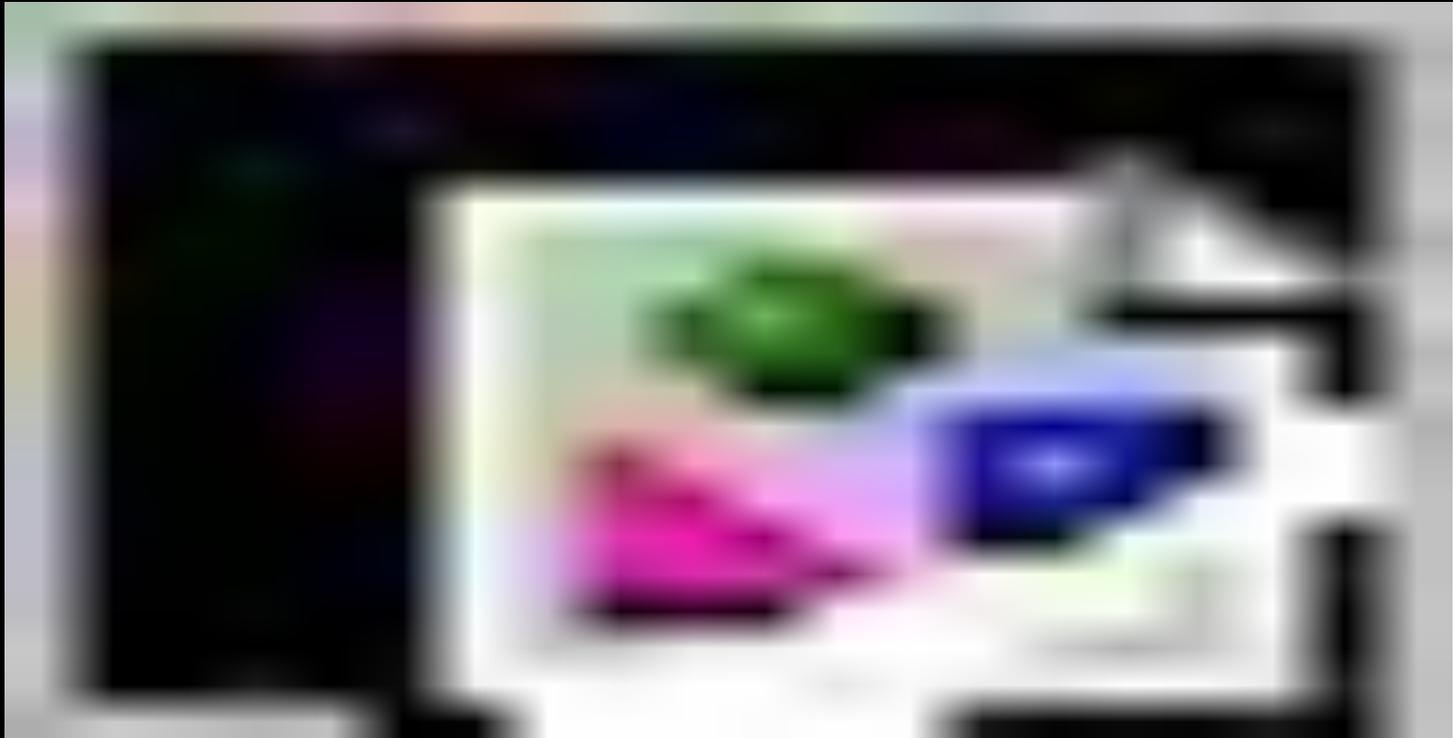


# Telescopes

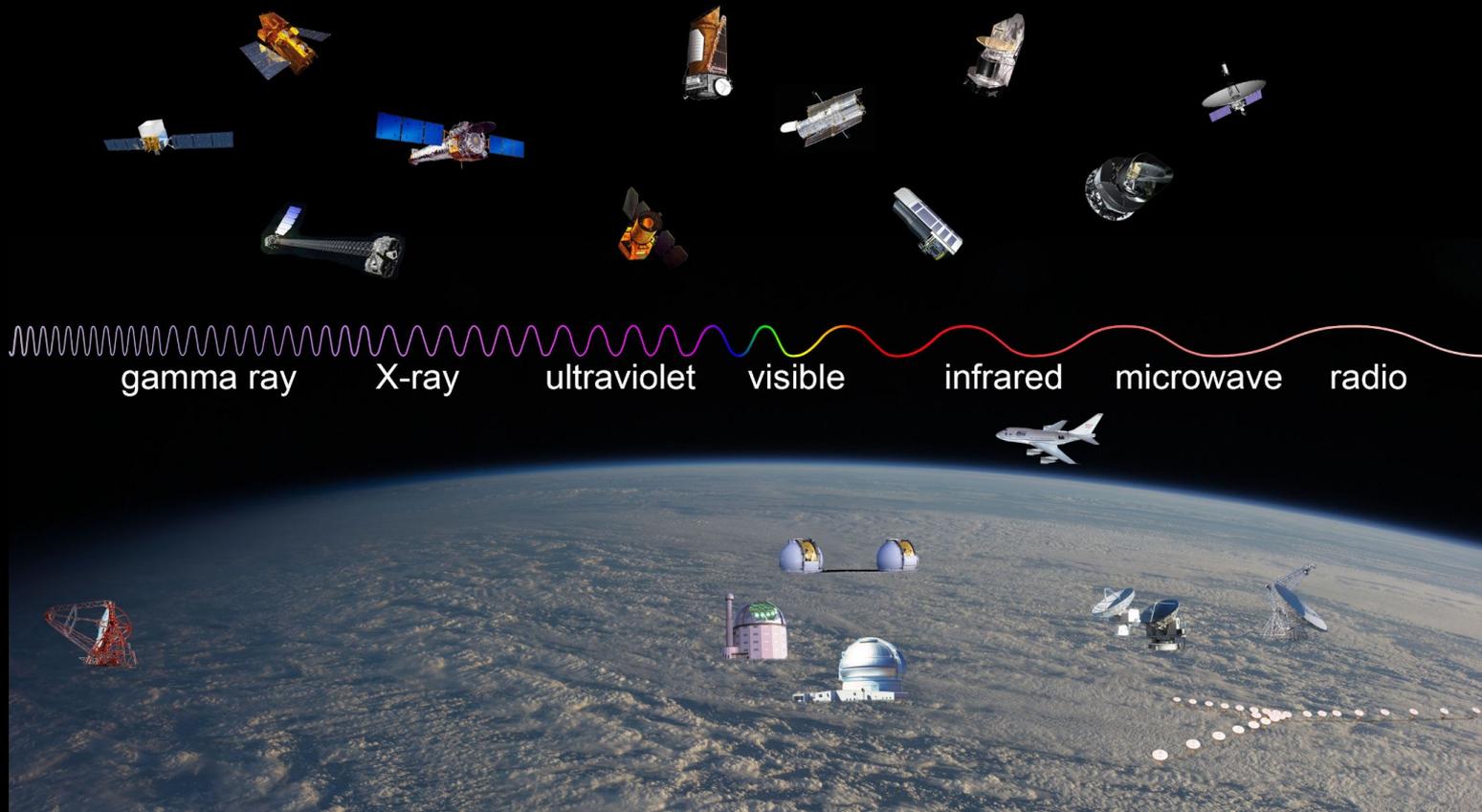
# *Let There Be Electromagnetic Radiation...*

Light is one form of electromagnetic radiation. Scientists refer to the light we see with our eyes “visible light.” The range is known as a spectrum. The electromagnetic spectrum includes the entire range of radio waves, microwaves infrared, visible light, ultraviolet radiation, X-rays, and gamma rays.



# *What ARE telescopes?*

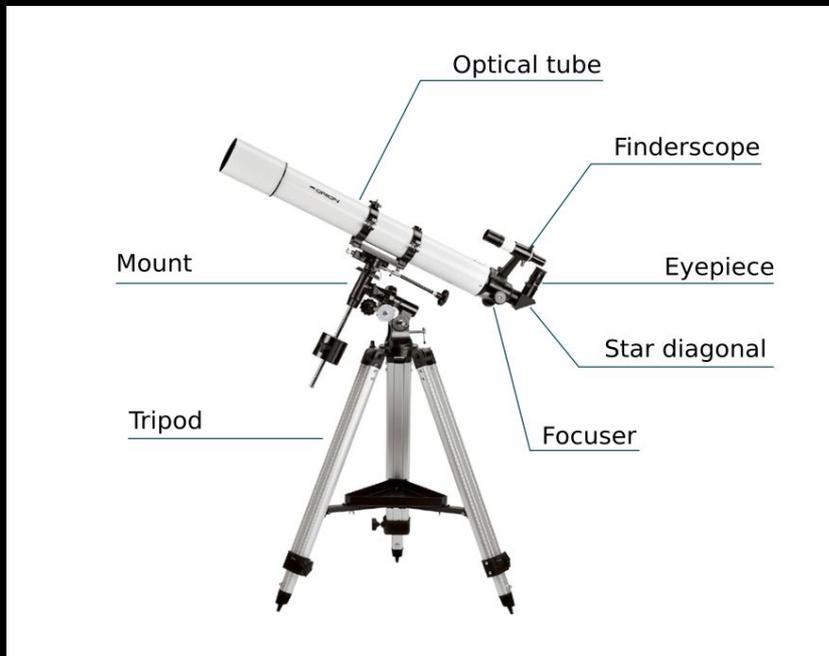
Telescopes are instruments that collect and focus forms of electromagnetic radiation.



# *Optical Telescopes*

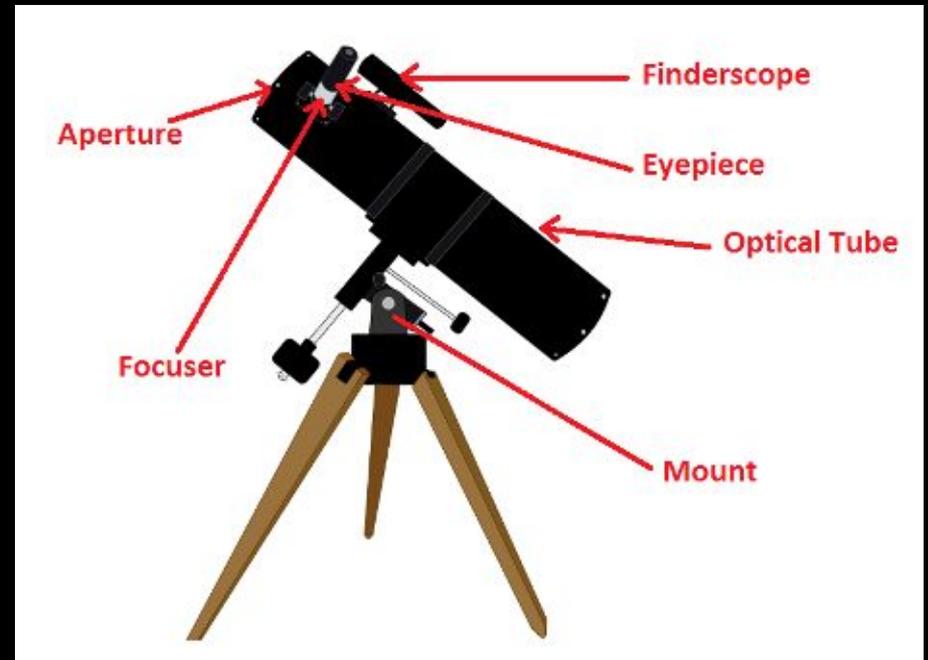
A telescope that uses lenses or mirrors to collect and focus visible light is called an optical telescope.

The two major types of optical telescopes are refracting telescopes and reflecting telescopes.



*Refractor Telescope*

Source: <https://nightskygazing.com/parts-of-telescope>



*Reflector Telescope*

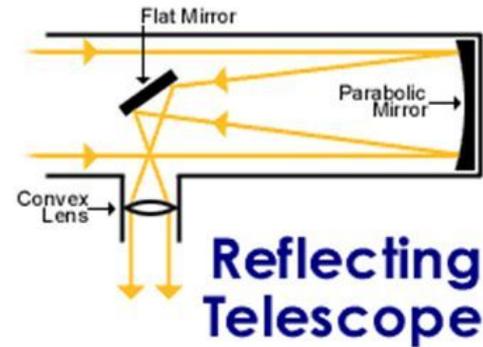
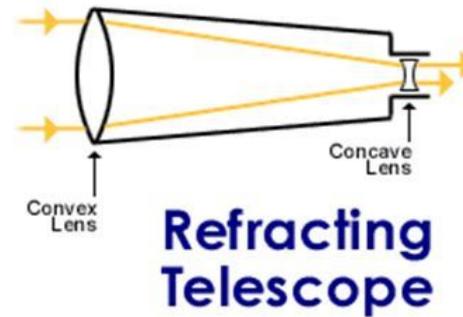
Source: <https://study.com/academy/lesson/refracting-telescope-definition-parts-facts.html>

# Optical Telescopes (Cont'd)

## Two Basic Telescope Designs

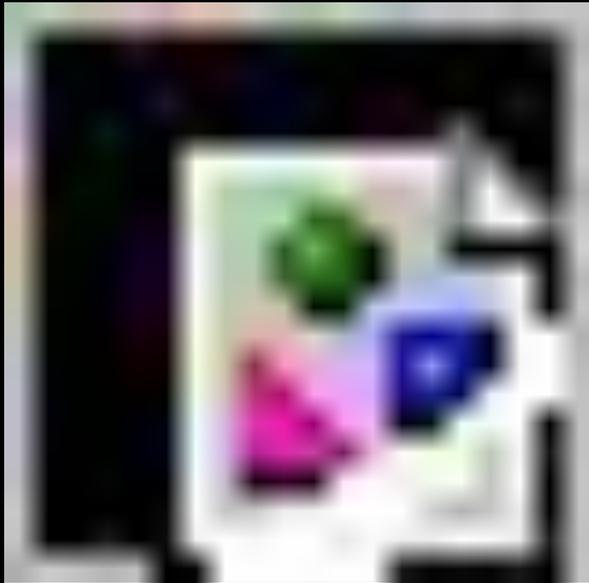
- Refractors
  - Use lenses to concentrate incoming light at a focus.
- Reflectors
  - Use mirrors to concentrate incoming light at a focus.

*The goal is always the same – gather as much light as possible and concentrate it at a focus.*

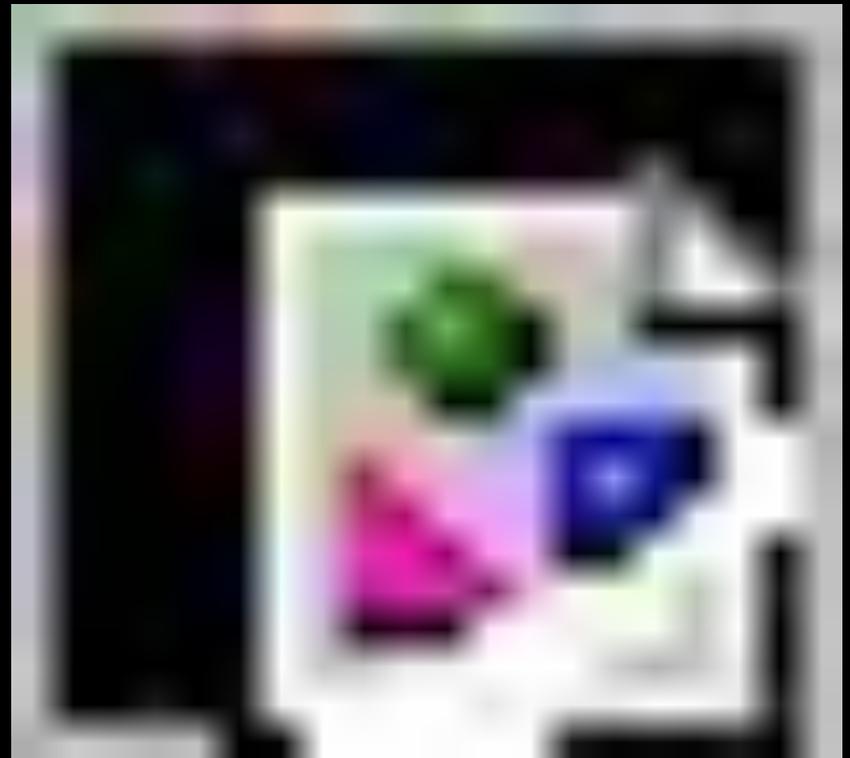


# *Radio Telescopes*

Telescopes that detect radio waves from space are called **radio** telescopes. Typical radio telescopes have a parabolic reflecting surface commonly referred to as a “dish.” Unlike most optical telescopes, radio telescopes may be used during the day or night. They may also be used when the sky is cloudy because radio waves pass through clouds.



Source: <https://www.collinsdictionary.com/dictionary/english/radio-telescope>



Source: [http://abyss.uoregon.edu/~js/glossary/radio\\_telescope.html](http://abyss.uoregon.edu/~js/glossary/radio_telescope.html)

# *Shared/Remote Telescopes*

<https://www.sierra-remote.com/>



## Sierra Remote Observatories

*Telescope Hosting for Remote  
Astronomical Imaging, Data  
Acquisition, Satellite Tracking  
and Space Communications*



Site Updates:

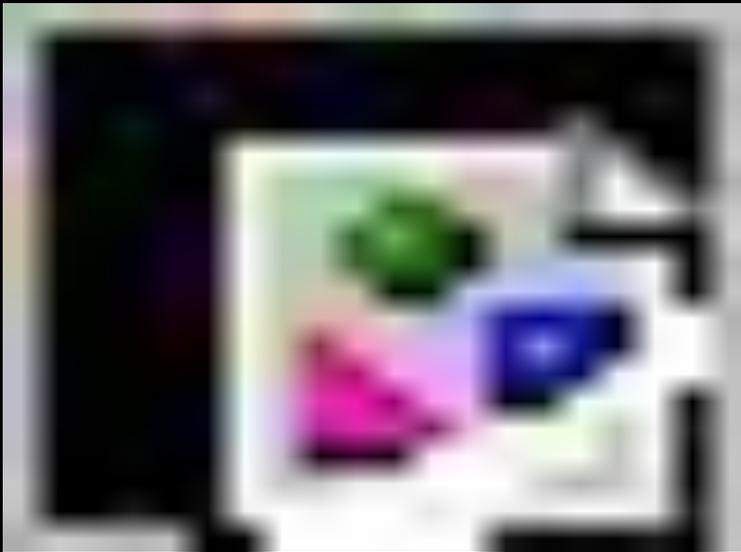
January 2022: SRO Newsletter  
SRO Virtual Astrophotographer  
Introductory Video of SRO  
Buildings 13 & 14  
Break Room Construction



# *Space Telescopes*

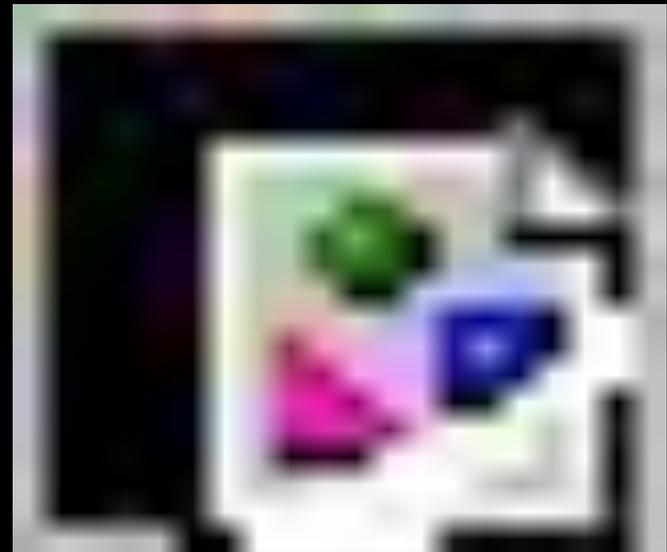
A majority of ultraviolet radiation, x-rays, and gamma rays are blocked by Earth's atmosphere. To detect electromagnetic radiation in these wavelengths, astronomers use spaceborne telescopes like the Hubble Space Telescope (HST), and the James Webb Space Telescope (JWST).

By placing telescopes in space, astronomers get a more clear picture of the universe.



*Hubble Space Telescope (HST)*

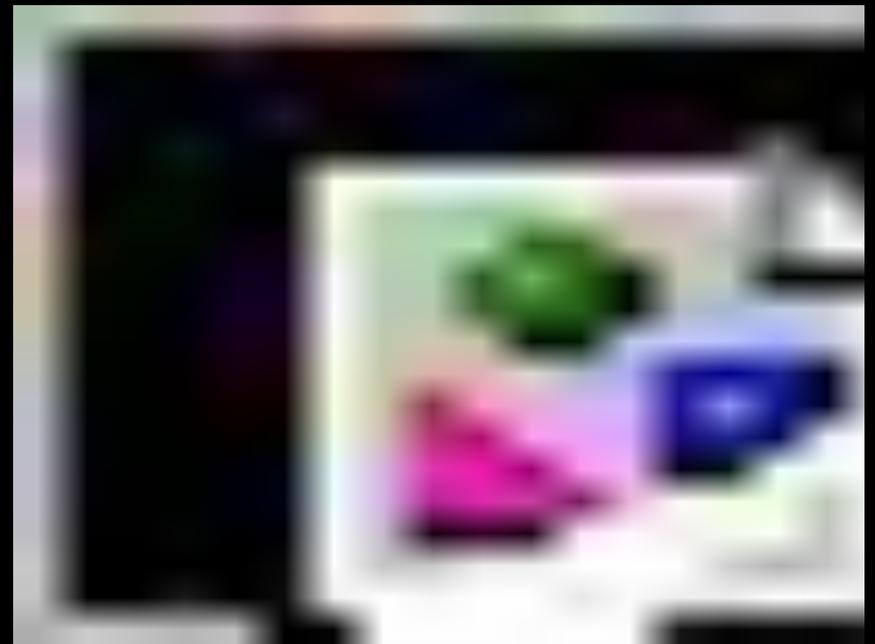
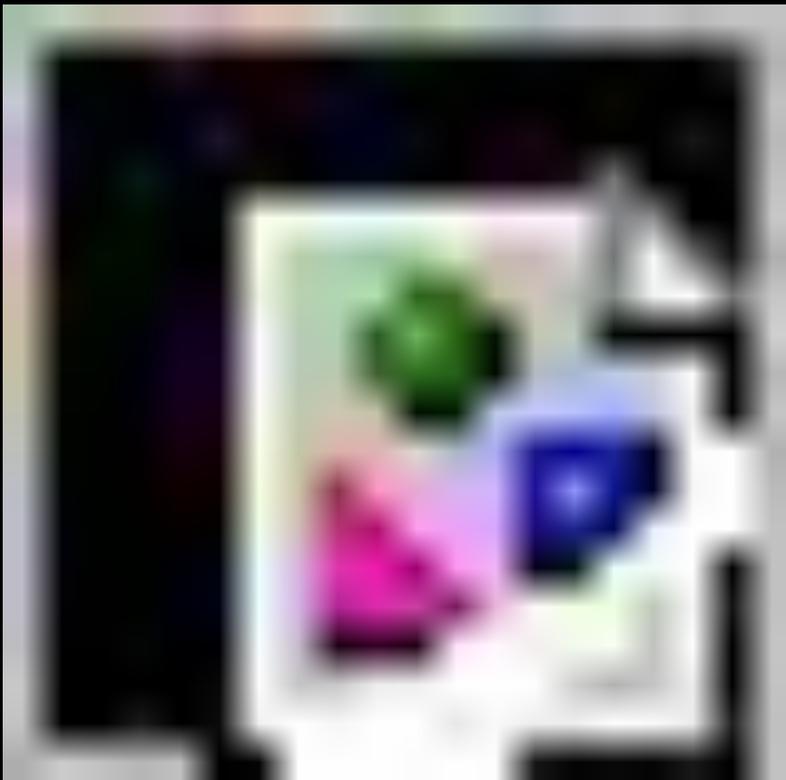
Source: [https://en.wikipedia.org/wiki/Hubble\\_Space\\_Telescope](https://en.wikipedia.org/wiki/Hubble_Space_Telescope)



*James Webb Space Telescope (JWST)*

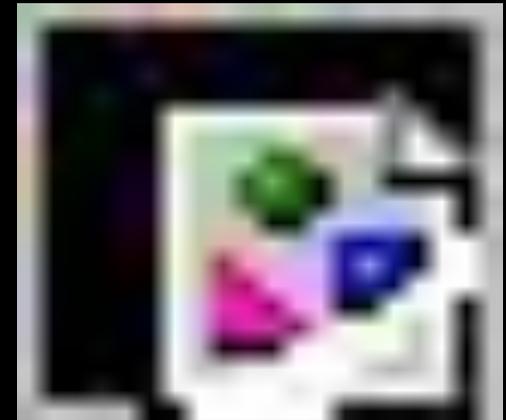
Source: [https://en.wikipedia.org/wiki/James\\_Webb\\_Space\\_Telescope](https://en.wikipedia.org/wiki/James_Webb_Space_Telescope)

# *Telescopes Changed Our Understanding of the Universe...*



STScI and NASA

# *Before Telescopes...*



*... We only had our eyes . . .*

*and a variety of measuring instruments.*

# *We also had many questions...*

Is Earth the  
center of  
the universe?

How far away are  
the stars?

Is there more  
than one  
galaxy?

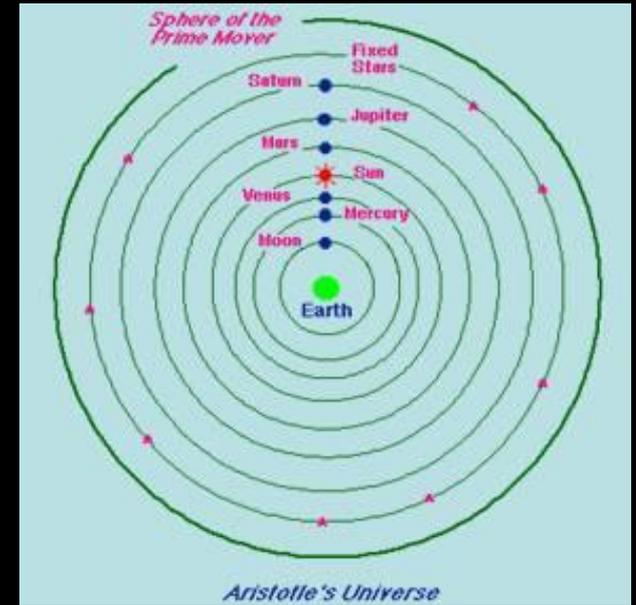


Are there  
other planets  
outside of  
our solar  
system?

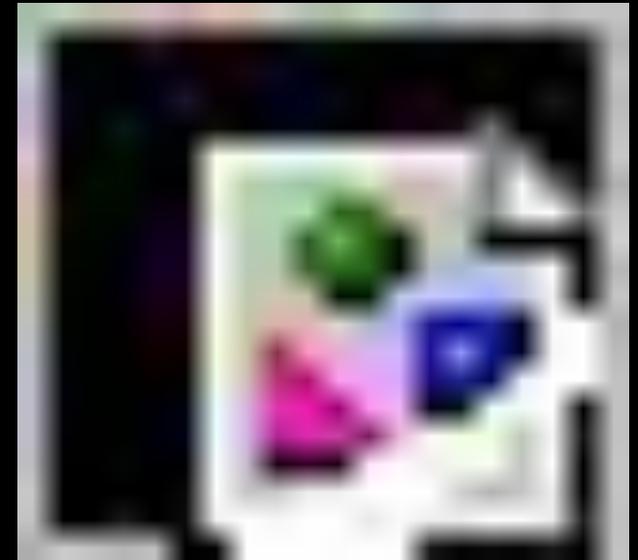
# Question 1: Is Earth or Sun at the center?

Is Earth the center of the universe?

*Aristotle said "Earth"*



*Copernicus said "Sun"*



## *Question 2: How far away are the stars?*

How far  
away  
are the  
stars?



M34 image courtesy of Glenn Spiegelman

# *Light Years!*

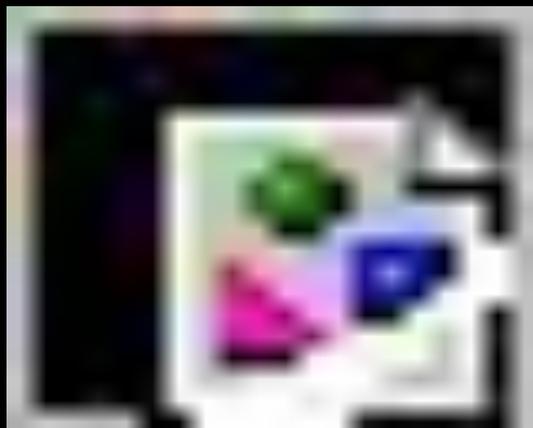
Light minute: a unit of astronomical distance equivalent to the distance that light travels in one minute, which is  $1.799 \times 10^7$  km (11,187,000 miles)

Light year: a unit of astronomical distance equivalent to the distance that light travels in one year, which is  $9.4607 \times 10^{12}$  km (nearly 6 trillion miles)

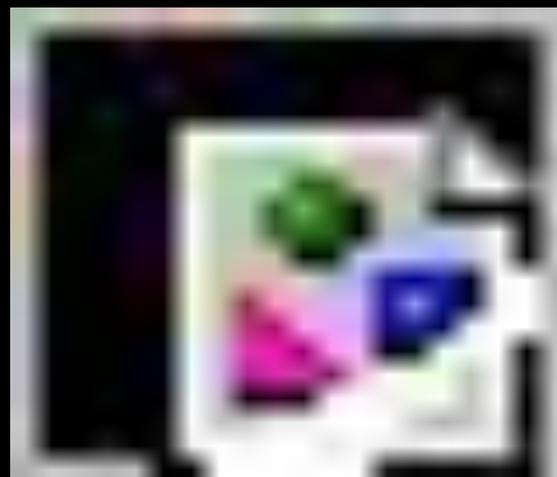
Moon: about 1.3 light-seconds from Earth (avg 238,855 miles)

Sun (Our Star): a little more than 8 light-minutes from Earth (93 million miles)

Polaris (North Star): 443 light-years from Earth (2,545,444,786,588,502 miles)



M51 courtesy of M. Harms



M31 - Andromeda courtesy of G. Spielgelman

## Question 3: *One Galaxy or Many?*

Is there  
more  
than one  
galaxy?



NGC 1232 courtesy of M. Harms



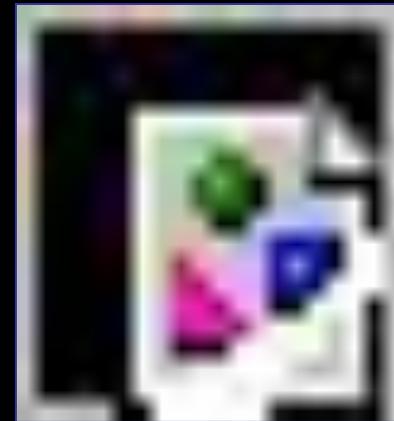
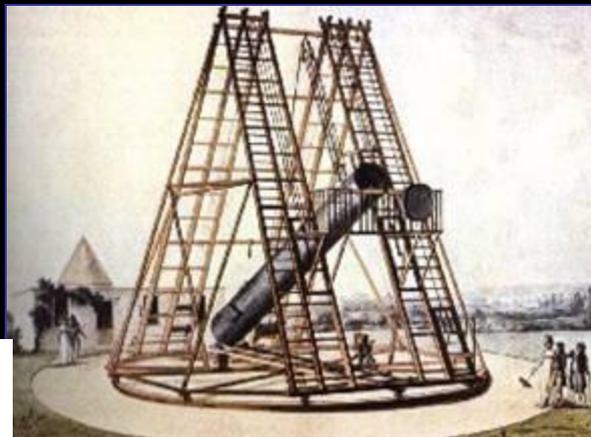
*Hubble Ultra-Deep Field*

Source: [https://en.wikipedia.org/wiki/Hubble\\_Ultra-Deep\\_Field](https://en.wikipedia.org/wiki/Hubble_Ultra-Deep_Field)

# Question 4: Are there other planets?

*In our own solar system, telescopes found planets our eyes could not see.*

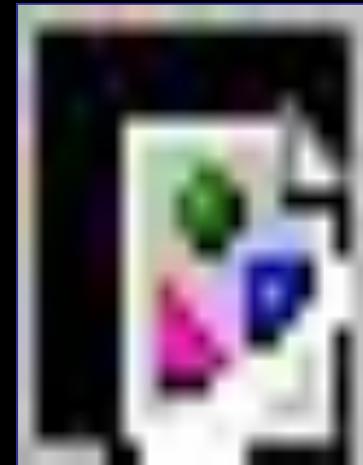
Are there other planets outside of our solar system?



*William Herschel*



*Herschel's telescope --  
used to discover  
Uranus in 1781*



# 90377 Sedna



*90377 Sedna (via HST)*

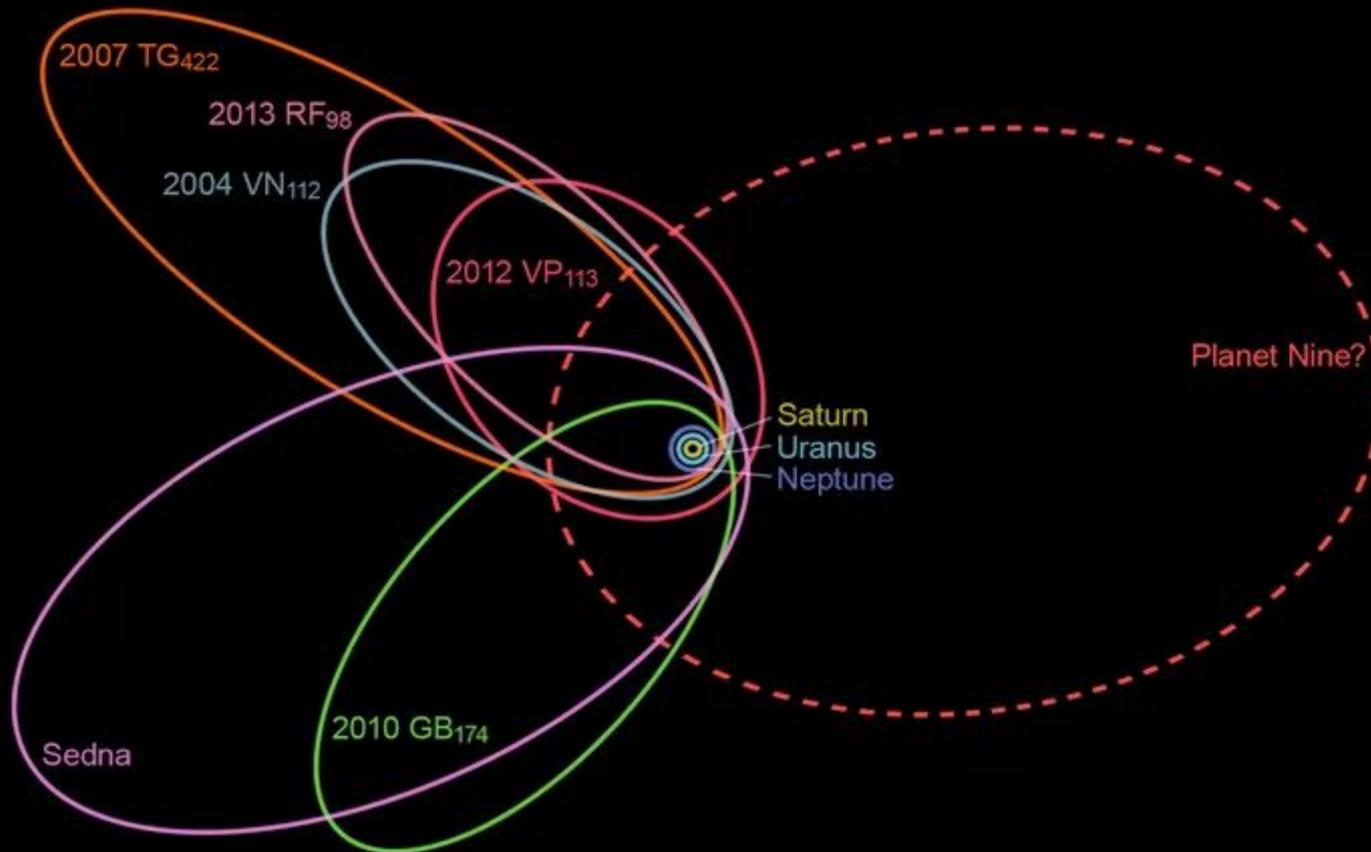
Source: [https://en.wikipedia.org/wiki/90377\\_Sedna](https://en.wikipedia.org/wiki/90377_Sedna)

**Sedna** (*minor-planet designation 90377 Sedna*) is a dwarf planet in the outer reaches of the Solar System that is currently in the innermost part of its orbit; as of 2021 it is 84 astronomical units ( $1.26 \times 10^{10}$  km) from the Sun, almost three times farther than Neptune.

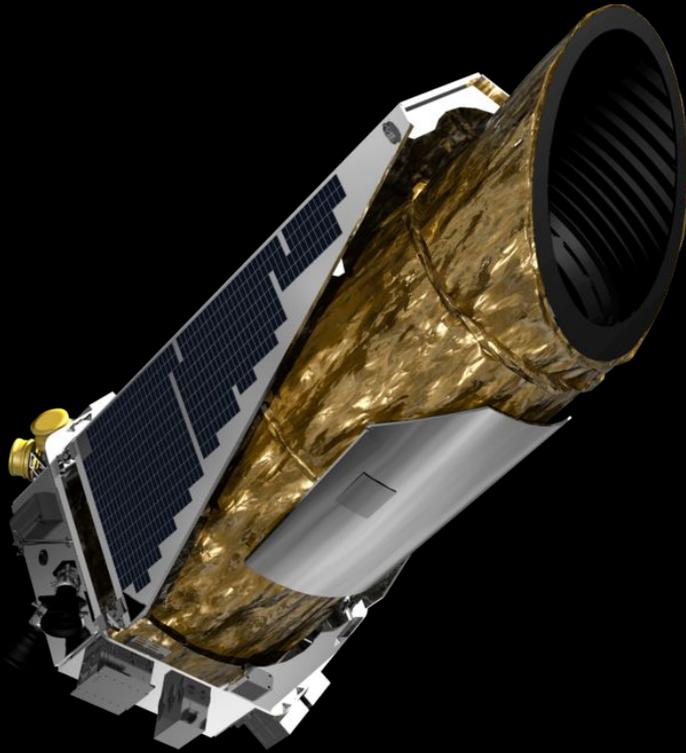
Sedna's orbital period is 11,408 years

# *Planet Nine*

Scientists believe that Planet Nine is comparable in mass to Neptune, moving on a highly eccentric orbit, with a period of around 15,000 years. Batygin and Brown are using the Subaru Telescope in Hawaii's Mauna Kea Observatory to find it.



# *Kepler Space Telescope*

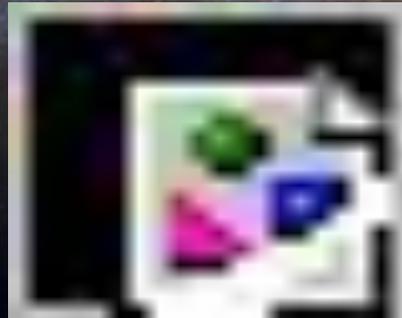
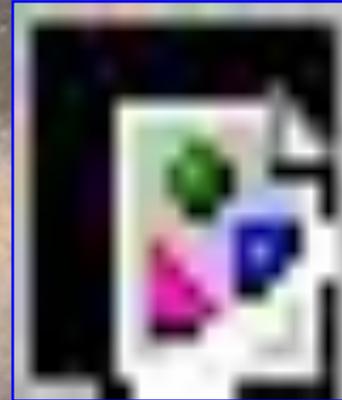


*Kepler Space Telescope (KST)*

Source: [https://en.wikipedia.org/wiki/Kepler\\_space\\_telescope](https://en.wikipedia.org/wiki/Kepler_space_telescope)

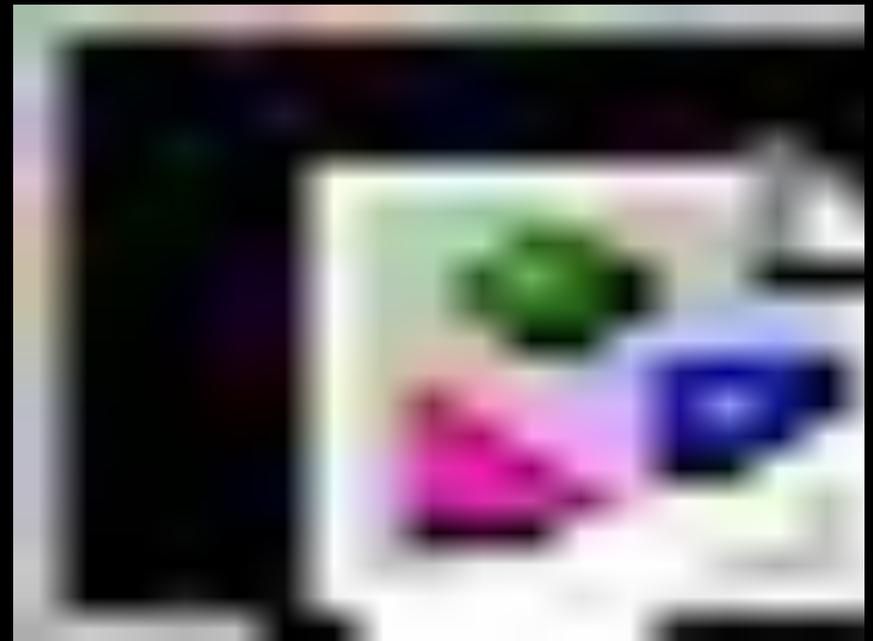
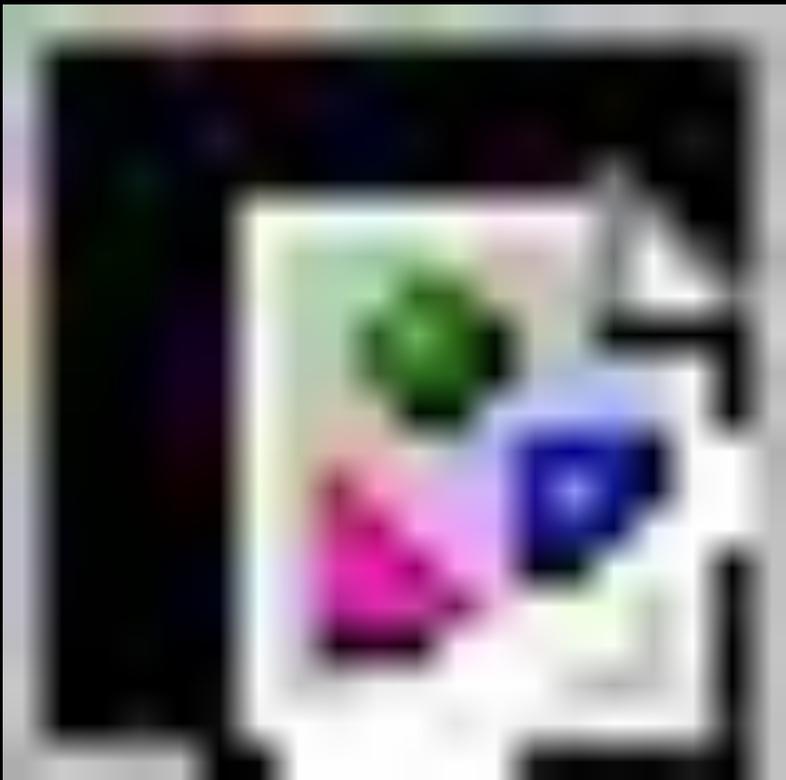
The Kepler space telescope is a retired space telescope launched by NASA in 2009 to discover Earth-size planets orbiting other stars. Named after astronomer Johannes Kepler, the spacecraft was launched into an Earth-trailing heliocentric orbit. The principal investigator was William J. Borucki.

*Telescopes have changed our understanding of the universe ...*



*... and they are still changing our understanding of our place in the universe!*

*From the center of the universe...*



*... to a very small planet in an immense expanding universe*

# *And the more we learn, the more questions emerge!*

What is beyond Pluto in our Solar System?

How do stars and planets form?

Why are there black holes in the center of galaxies?

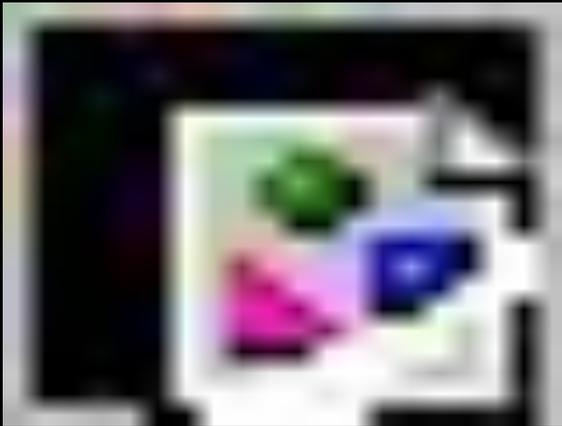
How did galaxies form?



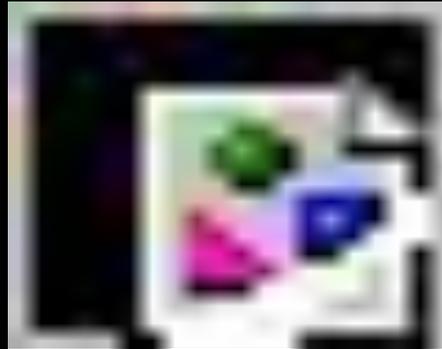
Do other planets harbor life ?

Why is space expanding?

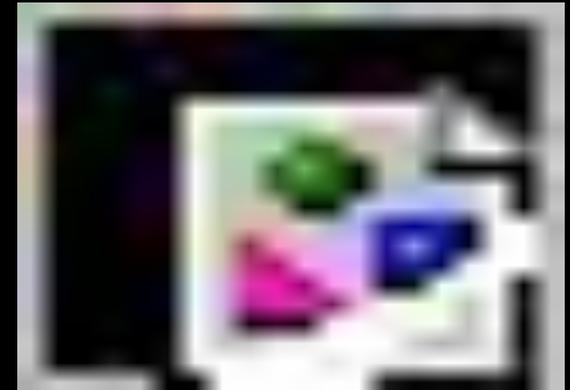
# *Telescopes will continue to expand our understanding of our universe.*



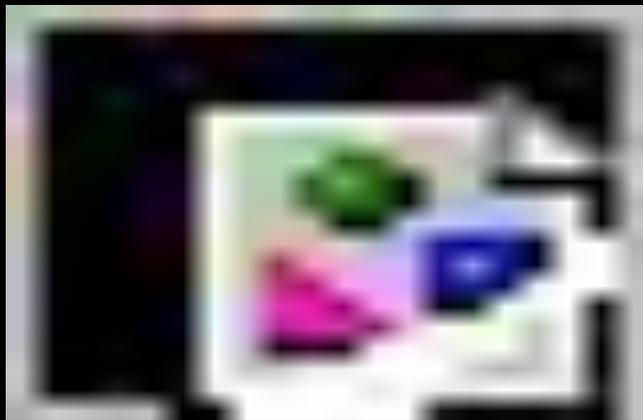
Chandra Illustration: CXC/NGST



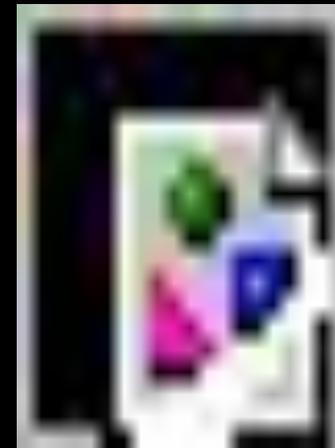
Spitzer Credit: NASA/JPL-Caltech



Arecibo Image Courtesy of the NAIC



Keck Image courtesy of NASA/JPL/Caltech



GLAST Credit: General Dynamics C4 Systems

# *Tomorrow Morning...*

Not since 1864, and not again until 2040!

