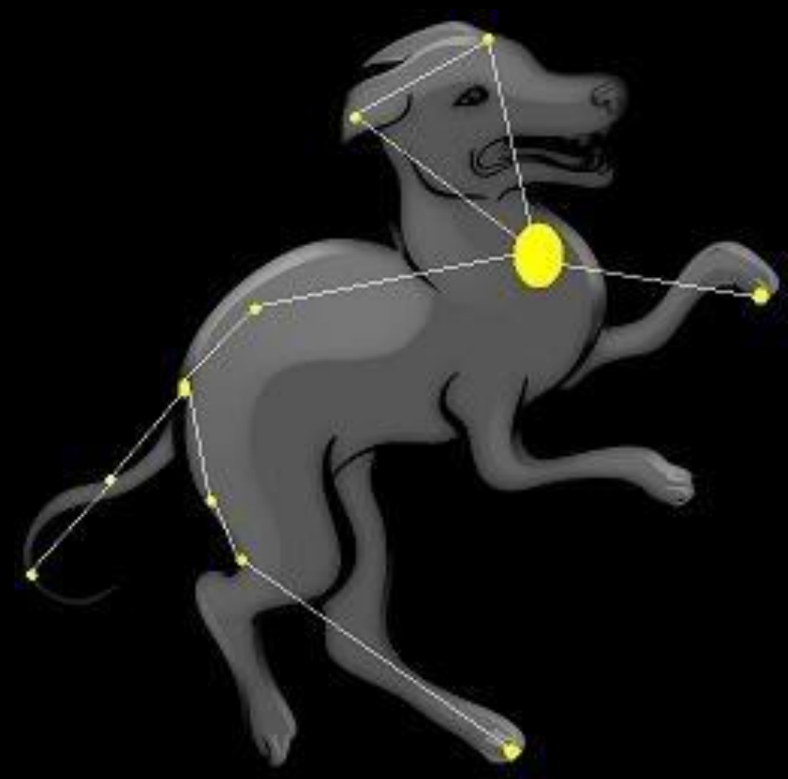


Canis Major Constellation

Canis Major is a constellation in the southern celestial hemisphere.

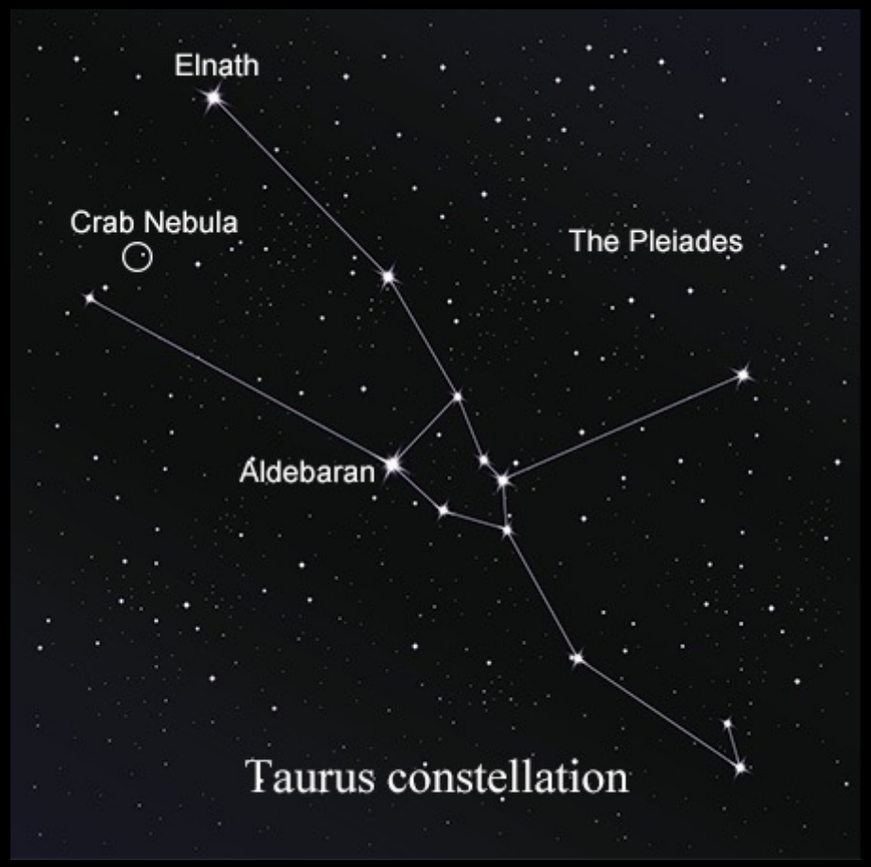
Canis Major contains Sirius, the brightest star in the night sky, known as the "dog star".

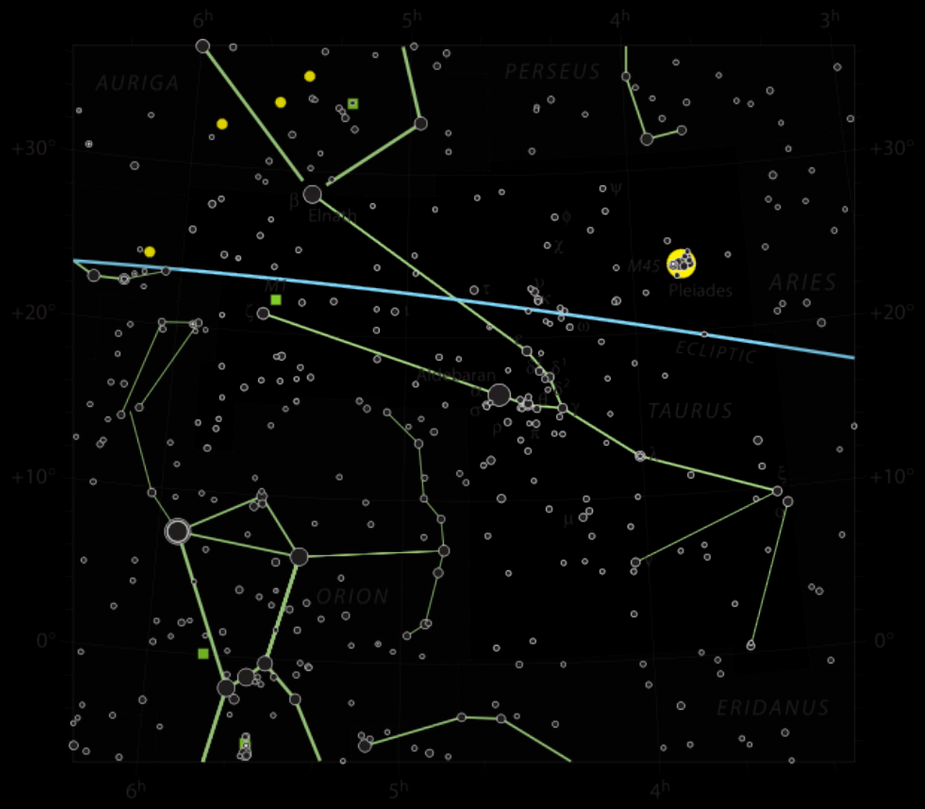




Taurus (constellation)

Taurus is one of the constellations of the zodiac.
Taurus is a large and prominent constellation in the northern hemisphere's winter sky.





Leo (constellation)

Leo is one of the constellations of the zodiac, lying between Cancer to the west and Virgo to the east. Its name is Latin for lion.