

## Galaxies & Solar System

### 1. Galaxies

Scientists used to think that all the stars in the universe were part of one giant grouping of stars. Then, in 1917, Thomas Wright suggested that there might be lots of different large groups of stars. A few years later this was proven by other astronomers and the idea of the galaxy became real.

#### What is a Galaxy?

A galaxy is a group of stars and other space stuff. The stars tend to spin around a center of high gravity, sort of like the planets spin around the Sun in the Solar System. Galaxies are huge and can have trillions (way bigger than billions!) of stars.

As big as galaxies are, they are generally separated by large areas of empty space. There are even clusters of galaxies that are separated by even larger areas of space. Scientists think there are over 100 billion galaxies. Wow, the universe is huge!

#### Milky Way

We live in the galaxy called the Milky Way. The Milky Way is part of cluster of around 3,000 galaxies called the Local Group. The Milky Way is a spiral shaped galaxy and is estimated to be made up of around 300 billion stars. The Solar System orbits around the center of the Milky Way.

#### Types of Galaxies

There are four main types of galaxies depending on their shape:

**\*Spiral:** The spiral galaxy has a number of long arms that are spiraling around the center. In the center of the spiral galaxy are older stars while the arms are generally made of new stars.

**\*Barred spiral:** This type of galaxy is similar to the spiral but has a long bar in the middle with spirals coming off the ends.

**\*Elliptical:** A mass of stars clumped together in the shape of an elliptical disc.

**Irregular:** Any other shaped galaxy is generally lumped into the category of irregular. It is thought that most irregular galaxies are formed by two of the other three types of galaxies crashing into each other.

#### Facts about Galaxies

\*The word galaxy comes from the Greek word for "milky".

\*Some scientists think that most of the mass of a galaxy is made up of a mysterious substance called dark matter.

\*It is thought that there is a massive black hole in the center of galaxies.

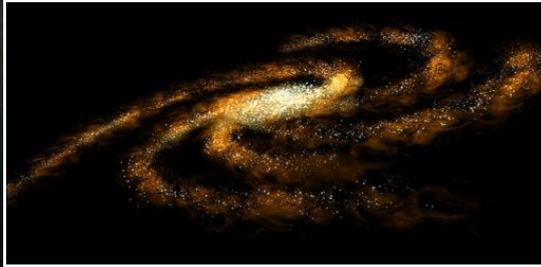
\*The closest galaxy to the Milky Way is Andromeda, which is around 2.6 million light years away from us.

\*Many galaxies are more than 100,000 light years across in distance.

\*It takes over two hundred million years for the sun to orbit the center of the galaxy. This is called a galactic year.



The Whirlpool Galaxy.  
Source: NASA and ESA.



Drawing of the Milky Way galaxy.  
Source: NASA



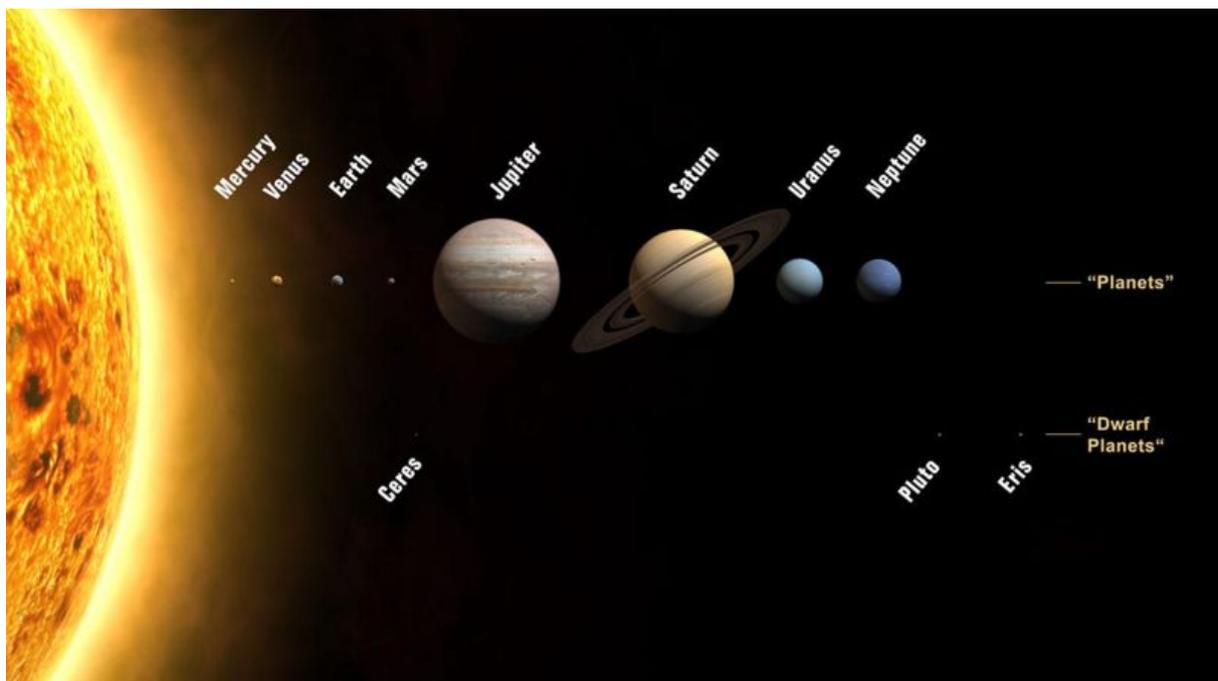
Barred spiral galaxy NGC 1300.  
Source: NASA, ESA, and The Hubble Heritage Team

## 2. The Solar System

The center of the Solar System is the Sun. The Solar System is made up of the Sun and all the planets, asteroids, and other objects that orbit the Sun.

### The Planets

There are eight planets in our Solar System. Starting with the closest to the sun they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The closest four planets (Mercury, Venus, Earth, and Mars) are termed terrestrial planets, meaning they have a hard rocky surface. The furthest four planets (Jupiter, Saturn, Uranus, and Neptune) are called gas giants. These planets are much larger and their surface is composed of gas elements (mostly hydrogen).



In addition to the Sun and the eight planets, there are other objects that are part of the Solar System.

**\*Dwarf planets:** Dwarf planets are objects similar to planets in the Solar System, however they are defined as not large enough to have "cleared their orbital region of other objects." Some of the dwarf planets in the Solar System include Pluto, Ceres, Eris, Haumea, and Makemake.

**\*Comets:** Comets are objects made of ice, dust, and rocks that orbit the sun. They often have a visible "tail" of gas that comes from solar radiation and solar wind. Comets originate from the Kuiper belt and the Oort cloud.

**\*Asteroid belt:** The asteroid belt is a region between the planets Mars and Jupiter. In this region thousands of rocky objects orbit the Sun. They range in size from tiny dust like particles to the dwarf planet Ceres.

**\*Kuiper belt:** The Kuiper belt is a region of thousands of small bodies that exists outside the orbit of the planets. Objects in the Kuiper belt consist of "ices" such as ammonia, water, and methane.

**\*Oort cloud:** The Oort cloud exists much further out than the Kuiper belt. Around a thousand times as far away from the Sun. Up to now scientists have only guessed at the existence of the Oort cloud which they think consists of thousands of small icy objects. The Oort cloud is at the very edge of the Solar System.

### **Facts about the Solar System**

\*Because Uranus and Neptune contain many "ices" such as water, methane, and ammonia they are often referred to as the "ice giants."

\*Scientists estimate there are around 200 billion stars in the Milky Way galaxy.

\*Pluto was once considered a full planet, but was redefined as a dwarf planet in 2006.

\*About 99.85% of the mass of the Solar System is the Sun. All the other planets, asteroids, moon, etc. together make up less than 0.15% of the Solar System's mass.

\*The area around the Sun where the Sun's solar wind has an influence is called the heliosphere.

\*All of the planets orbit the Sun in the same counterclockwise direction.

\*Scientists who study the solar system and outer space are called astronomers.

### **3. Black Holes**

Black holes are one of the most mysterious and powerful forces in the universe. A black hole is where gravity has become so strong that nothing around it can escape, not even light. The mass of a black hole is so compact, or dense, that the force of gravity is too strong for even light to escape.

Black holes are truly invisible. We can't actually see black holes because they don't reflect light. Scientists know they exist by observing light and objects around black holes. Strange things happen around black holes to do with quantum physics and space time. This makes them a popular subject of science fiction stories even though they are very real.

### How are they formed?

Black holes are formed when giant stars explode at the end of their lifecycle. This explosion is called a supernova. If the star has enough mass, it will collapse on itself down to a very small size. Due to its small size and enormous mass, the gravity will be so strong it will absorb light and become a black hole. Black holes can grow incredibly huge as they continue to absorb light and mass around them. They can even absorb other stars. Many scientists think that there are super-massive black holes at the center of galaxies.

### Event Horizon

There is a special boundary around a black hole called an event horizon. It is at this point that everything, even light, must go toward the black hole. There is no escape once you've crossed the event horizon!

### Who discovered the black hole?

The idea of the black hole was first proposed by two different scientists in the 18th century: John Michell and Pierre-Simon Laplace. In 1967, a physicist named John Archibald Wheeler came up with the term "black hole".

### Facts about black holes

- \*Black holes can have the mass of several million suns.
- \*They don't live forever, but slowly evaporate returning their energy to the universe.
- \*The center of a black hole, where all its mass resides, is a point called a singularity.
- \*Black holes differ from each other in mass and their spin. Other than that, they are all very similar.
- \*The black holes we know about tend to fit into two size categories: "stellar" size are around the mass of one star while "supermassive" are the mass of several millions of stars. The big ones are located at the centers of large galaxies.



Black Hole.  
Source: NASA.



Artist's drawing of a supermassive black hole.  
Source: NASA/JPL-Caltech



Black hole absorbing light.  
Source/Author: XMM-Newton,  
ESA, NASA