

ASTRONOMY

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Chester County Senior Centers

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Etymology

- ▶ Greek word astron...means star
- ▶ Greek word nomos...means law

Law of the Stars

Astronomy is the study of objects and matter outside the Earth's atmosphere and of their physical and chemical properties.



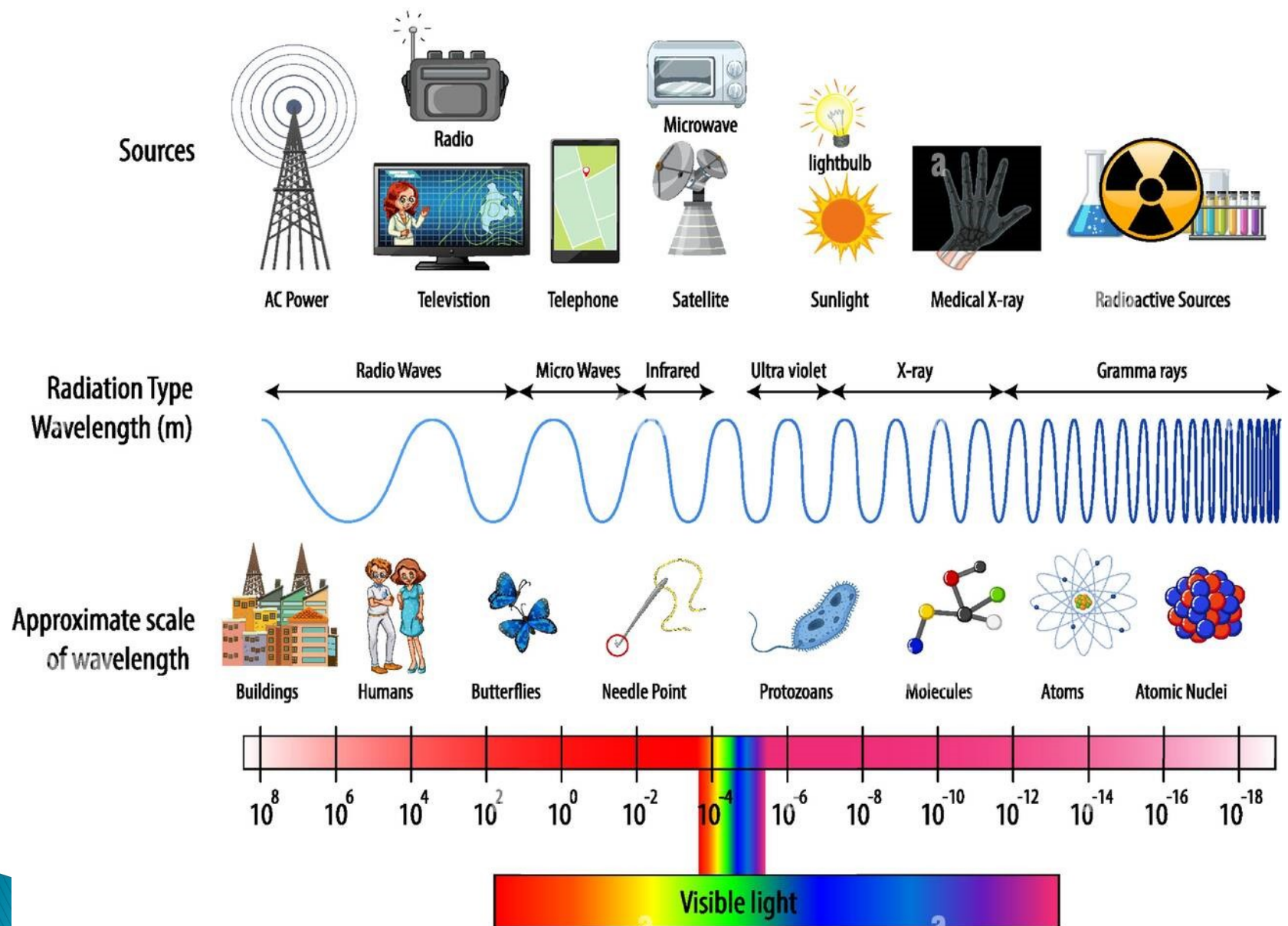
Branches

- ▶ **Optical Astronomy** is the study of visible celestial objects
- ▶ **Non-Optical Astronomy** uses instruments other than telescopes to create a picture of the universe that spans the entire electromagnetic spectrum

Subfields include:

- ▶ **Planetary astronomy**: focuses on planets within and outside our solar system.
- ▶ **Stellar astronomy**: study of the stars including their origin, evolution and death.
- ▶ **Galactic astronomy**: studies the complex system of stars, nebulae and dust that make up the Milky Way. It also studies the motion and evolution of the Milky Way and the formation of galaxies.
- ▶ **Extragalactic astronomy**: This is a study of galaxies in the universe outside of the Milky Way to learn how galaxies are grouped and interact on a large scale.
- ▶ **Cosmology**: Cosmologists study the structure of the universe to understand its origin. They attempt to model what the Universe would have looked like soon after the Big Bang occurred.

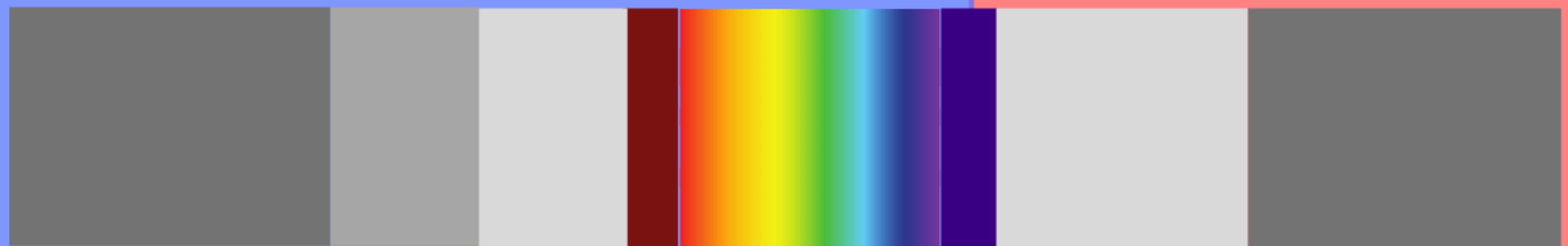
THE ELECTROMAGNETIC SPECTRUM



Non-ionizing and Ionizing Radiation

Non-ionizing

Ionizing



extremely low frequency

radio

microwave

infrared

visible light

ultraviolet


x-rays

gamma rays



alpha particles
beta particles
neutrons

What will we learn?


- ▶ The sun, earth, moon system
 - ▶ Our solar system
 - ▶ Stars
 - ▶ Constellations
 - ▶ Galaxies
 - ▶ The Big Bang
- 

The Earth

- ▶ What do you see?



By the numbers

- ▶ The diameter of the earth is 7,926 miles – 12,756 km at the equator. Same at poles?
 - ▶ The circumference is 24,901 miles – 40,075 km
 - ▶ The earth is 71% covered by water, 29% by land
 - ▶ How long is a day?
 - ▶ Who can tell me, based on what we have learned so far, how fast the earth is rotating?
 - ▶ The earth is 92,960,000 miles – 149,600,000 km from the sun
 - ▶ The earth is about 4.5 billion years old
- 

The earth has 1 moon

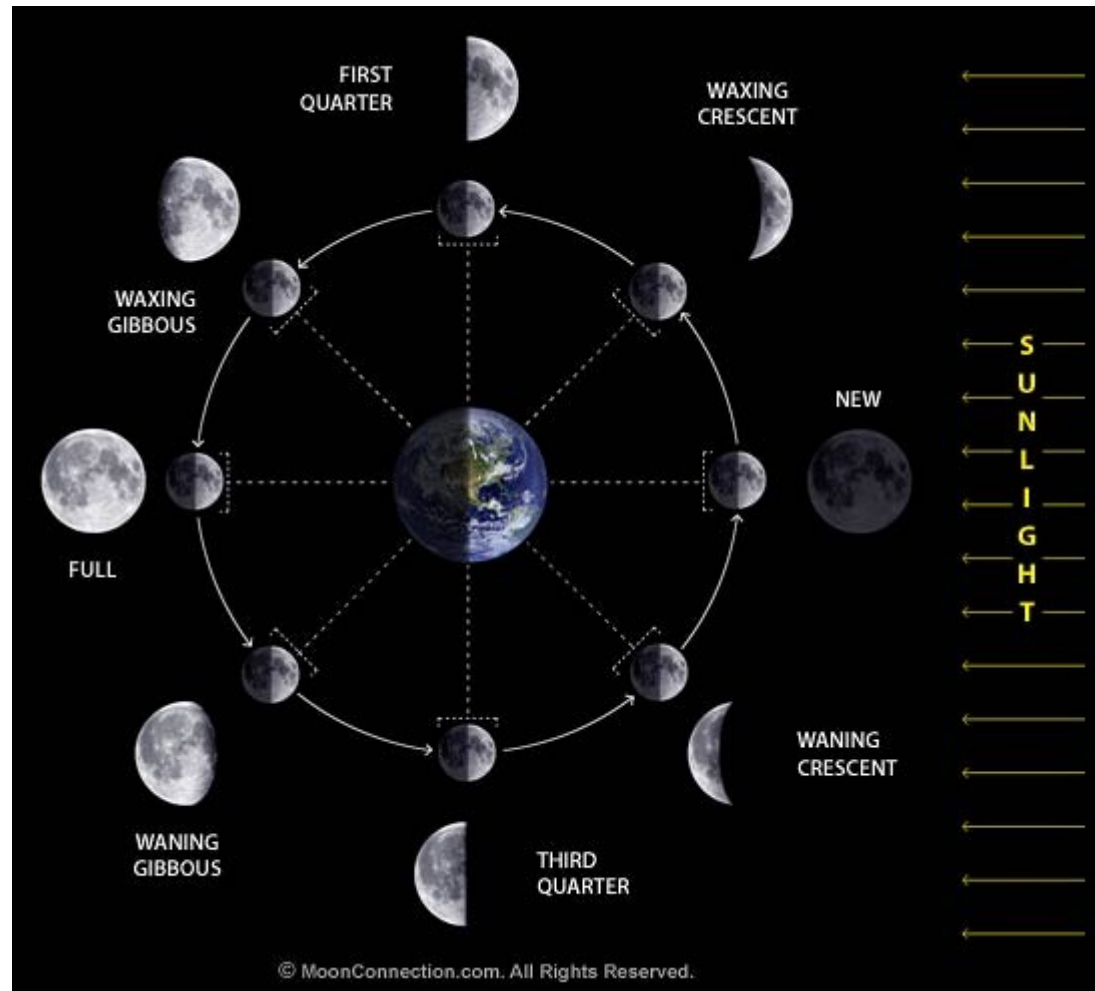
What do you see?



The moon

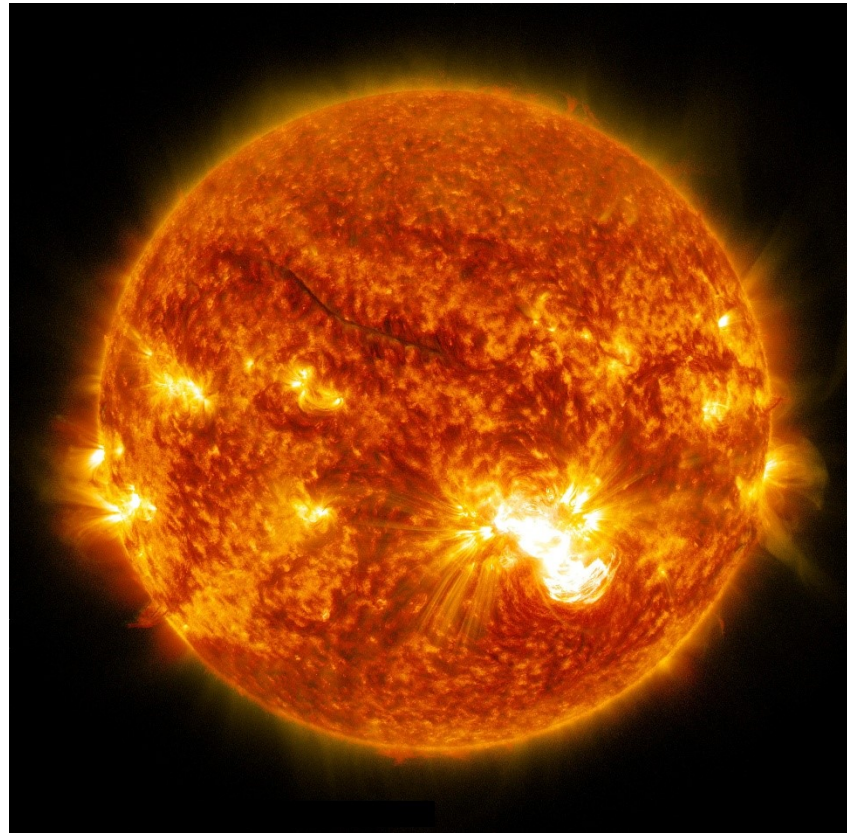
- ▶ Is 238,900 miles – 384,400 km from earth
 - It takes about 3 days to get there on a space ship
- ▶ The moon is about 4.4 billion years old
- ▶ It formed as the result of a collision of a mars sized object with earth.
- ▶ The moon is the main cause of tides on earth
- ▶ Life as we know it would not be possible without the moon.
- ▶ Man first landed on the moon 20 July 1969.
- ▶ Circumference is 6,784 miles – 10,917 km
- ▶ Our moon is the 5th largest in the solar system and the largest relative to the size of its primary.

Phases of the moon



The Sun

- ▶ What do you see?



What *is* the sun?

- ▶ The sun is a yellow dwarf star (white when viewed from space)
- ▶ Diameter is 865,374 mi – 1,392,684 km
- ▶ Ongoing thermonuclear reaction converts H into He and releases energy and light
- ▶ Sun formed just over 4.5 billion years ago
- ▶ Sun's light takes 8 minutes to reach earth
- ▶ The sun has an atmosphere called the corona
- ▶ The temperature at the core is about 27 million degrees F, 15 million C, and at the surface (photosphere) about 10,000 F, 5,500 C, but the corona is about 1.8 million degrees F, 1 million C.

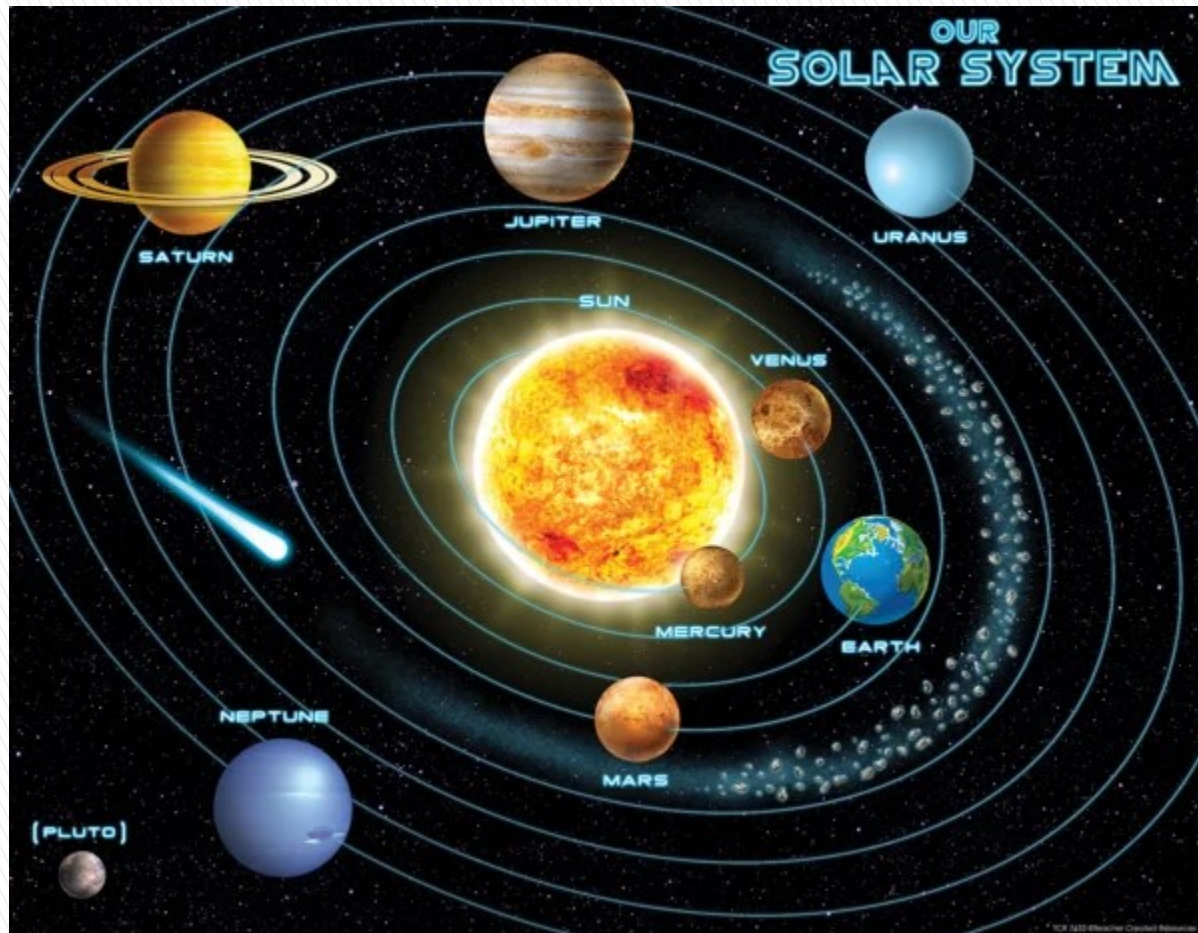
The Sun Is An Ordinary Star

- ▶ The other stars are suns that are very far away
- ▶ Spectroscopic analysis allowed us to see that the other stars have the same chemical make up as the sun. They are all the same.

Our Solar System

Who else is in the neighborhood?

- Not to scale...



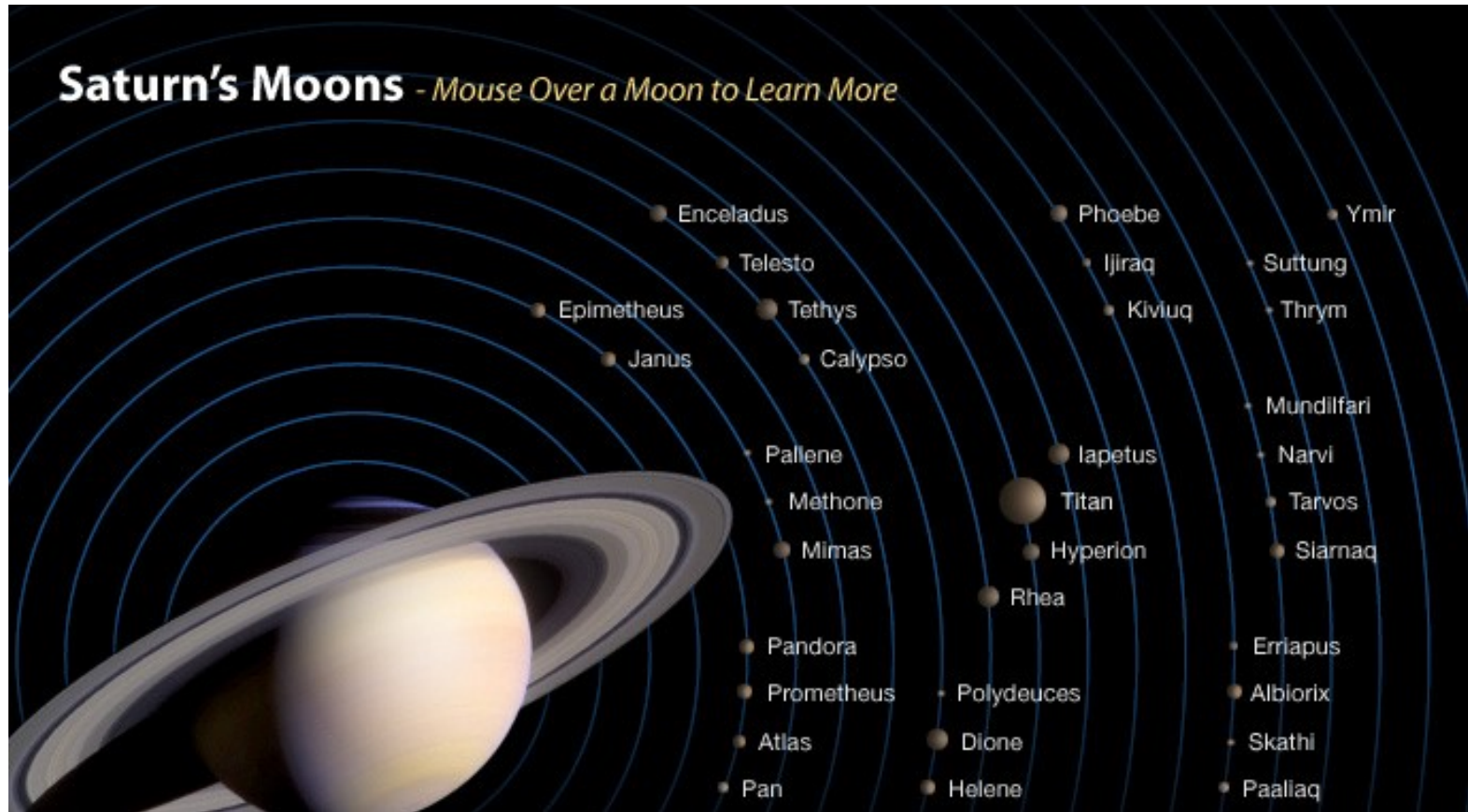
MVEMJSUN

M(r) Vem J Sun

3rd Rock from the Sun

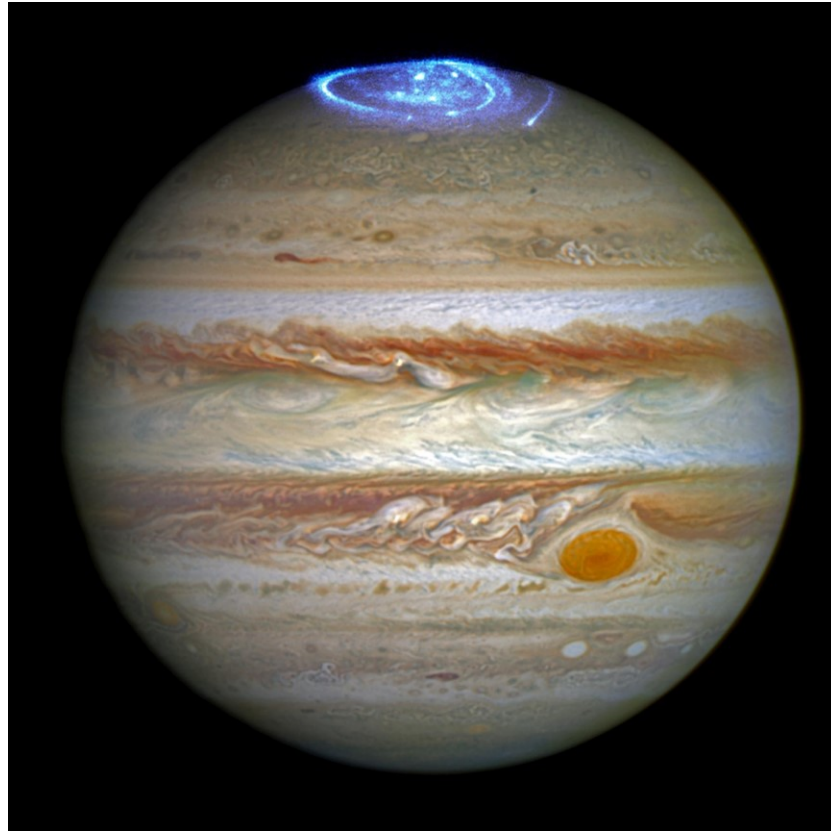
- ▶ Mercury, Venus, Earth and Mars are the inner, rocky planets.
- ▶ The asteroid belt (Mars – Jupiter) is probably comprised of leftovers from the sun's accretion disk
- ▶ Jupiter, Saturn, Uranus and Neptune are the outer gas giants

Saturn



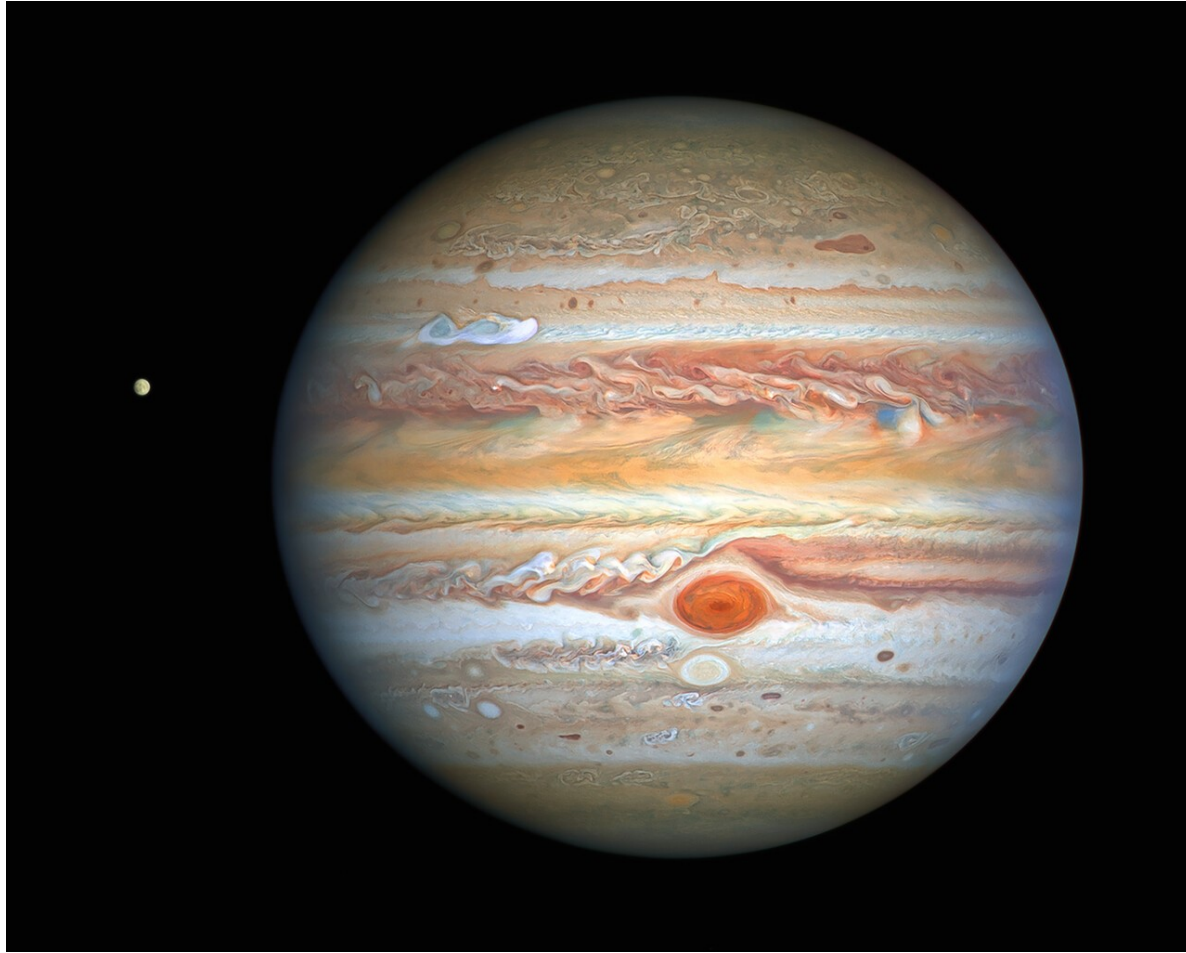
Saturn's magnificent rings are mostly water ice chunks under 30'
All of the outer planets have rings.

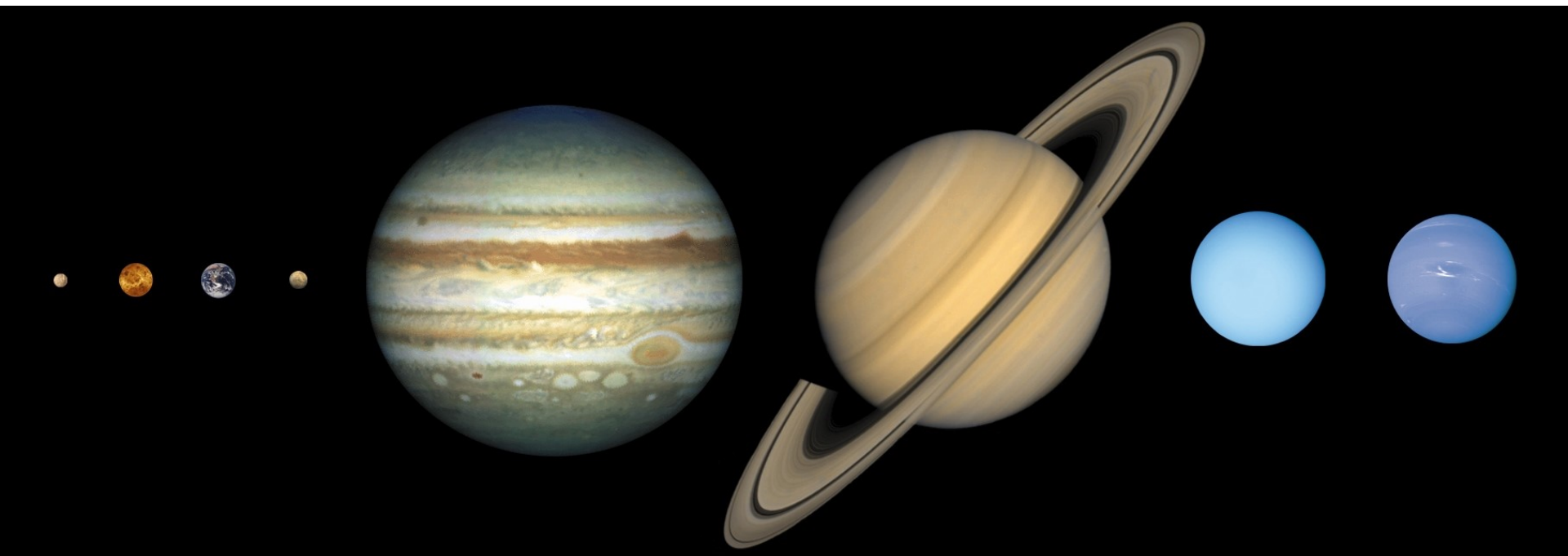
Jupiter



Jupiter's composition is similar to a star. If it were a little bigger, it would have become a star. It is the largest planet in our solar system. Life as we know it on earth would not be possible without Jupiter.

Hubble's View of Jupiter and Europa in August 2020





THE LIFE CYCLES OF STARS

MAIN SEQUENCE

Composition is > 98% hydrogen and helium.
1/3 of the hydrogen is converted to helium.

- ☞ 10–150 solar masses
- 🕒 90% of lifespan
- ✦ Spica, Theta Orionis C

GIANT/SUPERGIANT

Massive stars are capable of producing heavier elements, like iron, through fusion.

- ☞ significant loss of mass
- 🕒 10% of lifespan
- ✦ Betelgeuse, Rigel

SUPERNOVA

Outer layers of hydrogen and helium are ejected along with some heavier elements.

- ☞ All but 10% of the original mass is ejected
- 🕒 seconds
- ✦ Cassiopeia A, Kepler's Supernova

BLACK HOLE

A star's core collapses into extremely dense matter. Even light cannot escape the gravitational pull.

- ☞ 3 solar masses or larger
- 🕒 10^{10} years
- ✦ Cygnus X-1, Sagittarius A

OR

NEUTRON STAR

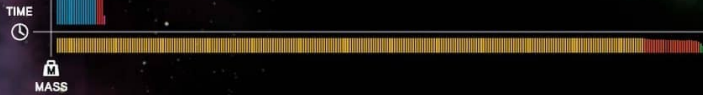
A star's core collapses into a dense mass of neutrons.

- ☞ 1.4–3 solar masses
- 🕒 10^{12} – 10^{15} years
- ✦ Circinus X-1, The Mouse

H
ARS

EBULAE
collapse
accumulates
ar.

V
ARS



High-mass stars live for one million to tens of millions of years
while low-mass stars, like our Sun, live for tens of millions to trillions of years.

MAIN SEQUENCE

Composition is > 98% hydrogen and helium.
1/3 of the hydrogen is converted to helium.

- ☞ .08–10 solar masses
- 🕒 90% of lifespan
- ✦ Sun, Altair

RED GIANT

Expanding hydrogen in their cores, these stars extend their outer layers and can grow to > 100 times their main sequence size.

- ☞ 99% of original mass
- 🕒 10% of lifespan
- ✦ Aldebaran, Arcturus

PLANETARY NEBULA

The outer layers of gas are ejected while the star's core contracts into a white dwarf.

- ☞ All but 5–15% of the original mass is ejected
- 🕒 tens of thousands of years
- ✦ M27, NGC 40

WHITE DWARF

This star core is typically composed of carbon and oxygen. Neon, magnesium, and helium are possible.

- ☞ 5–15% of original mass
- 🕒 10^9 – 10^{25} years
- ✦ Mira B, Sirius B

BLACK DWARF

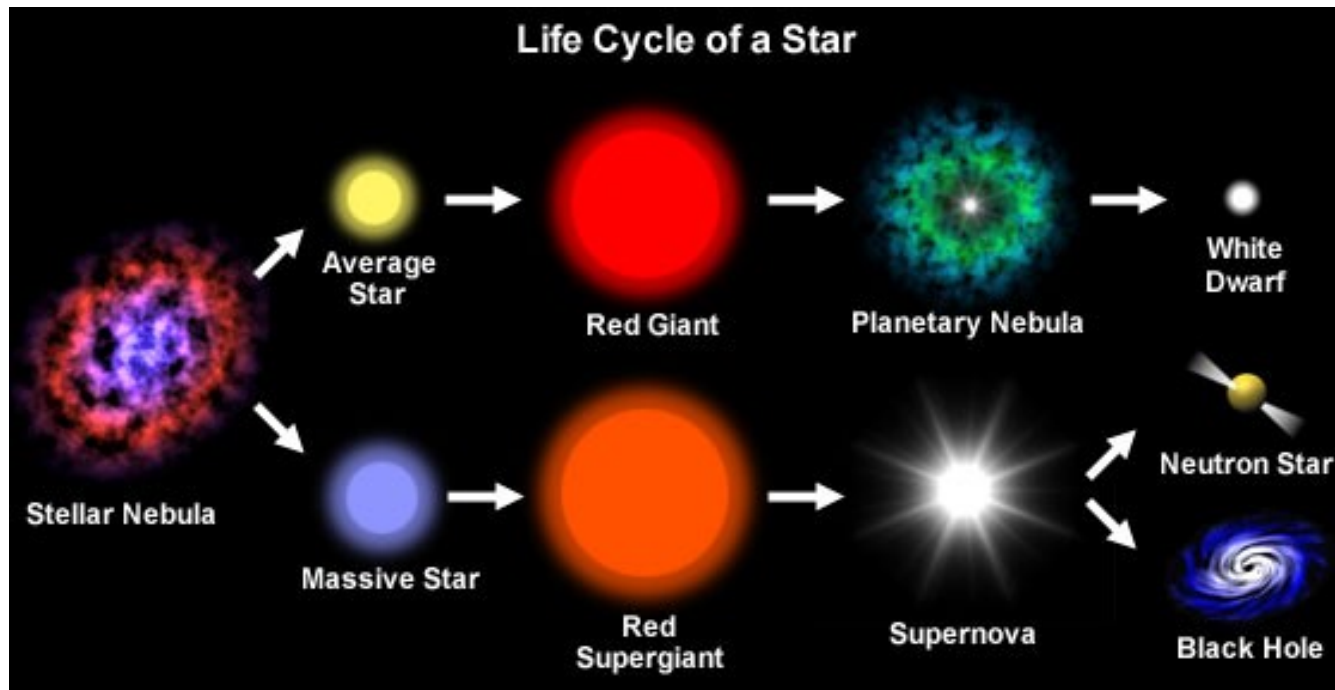
A hypothetical remnant of a cooled white dwarf, the Universe's existence is too short to prove its existence.

- ☞ < 1.4 solar masses
- 🕒 10^{12} – 10^{15} years

RETURN TO NEBULAE
Matter expelled from stars
can eventually accumulate to
new star-forming nebulae.

HISTORY PROJECT

A Star's Mass Determines Its Life Cycle



Main Sequence Stars

- ▶ 90% of stars, including our sun, are MS stars, also called dwarf stars. They fuse Hydrogen (H) into Helium (HE).
- ▶ When the helium is gone, the next step depends on the star's mass.
- ▶ All elements up to Iron (FE) are formed in MS stars.
- ▶ More massive stars become super novae. Almost all elements heavier than FE are formed inside supernovae (gold AU)

Periodic Table of the Elements

1 IA 11A H Hydrogen 1.008	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.61	33 As Arsenic 74.922	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 84.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.94	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.757	52 Te Tellurium 127.6	53 I Iodine 126.905	54 Xe Xenon 131.29
55 Cs Cesium 132.905	56 Ba Barium 137.327	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Fl Flerovium [289]	115 Uu Ununpentium [288]	116 Uu Ununhexium [288]	117 Uu Ununseptium [289]	118 Uu Ununoctium [294]

Lanthanide Series

Actinide Series

57 La Lanthanum 138.906	58 Ce Cerium 140.115	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.24	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.966	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.50	67 Ho Holmium 164.930	68 Er Erbium 167.26
89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095

Alkali Metal

Alkaline Earth

Transition Metal

Basic Metal

Semimetal

Nonmetal

Halogen

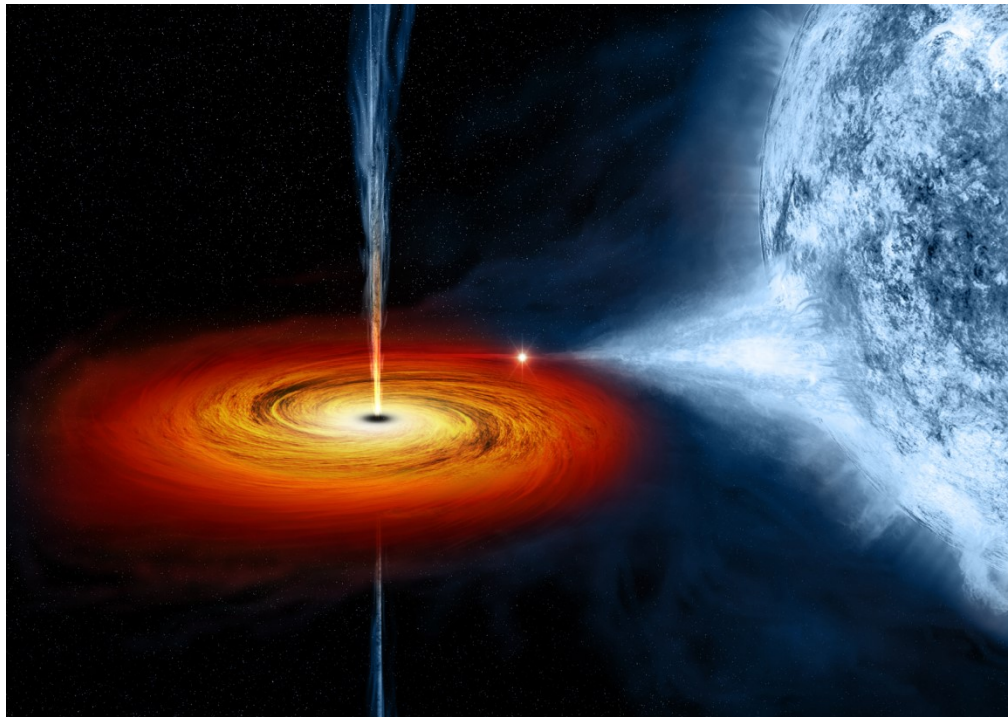
Noble Gas

Lanthanide

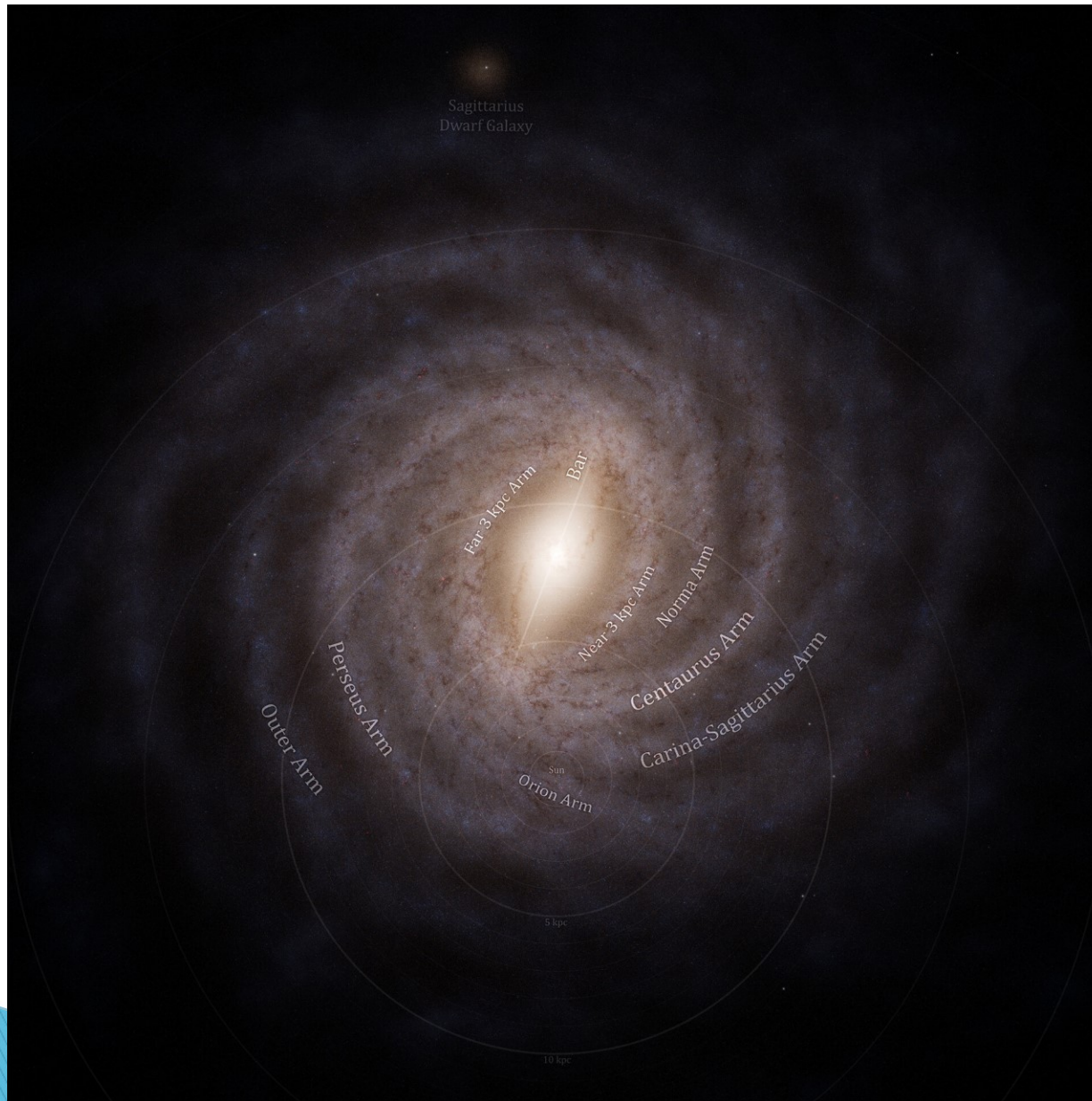
Actinide

Black Holes

- ▶ More massive stars eventually collapse into neutron stars and the most massive stars become black holes.



Milky Way Galaxy





The Milky Way contains between 100 Billion and 400 Billion stars (other galaxies contain between 10 billion and 100 trillion stars)

There are as many planets in the Milky Way as stars

All the stars you see on a dark night are in the Milky Way

The Milky Way has absorbed several smaller galaxies

It is 13.2 billion years old

The Milky Way has a Super Massive Black Hole at its Center (Sagittarius A*)

The Milky Way moves at about 1.3 million mph. Our solar system moves within the galaxy at about 500,000 mph



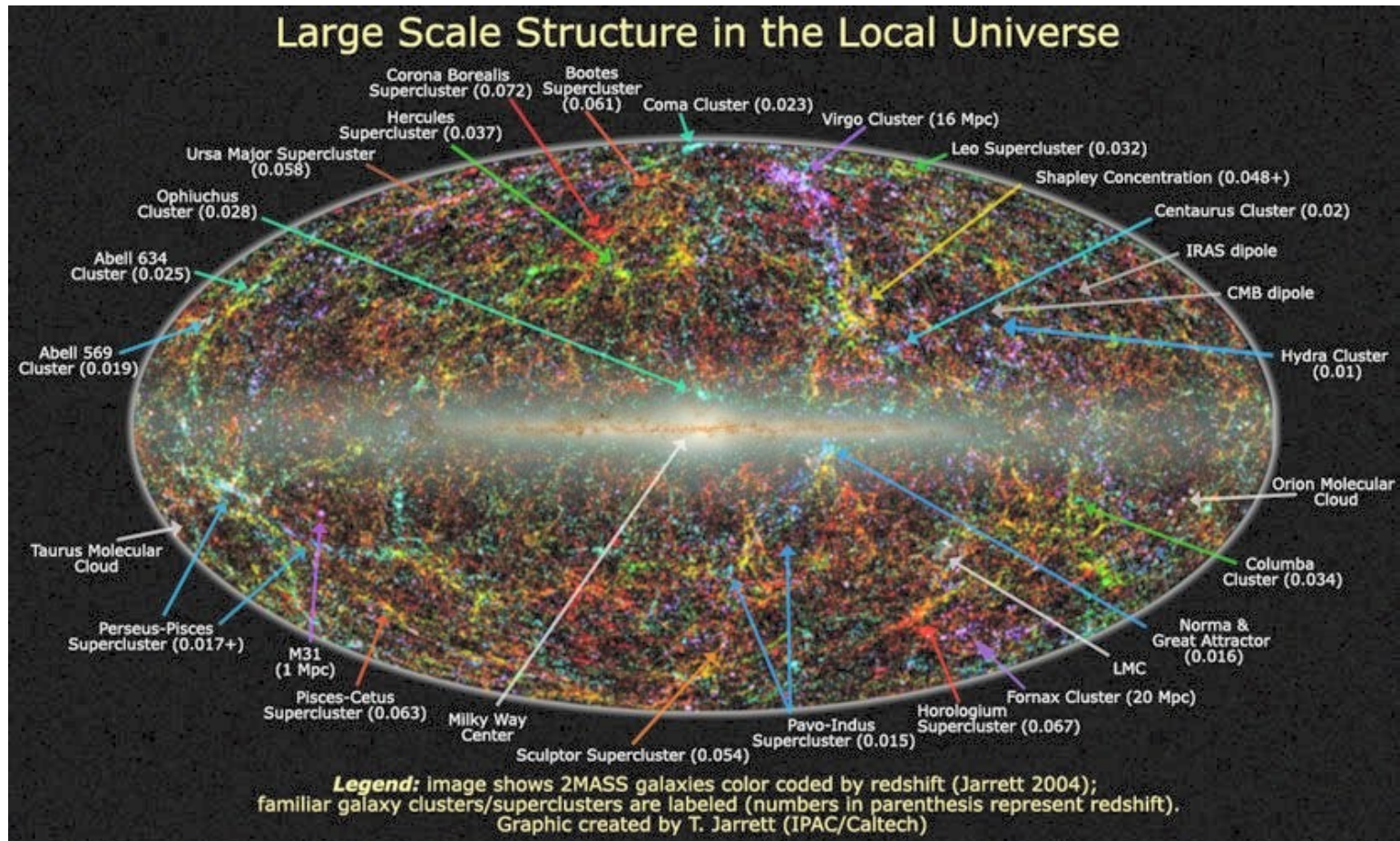
How Many Galaxies Are There?

- ▶ It wasn't until the late 1920s that Edwin Hubble proved that there are many Galaxies outside the Milky Way.
- ▶ The aptly named Hubble Telescope has allowed us to view a vast array of galaxies all across the universe. The estimate is that there are 200 Billion to 2 Trillion Galaxies. The most recent observations by Hubble and other telescopes put the number at 2 trillion or more.


Hubble Deep UV – August 2018



Distribution of Galaxies



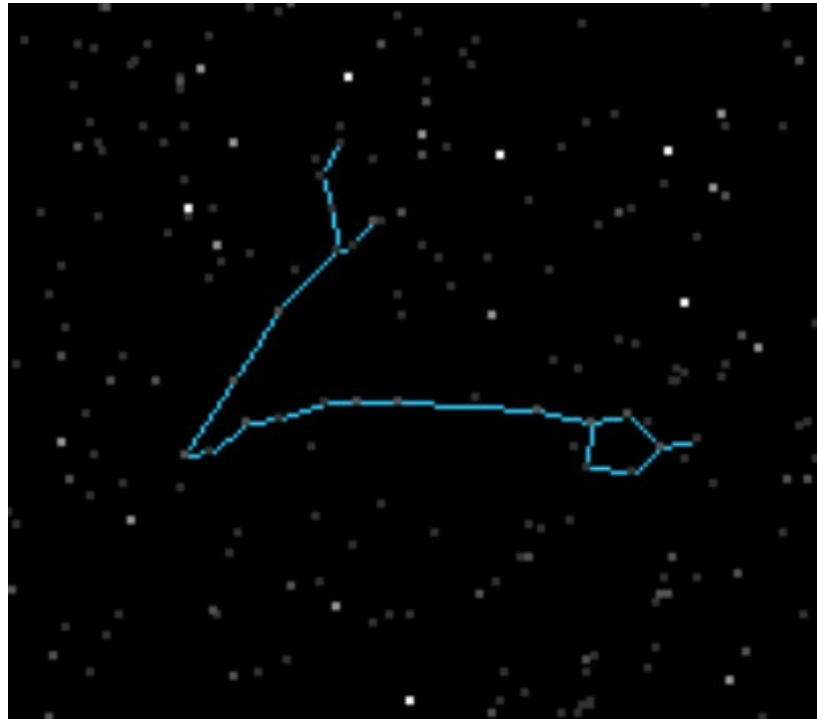
What are Constellations?

- ▶ Latin – “Set of stars”
 - ▶ In 1930 The International Astronomical Union recognized 88 constellations covering the northern and southern sky
 - ▶ The 12 constellations of the zodiac are no more important to astronomers than the other 76 constellations
 - ▶ The significance of the zodiac stems from the fact that the ecliptic -- the narrow path on the sky that the Sun, Moon, and planets appear to follow -- runs directly through these star groupings. They "wander" through the background stars of the zodiac. It was reasoned that these zodiacal constellations must be special to make up this path
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Where Did The Names Come From?

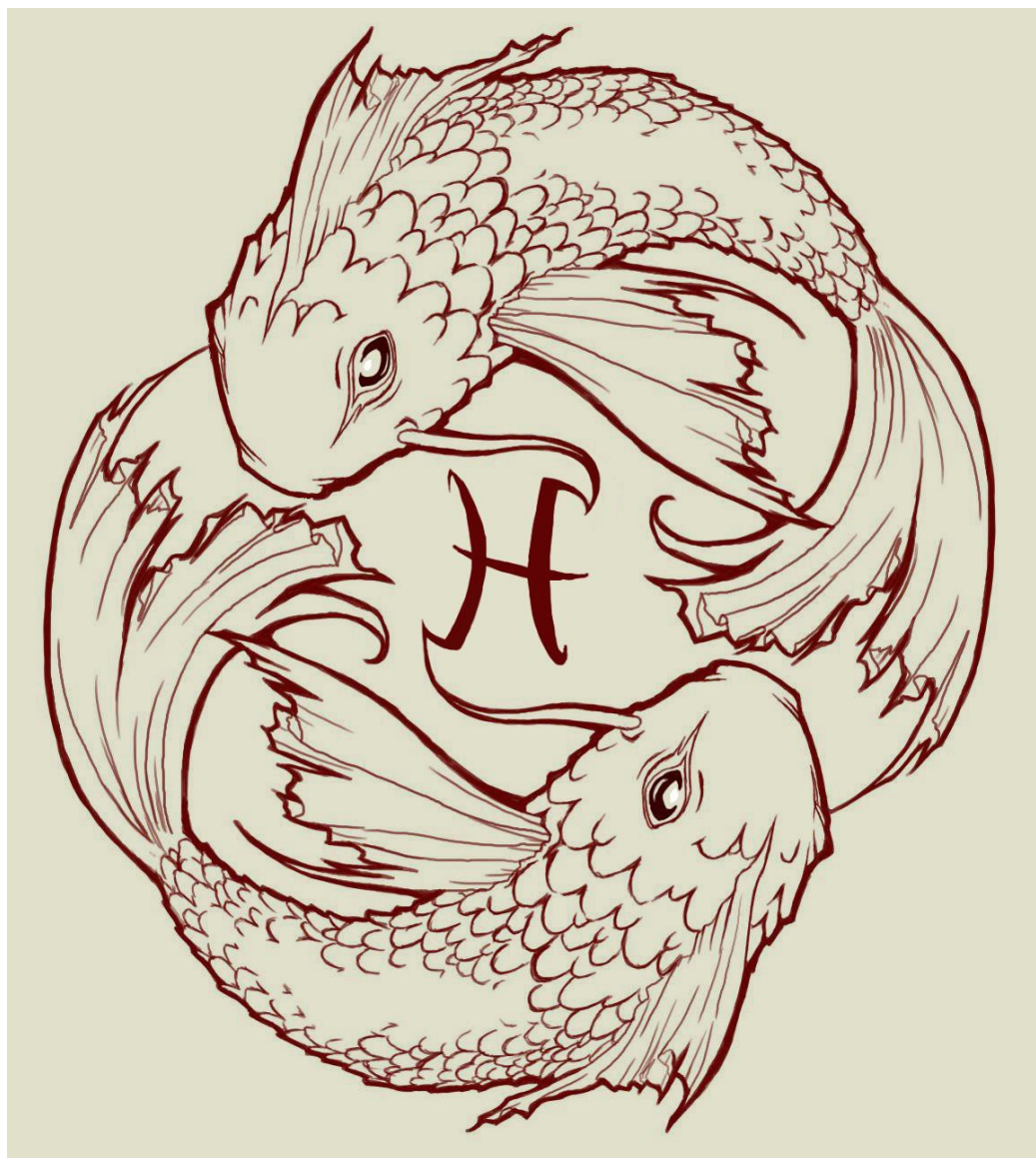
- ▶ Most constellation names are Latin in origin, dating from the Roman empire, but their meanings often originated in the distant past. Scorpius, for instance, was given its name from the Latin word for scorpion, but ancient Egyptian hieroglyphs from before 3000 BCE refer to the star group the scorpion king. Orion the hunter bears a Greek name, but had been seen as a hunter/hero figure since the times of ancient Babylon (2300 BCE)

What does it look like to you?




Who Says Pisces Looks Like A Fish?

- ▶ The horrible earthborn giant Typhoeus suddenly appeared one day, startling all the gods into taking on different forms to flee. Jupiter transformed himself into a ram; Mercury became an ibis; Apollo took on the shape of a crow; Diana hid herself as a cat; and Bacchus disguised himself as a goat. Venus and her son Cupid were bathing on the banks of the Euphrates River that day, and took on the shapes of a pair of fish to escape danger. Minerva later immortalized the event by placing the figures of two fish amongst the stars.




Short Version Is Someone Made It All Up Based On A Vivid Imagination

- ▶ Astronomers use patterns of stars called asterisms to find their way around the sky. An example is the big dipper (not a constellation)
 - ▶ Astronomers look for lines, shapes, characteristics and patterns to find objects in the sky.
 - ▶ Arcturus is an easy star to find and can lead you to many other objects.
- 

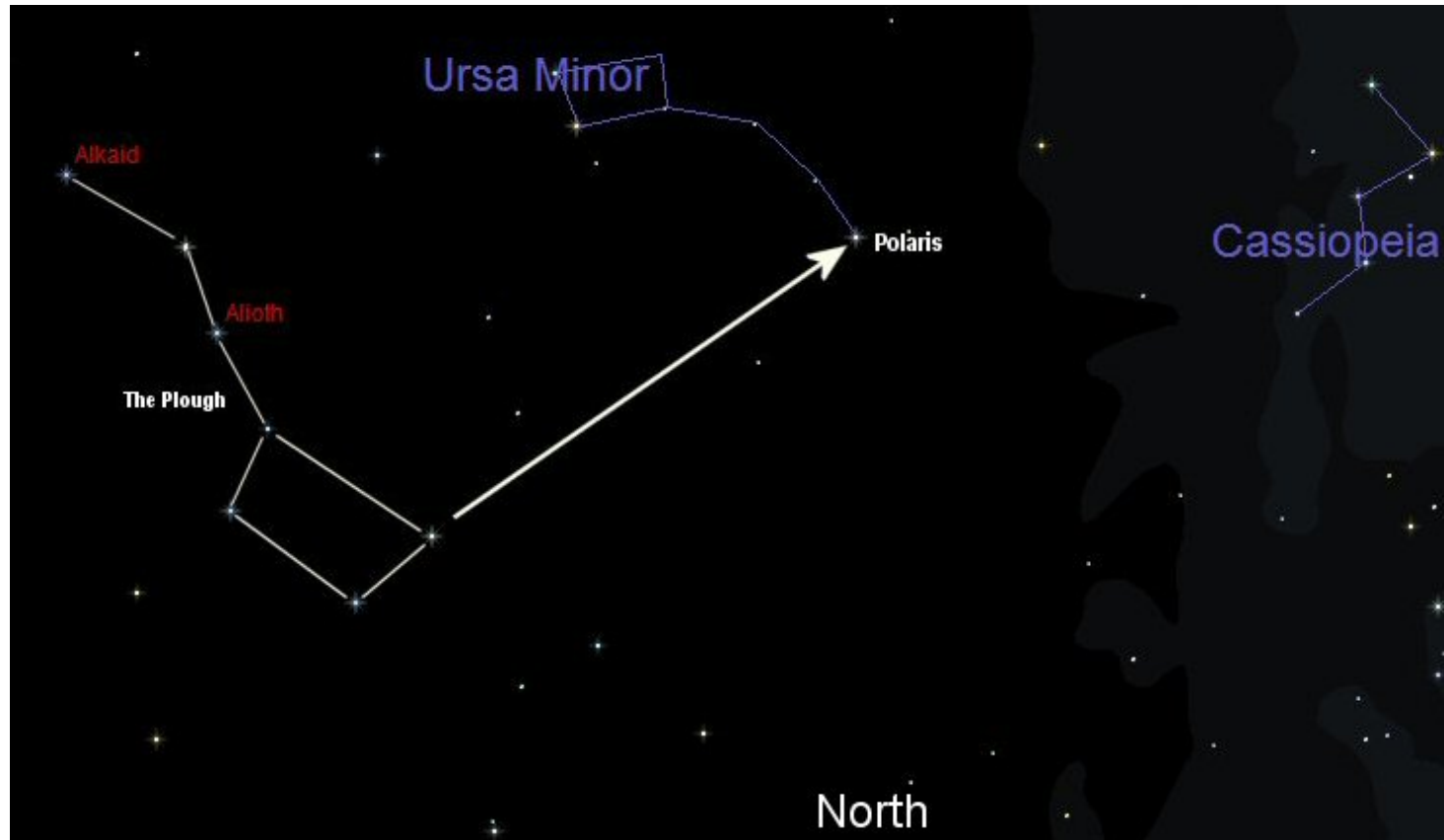
The Big Bang

- ▶ The Big Bang theory is the prevailing cosmological model for the universe from the earliest known periods through its large scale evolution. It states that the universe was in a very high density state and then rapidly expanded.

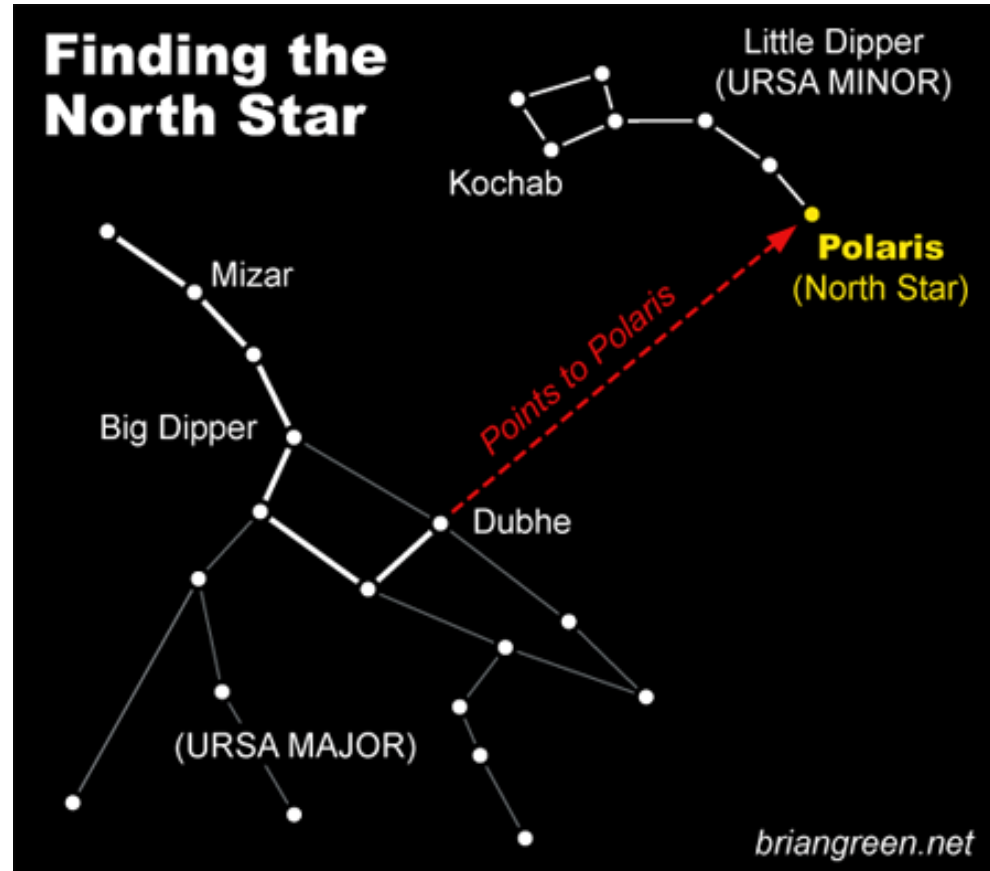
Observing Tips

- ▶ Stars twinkle, planets do not
 - ▶ Use known objects to find objects new to you
 - ▶ Binoculars are fine, you do not need a telescope
 - ▶ Check out space.com for information
 - ▶ Get used to finding Polaris
 - ▶ Find the darkest place you can (light pollution makes dimmer objects impossible to see)
 - ▶ Read about the objects you find (Polaris, Arcturus, Spica, Vega, Sirius, Betelgeuse, etc.)
- 

Finding Polaris



Big Dipper is an asterism in Ursa Major

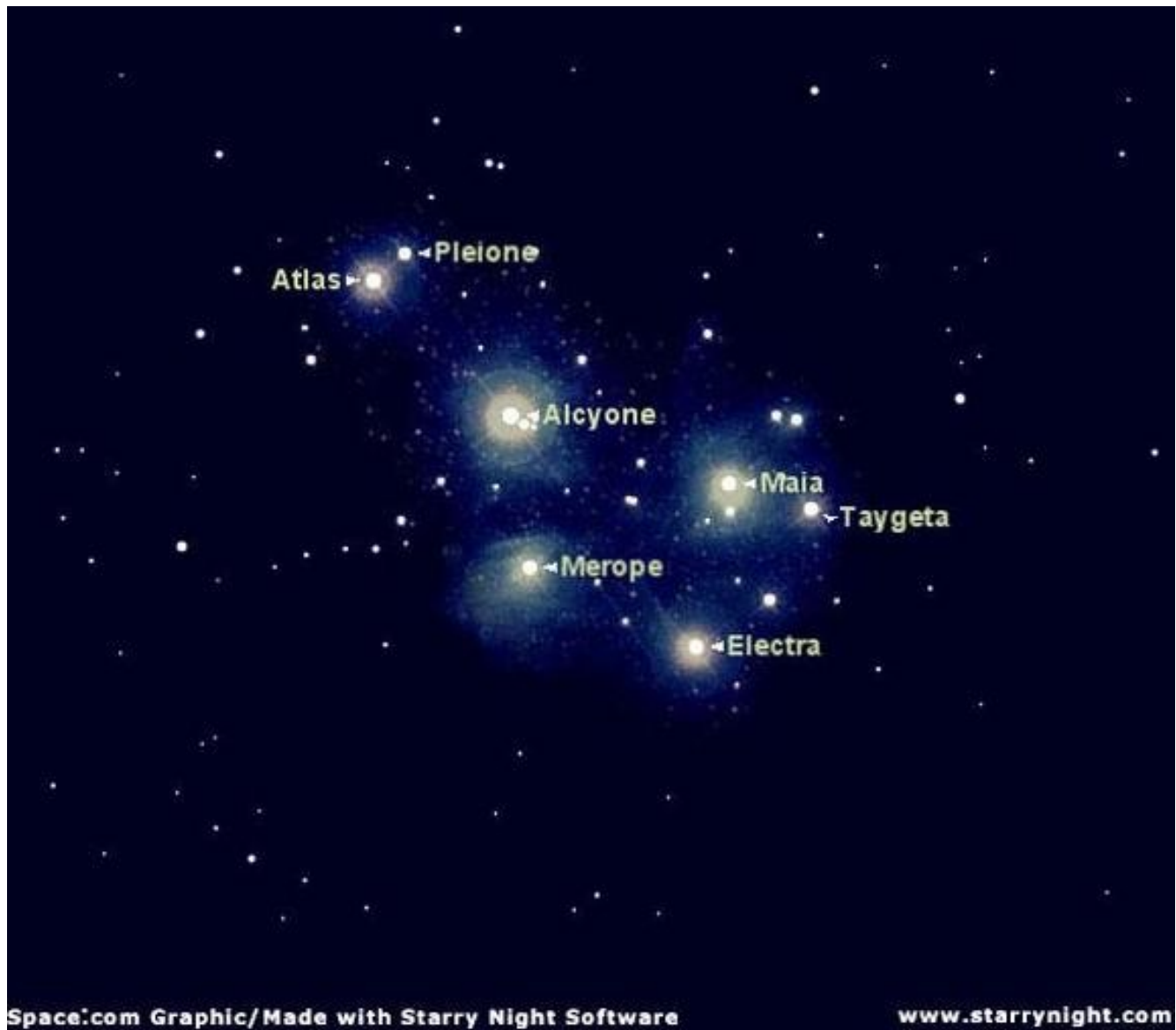


Finding Sirius (the brightest star)



The Seven Sisters

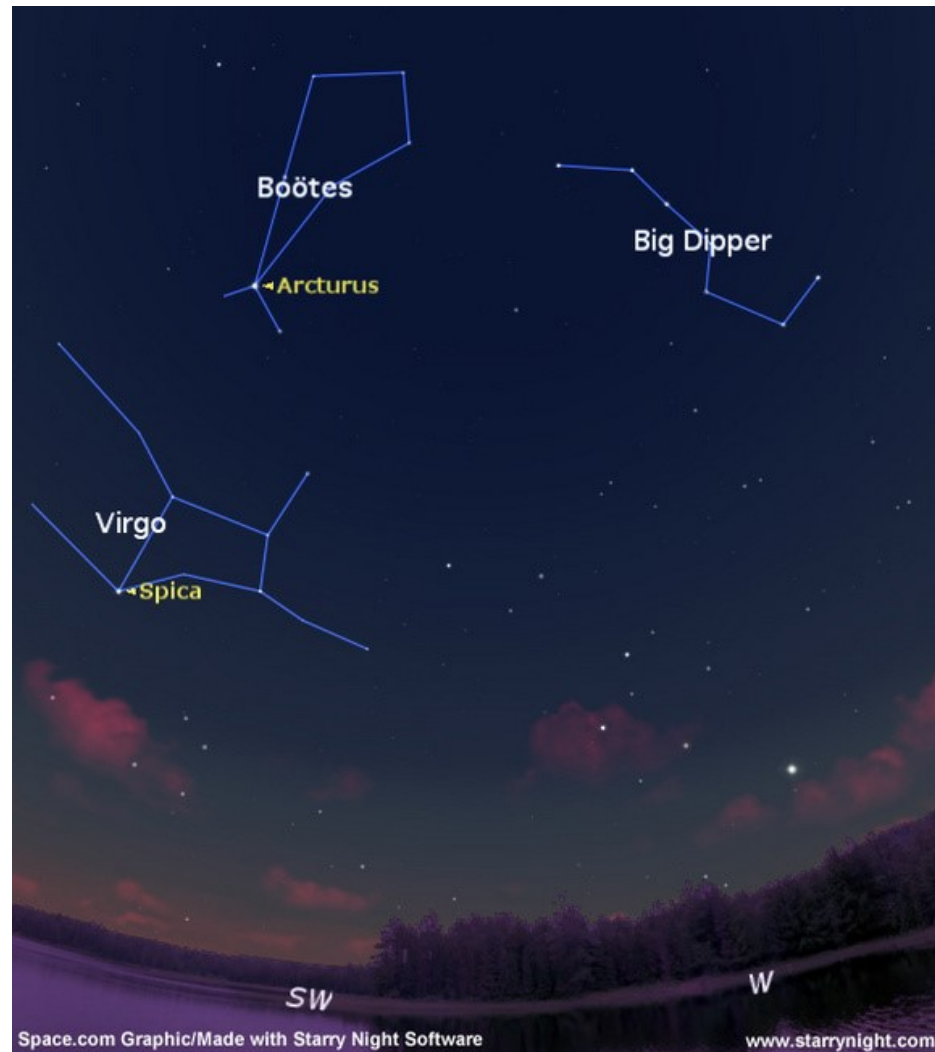




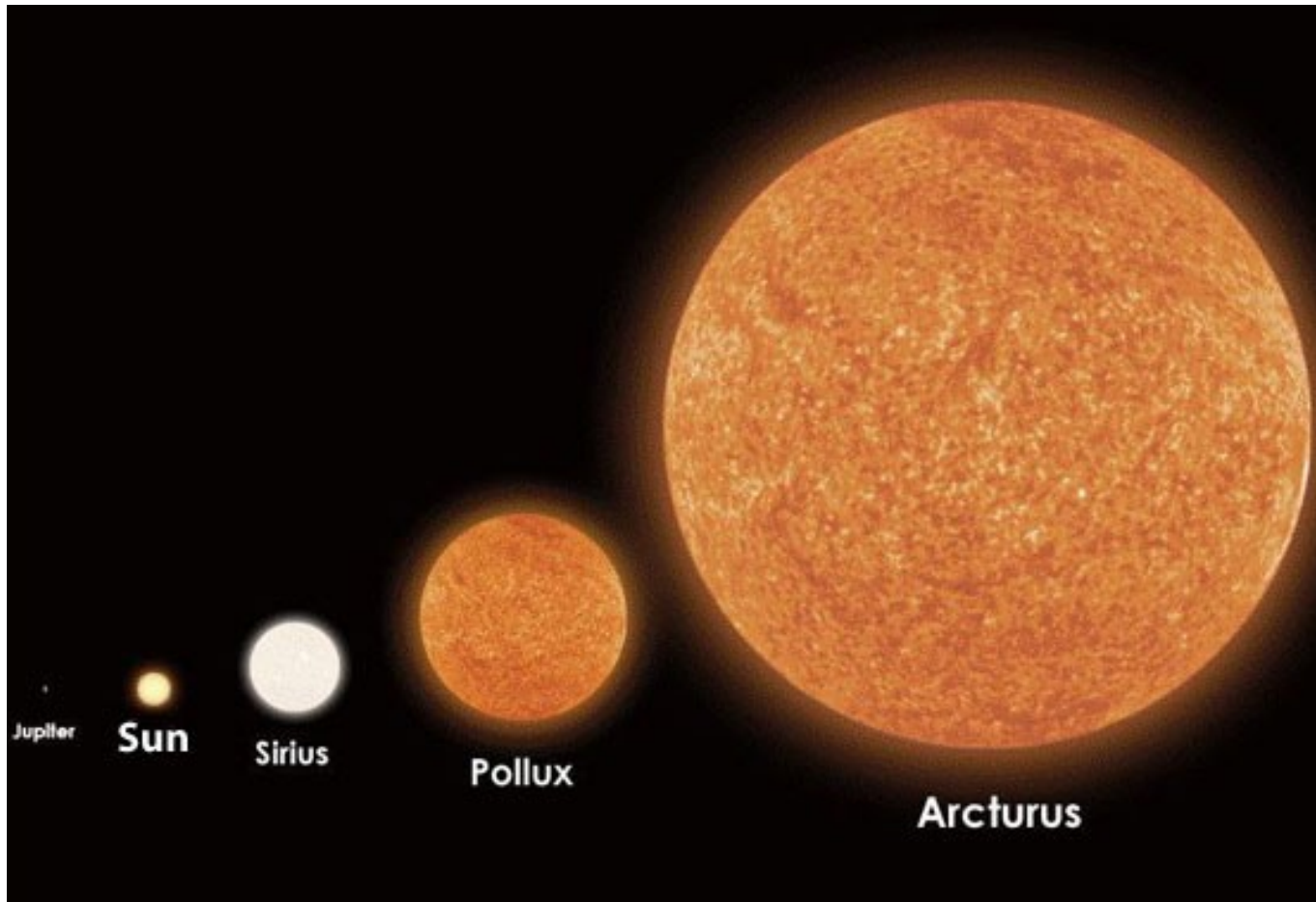


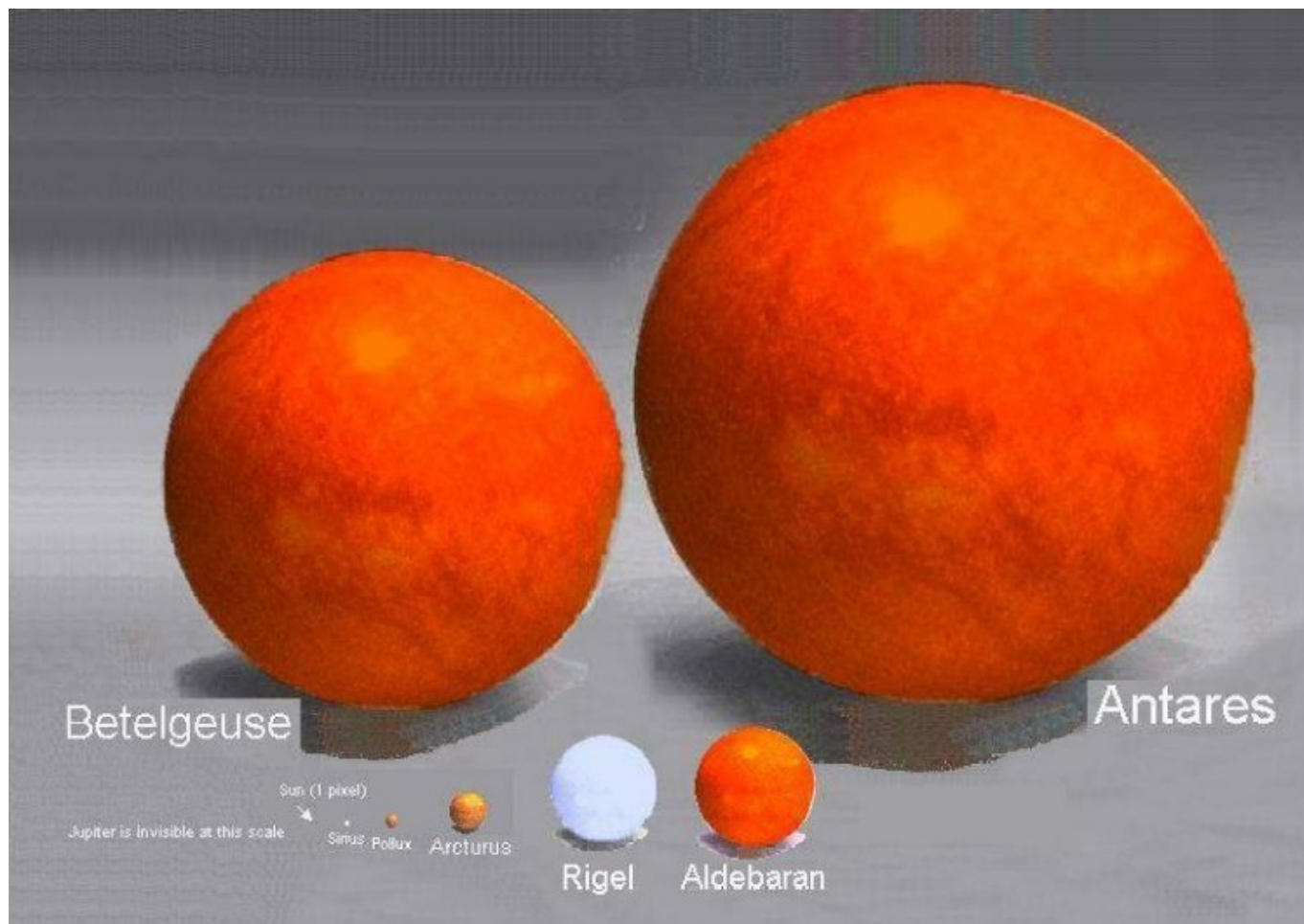
SUBARU®

Back to the Big Dipper...



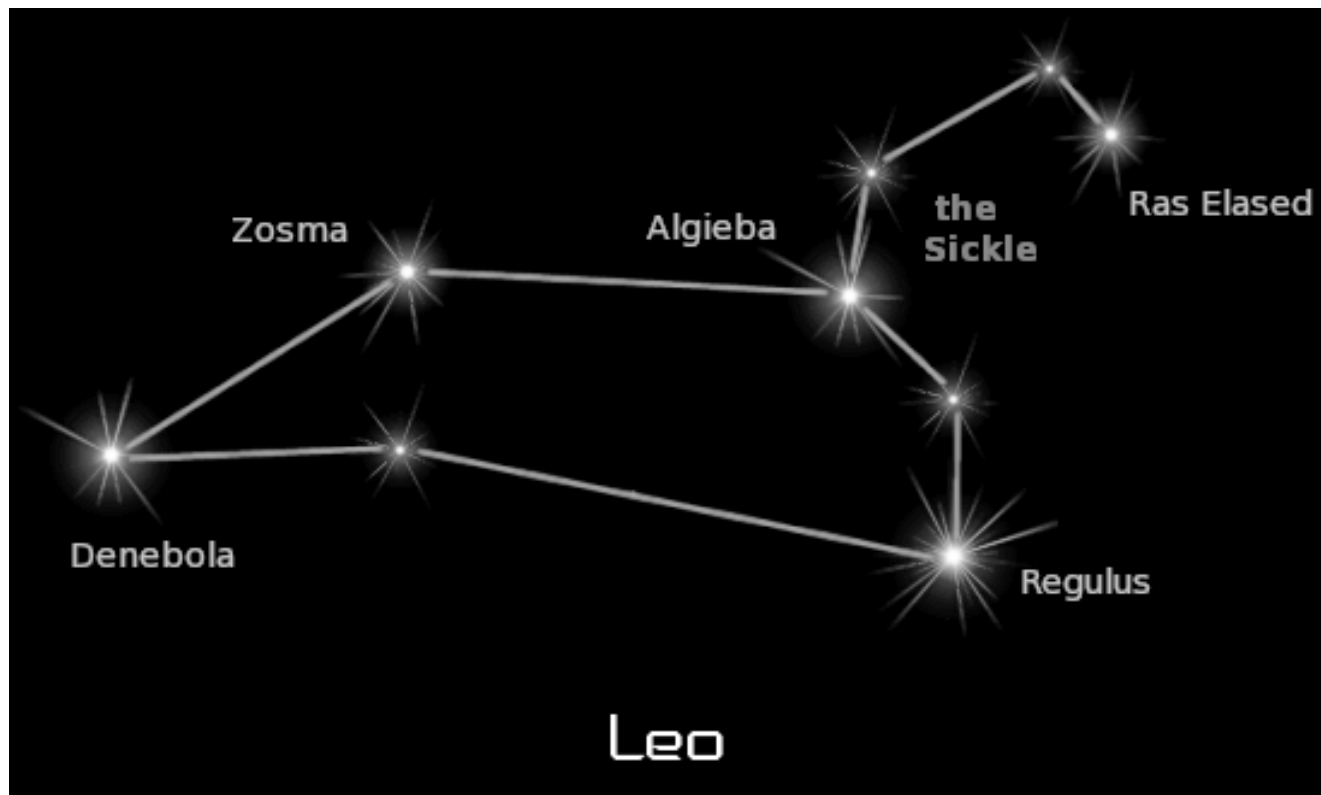
Arcturus

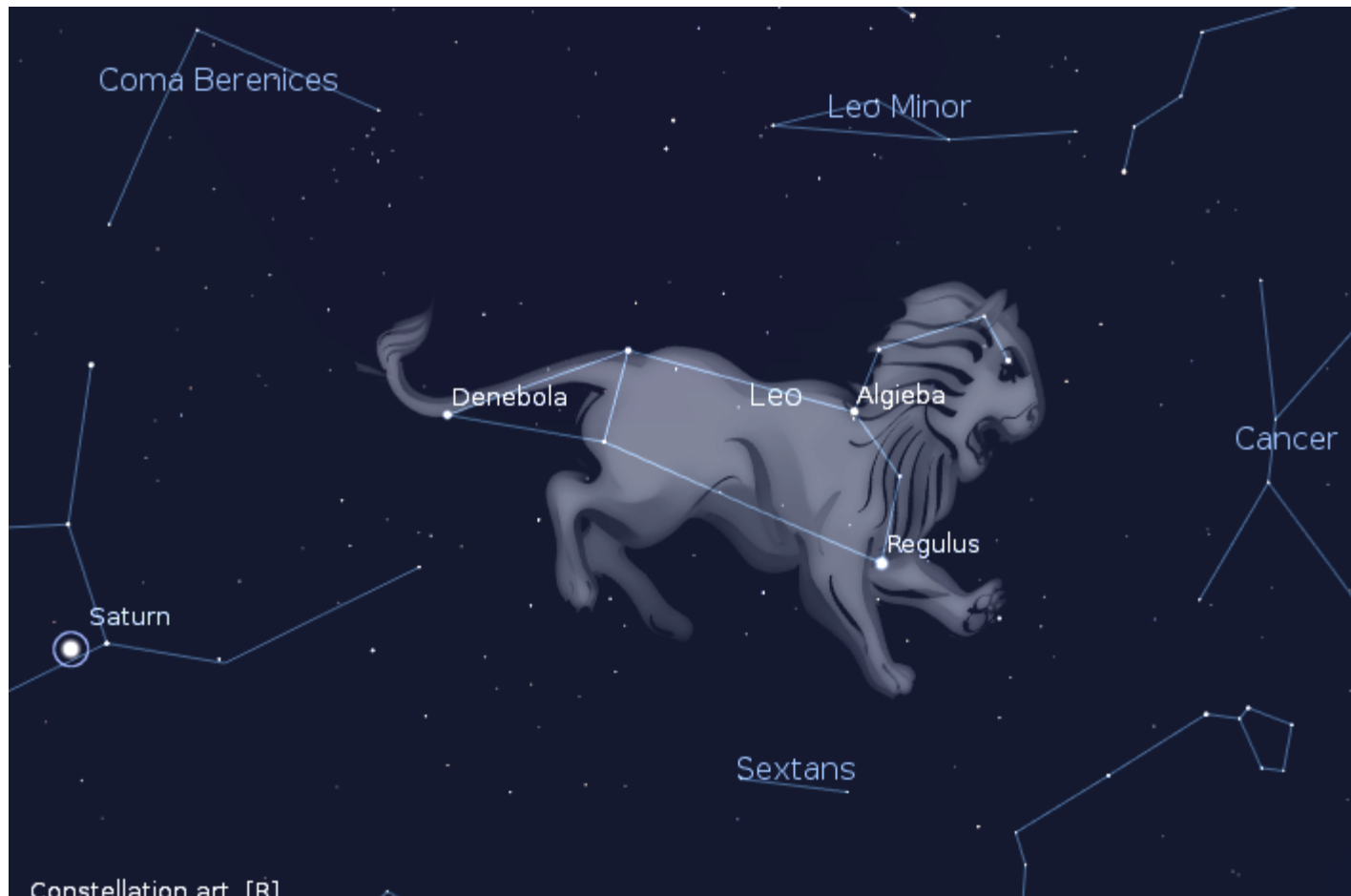




In The Sky Now

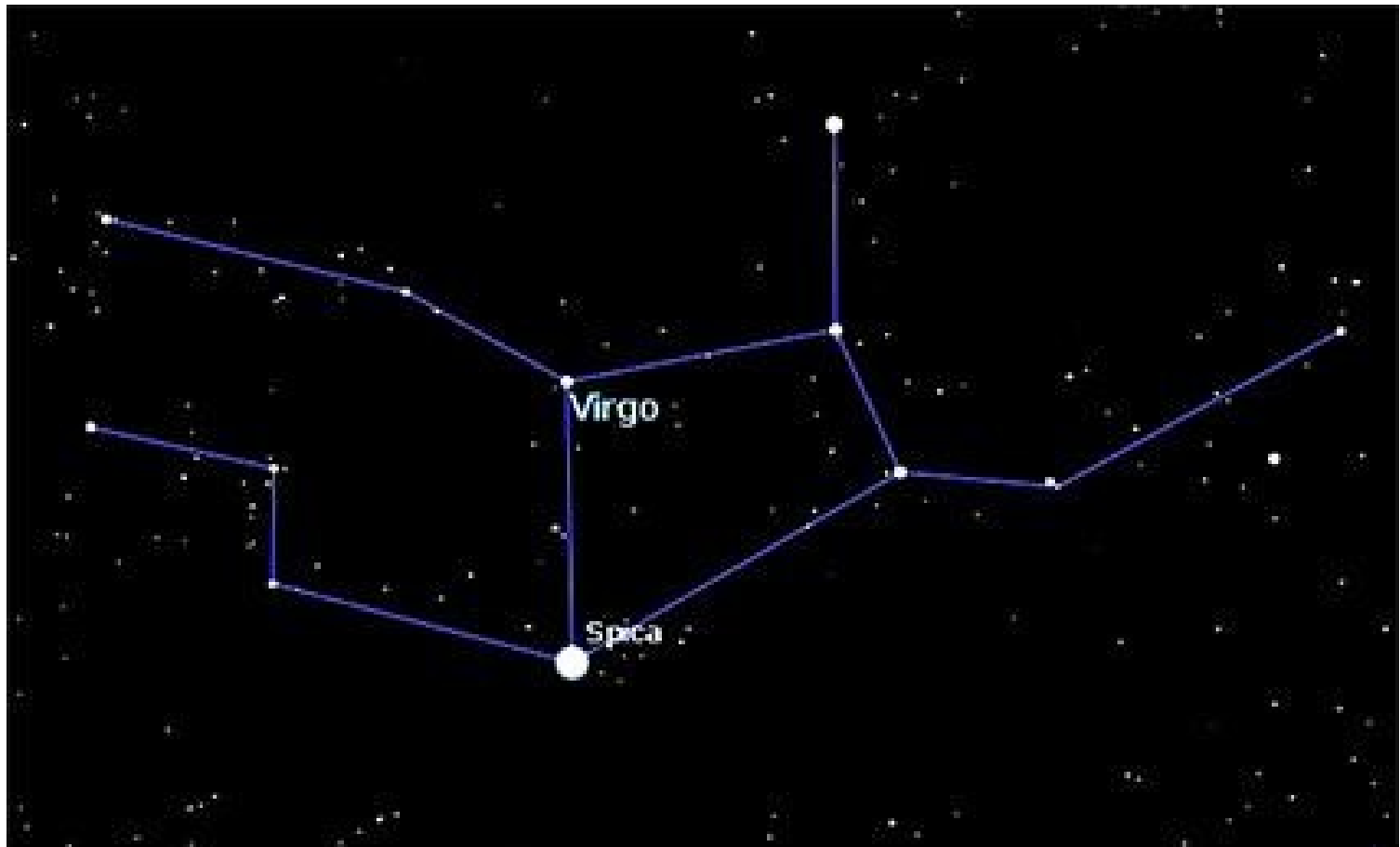
- ▶ Of the zodiacal constellations one of the best known is Leo, the Lion, which stands high above the southern horizon as darkness falls. Pretend that the bowl of the Dipper has a hole in it; the water streaming out of the bowl would fall directly on Leo. A backward question-mark-pattern of stars, known as the Sickle, forms the Lion's head and mane, while a triangle of stars to the left of the Sickle forms the Lion's hindquarters.





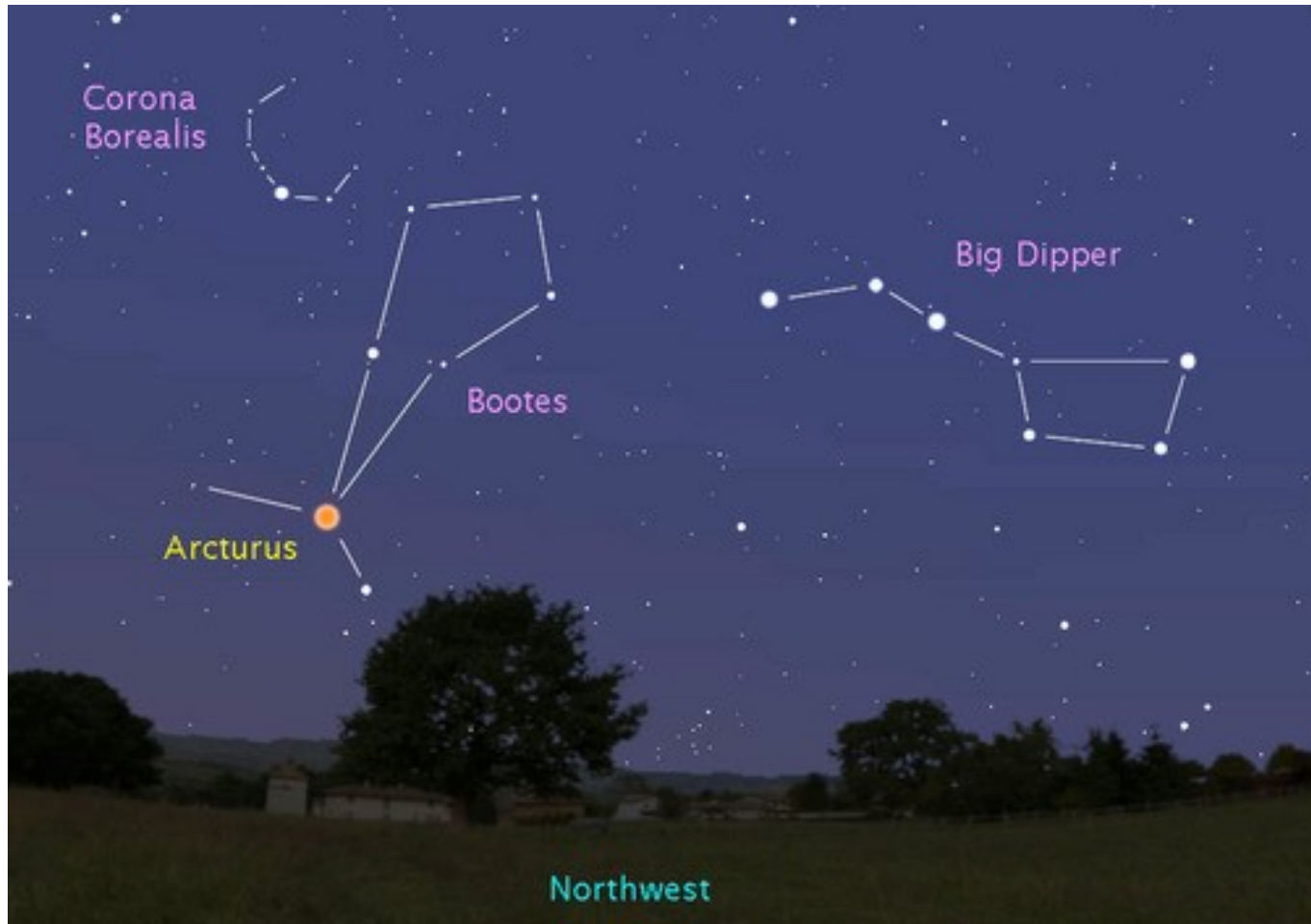
Constellation art [R]

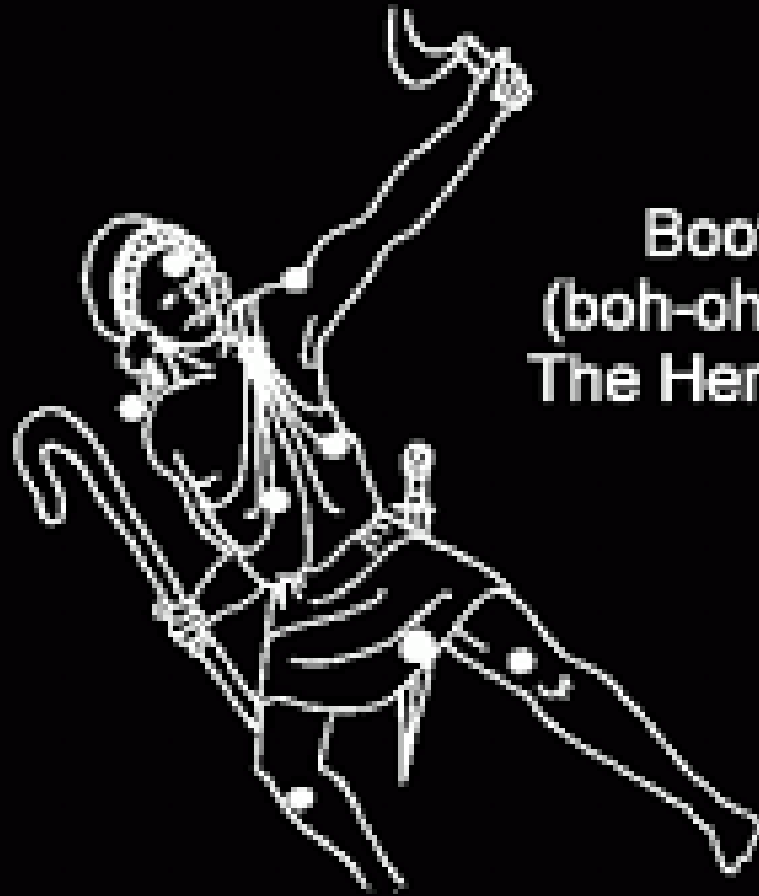
Another zodiacal constellation, situated to the lower left of Leo, is Virgo, the Young Maiden. Her brightest star is Spica, a blue-white first-magnitude star that is 250 light-years away. If you follow the curve of the Dipper's handle through Arcturus, you can "speed to Spica, or Spike to Spica."





Bootes





Bootes
(boh-oh'-teez)
The Herdsman



Summer



Spring

Polaris
NORTH STAR

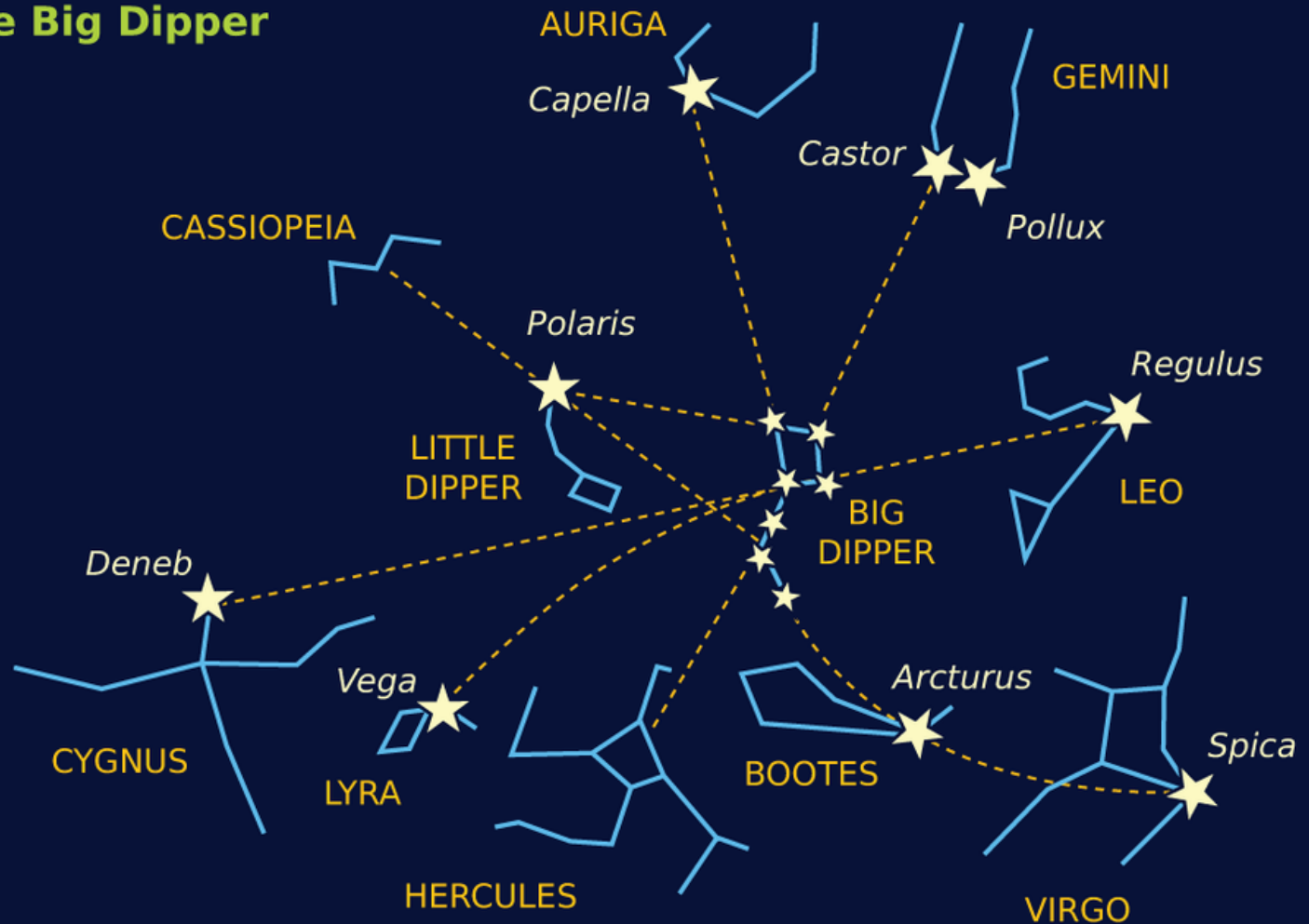


Fall



Winter

Navigating with the Big Dipper

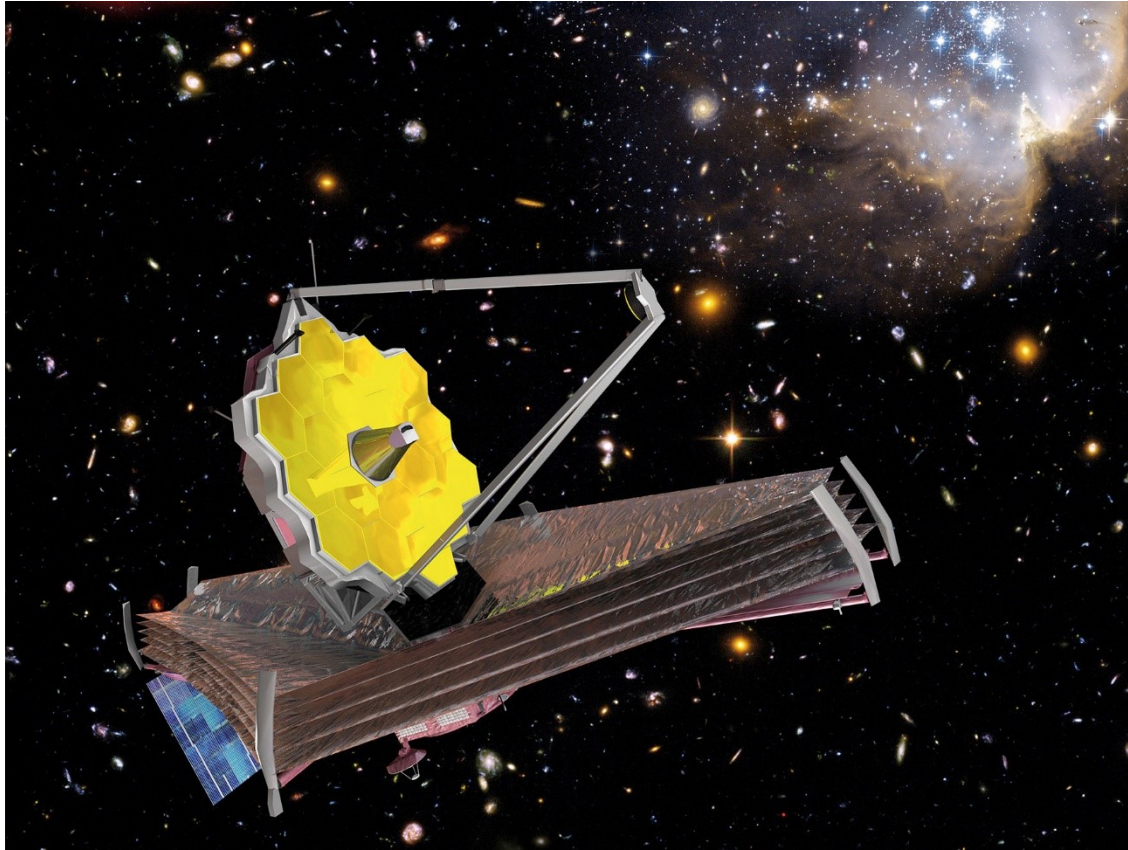




Hubble



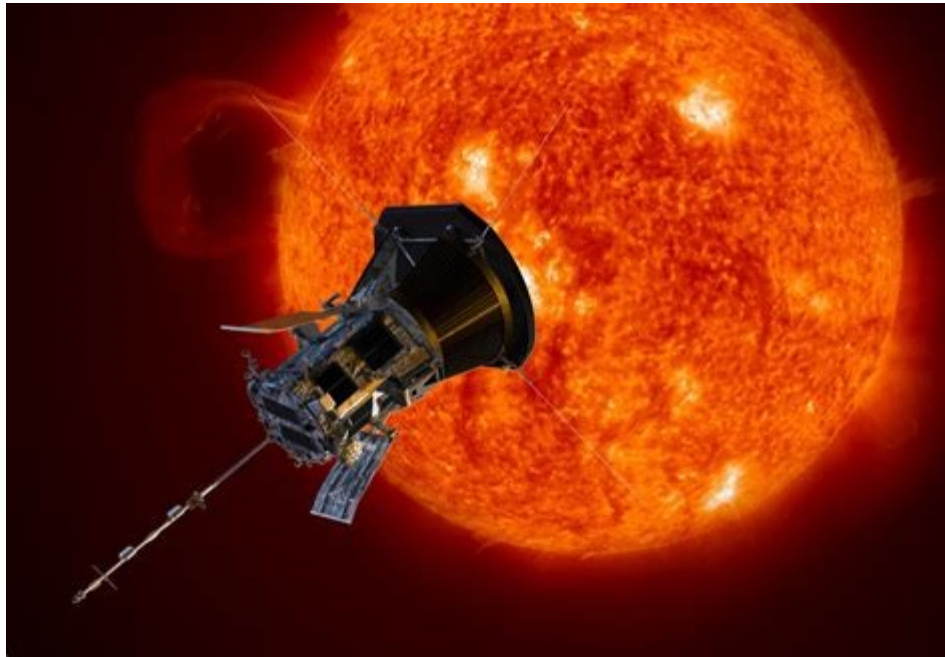
JWST



Small Patch Of Sky



Parker Solar Probe



Vera C Rubin Telescope



Vera Rubin Image – 2025



WHAT'S NEXT?

