The Astronomical League's

In the footsteps of Galileo

Discovery activities for
binoculars and small telescopes

Four hundred years ago, Galileo Galilei was the first person in history who turned a telescope to the heavens. What he saw forever changed our concept of the universe. Before that event, all astronomical knowledge was gained through naked-eye observations. After that, our understanding of the universe grew dramatically, and telescopes became larger and more powerful, eventually giving us the spectacular views that we see today.

The Astronomical League presents five observing activities suitable for binoculars and small telescopes. They allow you to follow in Galileo's footsteps along a path of discovery of the nature of the celestial dome.

Common ten power binoculars, while not quite as powerful as Galileo's telescope, give a clearer and sharper image than his equipment ever did. Today's binoculars will show you fascinating sights in our night sky, ones that are just out of reach of unaided eyes. Here are a few tips for getting the most out of your binocular use:

a. Make sure they are sharply focused.
b. If you can, place them on a tripod to steady their view. Some sky objects appear very small and a jiggling image will obscure their detail.
c. Try to observe from a site away from city lights. There is much more to see from a dark area than from a typical city location.

Once you complete your observations, feel free to download your certificate of discovery. You earned it!

We hope you enjoy your experience under the stars. Become your own Galileo!

Discovery Activities

1. Moon. November 30 through December 19, 1609.

> Regarding the markings on the face of the moon that can be seen with the unaided eye, Galileo wrote in his 1610 treatise, Sidereus Nuncius:
> *"Now those spots which are fairly dark and rather large are plain to everyone and have been seen throughout the ages; these I shall call the 'large' or 'ancient' spots, distinguishing them from others all over the lunar surface, and especially the lighter part. The latter spots have never been seen by anyone before me. From observations of these spots repeated many times I have been lead to the opinion and conviction that the surface of the moon is not smooth, uniform, and not precisely spherical as a great number of philosophers believe it (and the other heavenly bodies) to be, but it is uneven, rough, and full of cavities and prominences, being not unlike the face of the earth, relieved by chains of mountains and deep valleys..."*

Objective: Discover that the moon is not a flawless sphere, but has mountainous regions as well as smooth plains.

Activity: Observe and draw the moon through binoculars when its phase is between a waxing crescent and first quarter ("half" or "D" moon). Do this for two consecutive evenings.

How to locate the crescent moon: The thin crescent moon sets 1 - 2 hours after sunset. As the evenings pass, it appears to grow fatter, ie., it waxes, and it sets later. By the time of 1st quarter, the moon is high in the south at sunset and sets near midnight. Local moonrise and moonset times can be found at the US Naval Observatory site:

http://aa.usno.navy.mil/data/docs/RS_OneDay.php

2. The phases of Venus. December 1610 and January 1611.

> Galileo announced his observations of the phases of Venus by using a Latin anagram. Unscrambled, it gave, *"Cynthiae figuras aemulatur mater amorum."* Translated, it read, *the mother of love* [Venus] *emulates the figures of Cynthia* [the moon]*."*

Objective: Discover that Venus exhibits phases, similar to the moon's, as it orbits the sun.

Activity: Observe and draw Venus when it is in its crescent phase. To see a change in its crescent shape and its apparent size, try again a week later.

How to locate Venus in its crescent phase: Venus can be found in its crescent phase as the very bright object on the dates, times and sky location given.

Times and location of the crescent Venus:

Evening 2009:	at least 30 minutes after sunset in the west-southwest February 1 - March 14, 2009
Morning 2009:	at least 30 minutes before sunrise in the east-southeast April 15 - May 18, 2009
Evening 2010:	at least 30 minutes after sunset in the west-southwest September 4 - 19, 2010
Morning 2010:	at least 30 minutes before sunrise in the southeast November 10 - December 24, 2010
Evening 2011:	at least 30 minutes after sunset No evening crescent phase in 2011
Morning 2011:	at least 30 minutes before sunrise No morning crescent phase in 2011
Evening 2012:	at least 30 minutes after sunset in the west-northwest April 14 - May 24
Morning 2012:	at least 30 minutes before sunrise in the east-northeast June 23 - July 27

3. Jupiter and its four large moons. Beginning January 7, 1610.

> After viewing Jupiter and its accompanying four "stars," Galileo wrote, *"And in the first place, since they are sometimes behind, sometimes before Jupiter at like distances, and withdraw from the planet towards the east and towards the west only within very narrow limits of divergence, and since they accompany this planet alike when its motion is retrograde and direct, it can be a matter of doubt to no one that they perform their revolutions about this planet while at the same time they all accomplish together orbits of twelve years' length about the center of the world."*

Objective: Discover that Jupiter exhibits a small disk as viewed with binoculars and that it has four moons which orbit around it.

Activity: Observe and draw Jupiter and its four moons at about the same time on at least two evenings. Your drawings should have Jupiter centered with its moons proportionally placed on either side of it accordingly. Be sure to write down the dates and times when you make your observations.

Two of its moons are difficult to spot due to their close proximity to glaring Jupiter. Not all four moons are always visible, but they all should make an appearance sometime during a two week span.

How to locate Jupiter: In 2009 and 2010, bright Jupiter can be found in the sky locations on the dates and times (as seen from the contiguous United States) given on the following chart.

Position of Jupiter

	2009			2010		
	Rises in east-	Lies in the south	Sets in the west-	Rises in east-	Lies in the south	Sets in the west-
July 1 - 15	Midnight					
July 16 - 31	11:00 p.m.			Midnight		
August 1 - 15	10:00 p.m.			11:00 p.m.		
August 16 - 31	9:00 p.m.	1:00 a.m.		10:00 p.m.		
Sept. 1 - 15		Midnight		9:00 p.m.		
Sept. 16 - 30		11:00 p.m.		8:00 p.m.		
October 1 - 15		10:00 p.m.		7:00 p.m.	Midnight	
October 16 - 31		9:00 p.m.			11:00 p.m.	
Nov. 1 - 15		8:00 p.m.	11:00 p.m.		10:00 p.m.	
Nov. 16 - 30		7:00 p.m.	10:00 p.m.		9:00 p.m.	
Dec. 1 - 15			9:00 p.m.		8:00 p.m.	Midnight
Dec. 16 - 31			8:00 p.m.		7:00 p.m.	11:00 p.m.
Jan. 1 - 15, 2010			7:00 p.m.			10:00 p.m.

4. Pleiades Star Cluster (aka Seven Sisters or M45). Early 1610.

> Galileo described his view of the Pleiades, also known as the "Seven Sisters," *"I have depicted the six stars of Taurus known as the Pleiades (I say six inasmuch as the seventh is hardly ever visible) which lie within very narrow limits in the sky. Near them are more than forty others."*

Objective: Discover that many celestial features that are visible to the unaided eye as "blurry" areas are, in reality, composed of many stars that you can not readily see. This applies to the Pleiades star cluster, a popular stargazing target in the skies of late fall, winter, and early spring.

Activity: Draw the Pleiades star cluster using the unaided eye. Draw it again, this time using binoculars.

How to find the Pleiades: The Pleiades resemble a very little dipper. It can be found to the far upper right of the constellation Orion.

Location of the Pleiades in the early evening hours:

September	10:00 p.m.	low in the east - northeast
October	9:00 p.m.	low in the east - northeast
November	8:00 p.m.	in the east
December	8:00 p.m.	high in the east
January	8:00 p.m.	nearly overhead
February	8:00 p.m.	nearly overhead
March	9:00 p.m.	high in the west
April	10:00 p.m.	low in the northwest

5. Milky Way. Early 1610.

The mystery of the nature of the glowing band of the Milky Way

was partially solved by Galileo. He wrote that the Milky Way *"is nothing but a congeries of innumerable stars grouped together in clusters. Upon whatever part of the instrument is directed, a vast crowd of stars is immediately presented to view. Many of them are rather large and quite bright, while the number of smaller ones is quite beyond calculation."*

Objective: Discover that the band of the Milky Way is primarily composed of an uncountable number of very faint stars.

Activity: Pick a brighter part of the Milky Way's band and draw its star field as seen through binoculars. Most likely, there will be too many stars to draw. Pick another area of the sky far from the Milky Way and draw its star field. Most likely, there will be fewer stars than before.

How to find the Milky Way. The softly glowing band of the Milky Way galaxy can not be seen from urban locations, although it can be faintly discerned from some of the darker, secluded suburban areas. Dark, rural locales, away from lights, are required to truly see this magnificent sight in all its splendor.

The Milky Way is not easily visible in the early evening hours from late April through late June. It lies too close to the eastern horizon for it to be a good stargazing target. During this period, the best time to view it is between 1:00 a. m. and 4:00 a.m.

Location of the Milky Way before midnight:

Month	Time	Direction of its band
January	8:00 p.m.	southeast - overhead - northwest
February	8:00 p.m.	southeast - overhead - northwest
March	9:00 p.m.	northeast - overhead - south
April	10:00 p.m.	north - west - south
May	11:00 p.m.	north - west - south horizons
June	11:00 p.m.	north - east - southeast
July	11:00 p.m.	northeast - east - south
August	11:00 p.m.	northeast - overhead - southwest
September	10:00 p.m.	northeast - overhead - southwest
October	9:00 p.m.	northeast - overhead - southwest
November	8:00 p.m.	east - overhead - northeast
December	8:00 p.m.	east - overhead - west