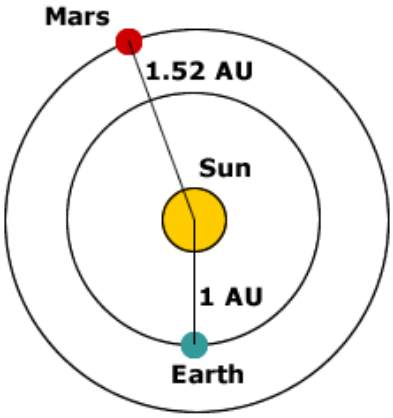
Name _____ Date _____ Period _____

Lab: Astronomical Distances

COORDINATED SCIENCE 1

Background: The distances in Astronomy are so great that using miles or kilometers is insufficient, because the numbers become too large to handle. When dealing with the great distances within our Solar System, ***astronomical units*** (***AU***), which are multiples of the distance from the Earth to the Sun, are used. However, that unit of measurement is not large enough when considering the distance to other stars or galaxies. In that case, distance is stated in ***light years***, which is how far light travels in a year. A third unit that is preferred by astronomers is the ***parsec***, which is even greater than a light year.
Questions you may have include:

- How far is an astronomical unit?
- How far is a light year?
- Why is a parsec used?



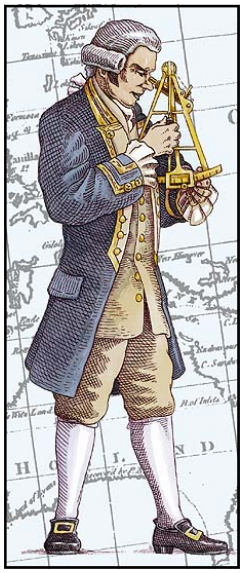
Astronomical units

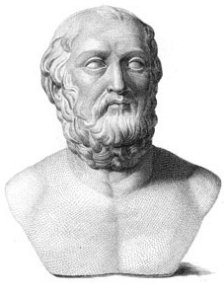
The unit of measurement that is convenient for stating the large distances within our Solar System is the astronomical unit (AU). It is defined as the **distance from the Earth to the Sun**. That distance is approximately **150 million kilometers** (150,000,000 km) or **93 million miles** (93,000,000 mi).
Some distances within the Solar System in AU are:

- By definition, the Earth is 1 AU from the Sun
- Mars is 1.52 AU from the Sun
- Jupiter is 5.20 AU from the Sun
- Pluto is about 39.5 AU from the Sun
- The distance between planets depends on their orientation in their orbits. Mars can be between 2.52 AU and 0.53 AU from Earth, depending on their relative positions.
- As of 2009, the American spacecraft Voyager 1 had traveled over 108 AU from the Sun, the furthest a man-made object has traveled. The distance of 108 AU equates to 16,200,000,000 km or 10,044,000,000 miles.

The historical record in determining AU:

- **Aristarchus of Samos** (ca. 310 BC - 230 BC) ≈ sun's distance is 19 times further away than the moon or about 7,300,000 km (4.5 million miles)
- **Tycho Brahe** ≈ 8,000,000 km (5 million miles)
- **Johannes Kepler** ≈ 24,000,000 km (15 million miles)
- **Giovanni Cassini** ≈ 140,000,000 km (87 million miles)
- **Captain James Cook** 1769 Tahiti voyage to view the Venus Transit ≈ 153,000,000 km (95 million miles)
- **Modern accepted** ≈ 150,000,000 km (93 million miles)





Aristarchus

Brahe

Kepler

Cassini

Light year

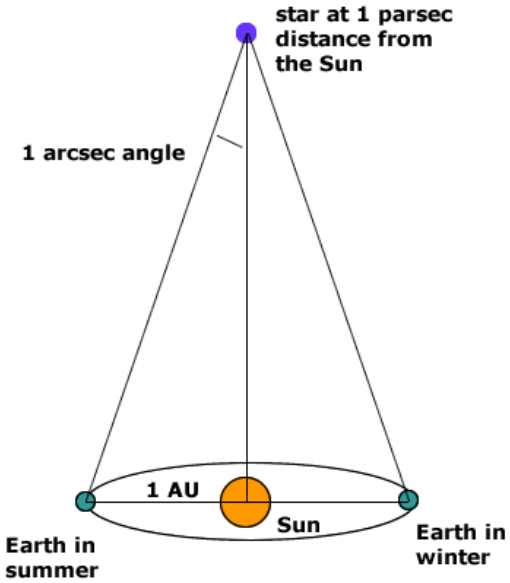
Although the astronomical unit is fine for our Solar System, it is not sufficient to designate the greater distances to other stars and galaxies. Instead, the light year is used as a unit of measurement.
A light year is the distance light travels in one year and can be calculated as the speed of light in kilometers/second or miles/second multiplied times the number of seconds in a year.
The speed of light is approximately 300,000 kilometers per second or 186,000 miles per second. One year equals 365 days × 24 hours in a day × 60 minutes in an hour × 60 seconds in a minute, which equals 31,536,000 seconds. Thus, a light year is about:

- 9,500,000,000,000 km or $9.5*10^{12}$ km
- 5,900,000,000,000 mi or $5.9 *10^{12}$ mi
- A light year is also equals 63,241 AU.

Common large distances
Common large distances in space, measured in light years, include:

- Proxima Centauri, the nearest star in our Milky Way galaxy, is 4.22 light years away.
- The Milky Way galaxy is about 100,000 light years across.
- The Andromeda Galaxy is approximately 2,500,000 light years away.
- The size of the Universe is estimated to be between 93 billion and 156 billion light years across.
- The time it takes light to travel from the Sun to the Earth (1 AU) is approximately 499 seconds or 8.32 minutes. You could say that 1 AU equals 8.33 light minutes

Parsec

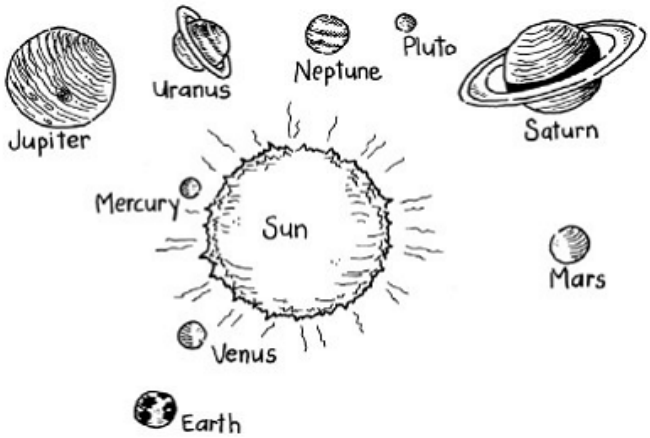


Astronomers prefer to use the parsec to designate extremely great distances in space, because it relates to the geometric method they commonly use to establish distance. Parsec stands for *parallax of one arcsecond*. It is 1 AU divided by the tangent of an arcsecond.
Parsec not popularly used
Although astronomers prefer to use the parsec, other scientists and the general public use the light year to designate large distances. The reason is that it is difficult to visualize a distance in terms of a small angle. Also, one parsec is approximately 3.262 light-years, so there isn't much advantage in using the term.
However, those working in Astronomy must be familiar with the unit of measurement.

Making a scale model of our Solar System

Background: Scale down the solar system with a scale model using the scale of **1 AU = 1 yard**. You'll have a better sense of the vast size of the solar system if you can actually visualize the great distances between planets.

You've probably seen lots of drawings and diagrams of the solar system. But, to make the drawings fit on a piece of paper, the artists have to draw the planets closer together than they really are. In this activity, you'll make a scale model of the solar system. You'll be surprised to see how much bigger some planets are than others, and how far apart some of them are.



Materials:

- 10 Sheets of paper
- Pencils
- Yard stick
- Metric ruler
- Football field

Proceedure:

Step 1: Prepare 10 sheets of paper representing the Sun and each of the 9 planets. Have individual students place a small dot to scale on a sheet of paper to represent each of the planets and one larger circle representing the Sun. Use the size listed in the chart below and write the name of the planet on each sheet of paper.

Step 2: Walk out to the football field and have one student standing on the goal line holding the sheet of paper representing the Sun.

Step 3: Have students stand at the distances in the chart below to represent each of the planets and the relative distances from the sun. Use the markings on the field (in yards) to measure distances from the Sun.

Step 4: After you return to the classroom answer the conclusion questions:

Distance from Sun to Planets (1 AU = 1 yard)		
Object	Size in millimeters	Distance in yards
Sun	9.3 mm	0 yards
Mercury	0.03 mm	0.39 yards
Venus	0.08 mm	0.72 yards
Earth	0.09 mm	1.0 yards
Mars	0.05 mm	1.5 yards
Jupiter	1 mm	5.2 yards
Saturn	1 mm	9.5 yards
Uranus	0.3 mm	19.2 yards
Neptune	0.3 mm	30.0 yards
Pluto	0.02 mm	39.5 yards

Conclusion Questions:

1. What is the definition of an Astronomical Unit?

2. Why do astronomers use different units to measure distances?

3. When might you use a Light Year to measure astronomical distances?

4. How many miles is it to the Sun?

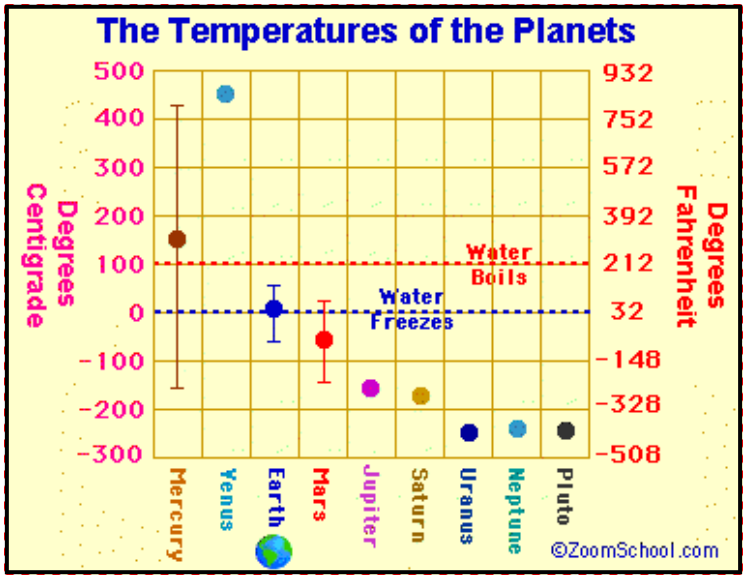
5. How long does it take the light from the Sun to reach the Earth?

6. How many light years across is the our Milky Way galaxy?

7. How many astronomical units (AU) does 1 light year equal?

8. How do the distances from the Sun to the planets explain the table to the right?

9. Why is the temperature of Venus higher than the temperature of Mercury?



10. What information from the table helps explain why life exists on Earth? What other planets might also support life?