STARS, GALAXIES AND THE UNIVERSE

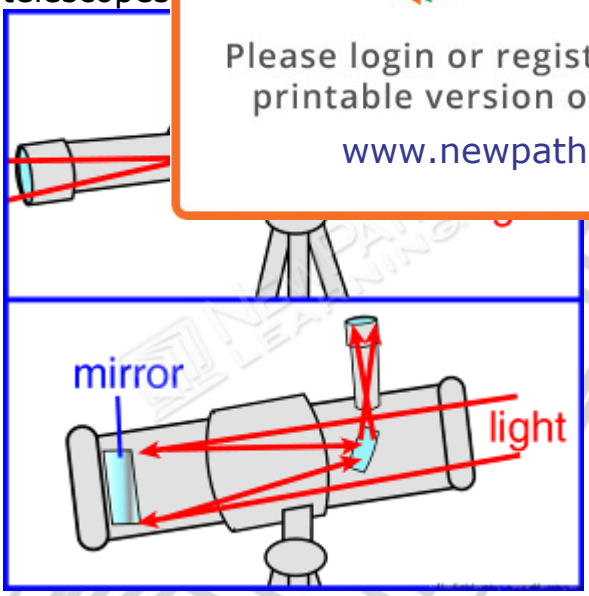
Types of Telescopes

Telescope literally means *far seeing*, from the Greek words *tele* meaning *far* and *skopein* meaning *to see or to look*. The word *telescope* most usually refers to **optical telescopes** that receive the visible wavelengths of light. There are also sophisticated telescopes that receive wavelengths from other parts of the electromagnetic spectrum, such as infrared and X-ray radiation.

There are several types of optical telescopes.

- **Refracting telescopes** receive light through a lens and the image is then viewed through an eyepiece.
- **Reflecting telescopes** reflect light off a series of mirrors. The image is then viewed through the eyepiece.
- **Catadioptric** telescopes use a combination of lenses and mirrors to gather light and focus the image for viewing.

Refracting optical telescopes



Unfortunately air pollution, generated light, and the atmosphere itself all interfere with the ability to clearly view the stars.

- Our atmosphere makes stars look fuzzy.
- Pollution and humidity make it difficult to see the stars.
- Light pollution makes it more difficult to see distant lights from the skies.

The best images from land-based optical telescopes, therefore, are from telescopes that are on mountaintops stationed far away from other human activity where the atmosphere is thinner and extraneous light does not obscure the view.

Beyond Earth's Atmosphere

Because the atmosphere, even at high altitudes, refracts light from stars and planets, the best images come from telescopes outside the Earth's atmosphere. Another physical reality is that some electromagnetic radiation cannot be detected on Earth. For example, X-ray telescopes must be outside the Earth's atmosphere because the atmosphere blocks X-rays from reaching the Earth. The Chandra X-ray telescope, pictured here, is one example.

To get the clearest view of the universe, one must get beyond Earth's atmosphere and use space-based telescopes. It may be very surprising to discover that some of the most basic information about our universe has been discovered very recently using space-based telescopes. In 1990, the Hubble

Space Telescope (named in honor of the great 20th century astronomer Edwin Hubble) was launched by NASA and has provided some of the most spectacular images of the universe ever seen. Despite a number of technical troubles, the Hubble telescope (shown in flight) has provided some of the most important images of stars, planets, and other phenomena in space.

Characteristics of Stars

From ancient times, observers of the sky have noticed that stars are different from one another. Some are brighter. Some are bluish. Some are red. Ancient astronomers attempted to *categorize* stars based on their brightness. Simply standing under the night sky and observing what they could see with their eyes, they would describe their characteristics and categorize them accordingly.

One of the easiest characteristics to observe is the star's **brightness**. Today we know that a star's brightness depends in part on its distance from the Earth. How bright a star appears to look to any observer on Earth is ca *parent* magnitude m the Earth. A s ve a certain bri rs away, would app

On the oth ance from the Earth, asured, the measured brightness would be called the **absolute magnitude**.

Stars have been classified based on a scientific basis since the 1800's. Since then they have been classified based on the elements determined to be in the stars. The elements in stars are identified by an instrument called a **spectrometer**. The spectrometer breaks incoming light (electromagnetic radiation) into all the individual wavelengths contained in that light. Spectrometers produce light emission patterns. The light emission pattern produced by a spectrograph indicates which elements are present in a particular star.

Based on such information, astronomers have discovered that there are a number of different types of stars in the universe.

The Lives and Deaths of Stars

The colors of stars give an indication as to the relative temperature of that star. Red stars are cooler. Blue stars are hotter. The colors also indicate the relative age of the star.

Blue stars are extremely massive stars that rapidly consume their hydrogen. Consequently they are also extremely hot stars. They do not live long by comparison to other stars. When their hydrogen is gone, they expand and become red giants.

A **red giar** ter this occurs, its is very cool by cor an older star. If gia eferred to as **superg**

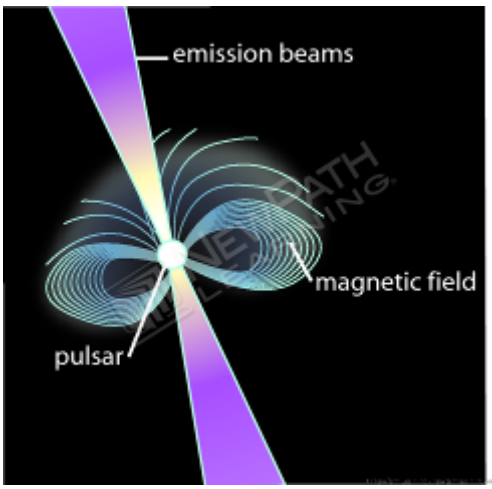
After a blue star has consumed its hydrogen, it can explode in a violent flash. Heavy elements like lead, gold, and silver are created by this explosion. This is literally the death of the star. Astronomers call this phenomenon a **supernova**. This NASA image (below) shows the remains of a supernova explosion.

Small, very hot stars that were once the center of younger stars are actually dying stars. They are known as **white-dwarf** stars. No nuclear fusion takes place in white-dwarf stars. They shine due to their residual heat.

The oldest stars in the universe are **red-dwarf** stars. They are low mass stars and burn for an extremely long time.

Sun compared to red-dwarf star

There are yet other types of stars. For example, a **neutron star** is the remains of a massive star that has collapsed on itself. A neutron star that is spinning is known as a **pulsar**.



As astronomers study stars, what they see may in reality no longer exist. Much of what we observe in the universe happened before the Earth and even our solar system formed. But it happened so far away that it has taken billions of years for the light to travel through space and reach the Earth. So what we see now occurred in real time millions, a

Star Sys

Stars do n ney are clustered i called **galaxies**.

The Milky Way (pictured here). Astronomers estimate that there are from 200 billion to 400 billion stars in the Milky Way. Galaxies are defined based on their appearance. The Milky Way is a particular type of galaxy known as a **spiral galaxy**. A spiral galaxy is disc-shaped and has a spiral form, much like a hurricane. There are a variety of other galaxies that are described based on their shape such as irregular galaxies and elliptical galaxies.

It is estimated that about 33% of the galaxies are large, rounded groupings of stars. There is little gas in these galaxies so new stars are not forming. These galaxies are known as **elliptical galaxies**.

Within galaxies are groups of stars, gas clouds and other features. A gas cloud in a galaxy in which stars can form is called a **nebula**.

NASA image of the Eagle Nebula

There are groups of older stars that look like a ball of stars within galaxies. These groupings are known as **open clusters**.

Astronomers believe that **quasars** are galaxies that are beginning to form. s are very e so bright, mu in the universe.

The Exp

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If the universe began with an explosion centered in a particular place, it would be logical to conclude that the universe is expanding, that is, the material in the universe is continually moving away from its point of origin. There is quantitative evidence to support this theory. At one time, scientists believed that other galaxies are moving away from ours. More recently, however, very careful measurements have shown that all the galaxies are actually moving away from each other. It is thought that the universe will continue to expand like this until it gets colder and darker and then eventually "dies." This is based on the assumption that there is not enough matter in the universe and therefore not enough gravitational pull to slow this expansion.

In actuality, scientists don't know for certain what the fate of the universe will be. It is also possible that there is so much matter in the universe that the gravitational pull between planets, stars, and other bodies will slow the expansion and eventually pull all matter together into a single mass.