OBSERVING THE MOON

The Moon is all too often dismissed by amateur astronomers as a nuisance, a source of light pollution that spoils an otherwise clear dark night. And in fact there are no celestial objects other than the Sun that can even remotely compete with old Luna when she rides high and bright in the night sky. For people devoted to the observation of deep sky objects the Moon means the end of observing for the night, or hours of waiting for the Moon to set. Or clear nights with no observing at all. Of course, a better way to think about the Moon is to see it as a source of observing opportunities, especially for smaller telescopes. The Moon is an entire world hanging above our heads, an alien planet that can be studied at a level of detail that Mars, Jupiter, or Saturn cannot come close to matching. The Moon is worth the time and effort to observe and study.

Or look at it this way. The Moon is not going to go away. So if you can't beat it, observe it!

Observing the Moon is all about learning your way around an alien landscape. When you learn terrestrial geography you learn to recognize features such as mountains, lakes, rivers, and canyons. Our approach to taking a better look at the Moon will parallel this idea, and although some geographical features (mountains) are recognizably similar to their Earthly counterparts, others (such as craters) are like nothing you will see here. And that is because the Moon is airless, with no weather, and consequently no weathering or erosion. Earth's impact craters, with a few rare exceptions, have been obscured, if not obliterated, by these processes. The craters on the Moon have remained relatively unchanged for billions of years. And yet, for all its apparent changelessness, the Moon never looks quite the same from one observing session to the next. The progression of phases of the Moon changes the angle of sunlight for any given feature from night to night, and libration tips first one limb (edge) of the lunar disk we can see toward us, then the other. There are other aspects of the Moon's orbit around the Earth that also affect the angle of sunlight and the shadows the sun casts across the lunar surface. Due to these varying influences, the angles of shadows are never entirely the same from one month of phases to the next. Although it is possible to become very familiar with the lunar surface, it is unlikely you would ever observe it in exactly the same way twice in one lifetime. (The books in the reference list at the end of this section contain detailed descriptions of phenomena such as phases and libration.)

This section of the program is perfectly suited to observations made at home. Lunar observing is not much affected by light pollution, and can even be done when high, thin clouds cover the sky. (Be sure to look for rings around the Moon when this happens.) You don't need dark skies, so you won't need to drive anywhere in particular to set up the telescope. You don't even need to be dark adapted, so you can read a lunar map or guide book with an ordinary flashlight. Observing the Moon certainly has its advantages.

To learn the features of the Moon you will need some way to identify those features. The best and least expensive way to acquire a good lunar reference map is to download the Virtual Moon Atlas (http://www.astrosurf.com/avl/UK_index.html). This

is a very flexible and user friendly reference, and it is available free of charge. If you do not use a laptop out of doors while observing, see the listing at the end of this section for printed references and maps.

A Word About Sketching

Sketching of lunar features can be quite a challenge. Since it is not the goal of this program to turn you into an artist, drawing what you see of the Moon, *with the exception of the very first lunar observing goal,* is optional. Instead, it is your written notes that will fulfill the goals of this section. What you need to take note of will vary slightly depending on the type of lunar feature to be observed, and so for each category there will be a few questions to keep in mind while you observe. The answers you write to those questions will be your formal observations. These answers can be as simple and straightforward as you like, or more elaborate. There is no need to produce an essay, and in fact, some of the questions can be answered with a simple yes or no.

There *is* a way to use sketching to help you learn the features of the Moon, a technique that you can include in your log if you wish, although it is not required. Let's say a crater other than one of those on the list of craters used here interests you, but you cannot find the name on the map you brought out with you. It might show up in a larger atlas or on the VMA, but you would need to go back in to check it. Instead, using a log sheet or blank page, draw a rough map of what you are seeing. This will not be a sketch, exactly, but a schematic representation of the region, something like what you would have if you drew a crude map to give someone directions out to TIMPA. Craters would be circles of the correct size relative to each other, mountains could be represented by triangles, etc. Label a couple of craters that *do* show up on your general purpose map, and use those craters to align the scene with what you find on the more detailed map or atlas. This sort of field note can be a big help in becoming familiar with the Moon.

Seeing Conditions and the Moon

Viewing lunar features is very much dependent on seeing conditions. Under conditions of poor seeing the Moon can look like it is under water, and finer details will be lost to the rippling effect of atmospheric turbulence. This is a special problem in summer and early autumn when the heat built up by the ground (and surrounding buildings) is being re-radiated back into space. You will also be viewing the Moon lower in the south, and therefore through even more of that turbulent atmosphere. (You can get around this summertime hassle by getting up before sunrise in the morning - or by waiting until winter...) Because the influence of seeing conditions can be so influential in whether or not you see details on the Moon you need a record of the seeing conditions on the night you observe. (Transparency is rarely an issue, unless clouds actually cover the Moon, of course.) However, the Pickering Scale used when viewing stars and DSOs does not apply well to a large, bright objects such as the Moon. The seeing scale used

for the Moon (and the brighter planets) was developed by the Greek astronomer E.M. Antoniadi and has five levels:

I = Perfectly calm, no quivering.
II = Slight undulations, with long periods on calm conditions.
III = Moderate seeing, with considerable distortion followed by short periods of steady seeing.
IV = Poor seeing, with nearly constant trembling or waviness.
V = Very bad seeing, with even major features rarely (or never) clearly seen.

Be sure to record your best estimate of the seeing conditions when you make lunar observations.

The Moon, The Whole Moon, and Nothing But…

Even to the naked eye the Moon has a mottled look, and this pattern of light and dark areas has been named the Man in the Moon, the Crone, and the Hare, to name but a few. The dichotomy of light and dark, the rugged lunar highlands and the flatter maria (seas), represents the most fundamental geographic feature of the Moon. You literally cannot miss it.

Your first goal can be accomplished using your eyes alone, binoculars, or your telescope with an eyepiece of low enough power that the entire lunar disc is shown. On a night at or near the Full Moon observe the Moon and get a sense for where the maria and the highlands are in relation to each other. On a copy of the naked eye observing log sheet (or the log format of your choice) draw a circle. Now, using the view you have decided upon (eyes, binocular, or telescope) roughly shade in portions of the circle that correspond with the dark maria. In effect, you are drawing a crude map of the seas of the Moon. All that is necessary is to get these dark areas as close to the right positions and proportions as you can manage. If you are blessed with the skills that allow an artistic rendering, by all means go into as much detail as you desire, but such is *not required.* Label the maria correctly, and include the usual information – time, date, conditions, etc. – on the log sheet.

Craters

After the dark maria, the craters of the Moon are its best known features. Even a casual look through a telescope eyepiece of moderate power will reveal that craters come in many sizes and types. Some are rings around smooth, gray floors, while others contain a jumble of cracks and smaller craterlets surrounding a central mountain peak. Although lunar craters are grouped into types (simple, complex, young and old, etc.) you will never find two that are exactly alike. The craters in the list were selected to give you an idea of this variety, and are ordered according to the day during the lunar cycle (lunation) on which they are most likely give the observer the best possible view. (The selection process was guided by Peter Grego's book *The Moon Observer's Guide.*) This

day by day arrangement is merely a guide, and it is not necessary to limit yourself to these days to observe specific features. But on the suggested days - and the days immediately following - the shadow relief that makes features stand out will be at or near its best for those features.

When you observe one of these craters, ask yourselves these questions:

1. Does it look perfectly round, or to some degree oblong?
2. Does the crater overlap other craters? Or is it overlapped *by* other craters?
3. Does the crater contain a central peak?
4. Is the floor smooth and dark or does it have a rough texture?
5. Does the crater contain cracks or other features such as small craterlets?
6. Is the crater rim complete, or is it open in one or more places?

Since the amount of shadow in or around a crater can vary considerably from day to day, and is not precisely the same from one lunation to the next, you may *not* be able to answer all the questions for a given crater on one night. Should that happen note what you were unable to investigate, and why (too much shadow, for example), and you will be able to check that crater off the list. For the most part, though, it should be possible to deal with any given crater in a single night. This is not to say, of course, that you should not try again on a different night for a better look at that crater.

The Mountains of the Moon

Lunar mountains are, for the most part, the result of impacts. This is especially obvious with the peaks that rise from the centers of many craters. Mountain ranges are often the rims of giant basins that have, in the millennia following the impacts responsible for their formation, filled with lava and become maria. Isolated mountain peaks are parts of older basin rings poking up through the long-since solidified lavas, like islands lost on a cold sea of stone. Lunar mountains are most easily found and identified when their shadows are longest, such as when the sun is just rising or setting in their vicinity. Observe the same peak on two successive nights and you will see a dramatic change.

For the mountain *ranges* on the list, ask yourself the following questions while you observe them:

1. Does the arc of mountains remain of the same width as curves around the mare associated with it?
2. Does it blend in with the mare, or stop abruptly as if falling in steep cliffs?
3. Does it look like a lot of distinct peaks, or a broad pile of rubble? Or both depending on where you look?
4. Are there craters in the range? (List a couple if your map names them.

For the isolated peaks on the feature list, consider the following questions in your notes:

1. Is the shadow cast by the mountain sharply pointed or blunt?
2. Is the mountain brighter that the landscape around it?
3. Is it a single peak, or multiple?

Observing lunar mountains really gives you a sense for how the shadows cast by the Sun reveal the topography of the Moon. Mountains that stand out clearly because of their shadows early in a lunation might not be so easily found in a few days, when the shadows are shorter. When the Moon is Full these features, among others, can be all but invisible. So-called 'shadow relief' exaggerates the topography of the Moon, making features that might be hard to detect stand out clearly. The shadows cast by mountains, crater walls and central peaks, and other features are also part of the beauty of the Moon as seen through the eyepiece.

The Moon is a Bit Cracked and Wrinkled

Given its violent history of asteroid and comet impacts, followed by massive lava flows, it's no surprise that the Moon is a bit of a mess in some regards. A variety of interesting features mark the surface of the Moon as the result of these ancient events. Some of the more interesting, and at times challenging to locate, are the rilles, faults, wrinkle ridges, and valleys. The formal Latin terms are *rupes* for faults, *rimae* for rilles, *dorsa* for wrinkle ridges, and *vallis* for valleys. Some maps use the older Latin words, while others use the modern equivalent, so it's a good idea to be aware of both. Explanations of these features, their origins and characteristics, are a bit beyond the scope of a workbook of this sort. Both Peter Grego's book and Charles Wood's recent *Modern Moon* do excellent jobs of covering these topics. Examples of each are listed in the lunar feature checklist. Consider the following questions when viewing these features.

For the cliff-like scarps or **faults** (*rupes*), how straight are they, and in what directions do the run? Depending on which day in the lunation you observe a fault it will look either dark (casting a shadow) or bright (Sun shining on the cliff face). Which do you see?

Rilles (*rimae*) are long grooves in the lunar surface, thought to be collapsed lava tubes from the Moon's more geologically active past. Are there craters near the rilles you observe? Does the rille cut across any craters? Is it straight, angular, or does it twist and turn?

Valleys (*vallis*) on the Moon, unlike most of their counterparts on Earth, are never the result of flowing water. The Alpine Valley is a graben, a block of the landscape that has sunk down between two faults. Schroter's Valley is believed to be a giant lava flow channel. When you observe these two features, briefly describe how they differ from

one another. Since the best viewing times for each is separated by several days from the other, you can use a photo of the valley that is *not* in your eyepiece when the observations are made.

Full Moon

It is often said and written that observing the Moon at or near Full Moon is a waste of time. And while the lack of shadow relief leaves the lunar surface bare of the details seen previously, there is one lunar feature that stands out better at Full Moon than at other times. When some craters, among them a few of the youngest on the Moon, were created long lines of debris that splashed out across the lunar surface, leaving whitish streaks called rays. The crater Tycho has some of the most spectacular rays, but rays are also clearly visible spreading out from Copernicus, Kepler, and several other craters.

On a night as close to the Full Moon as possible, find and list as many rayed craters as you can. It is completely acceptable to use a lunar map to help you track down rayed craters. In your notes, along with the list, discuss which crater has the longest ray, which has the most, which has the brightest, and any other details that seem worth recording. The Moon will be extremely bright, but although it might be dazzling, it will not harm your eyes. Most people quickly adjust to the brightness and can spend the time it takes to view the Moon when Full, and on the days immediately before and after Full Moon. Others find this very uncomfortable. When using higher magnifications the brightness is not a problem because increased magnification dims the view, but you quite like will not be using high power eyepieces in this case, since a view of the whole Moon makes it easier to trace rays. An investment in a neutral density filter ("Moon filter") or, better still, a variable polarizing filter (VPF) is highly recommended. They are not very expensive and the VPF in particular can also be used to improve the view of the brighter planets.

Lunar Observing References

The Modern Moon by Charles Wood (Sky Publishing)

Atlas of the Moon by Antonin Rukl (Sky Publishing)

Exploring the Moon Through Binoculars and Small Telescopes by Ernest H. Cherrington Jr (Dover Books)

Moon Observer's Guide by Peter Grego (Firefly)

Moon Phase Maps Anttlers Optics

Lunar Feature Checklist

		Day (approx)
Seas	Crisium	14
Maria	Fecunditatis	14
	Serenitatis	14
	Tranquillitatis	14
	Nectaris	14
	Imbrium	14
	Frigoris	14
	Nubium	14
	Humorum	14
	Oceanus Procellarum	14
Craters	Langrenus	3
	Petavius	3
	Cleomedes	4
	Messier/Messier A	4
	Fracastorius	5
	Theophilus	5
	Cyrillus	5
	Catharina	5
	Posidonius	5
	Maurolycus	6
	Plato	7
	Archimedes	7
	Cassini	7
	Copernicus	9
	Tycho	9
	Clavius	9
	Hippalus	10

		Day (Approx.)
	Gassendi	10
CRATERS	Aristarchus	11
	Schickard	11
Mountain Ranges	Montes Apenninus	7
Montes	Montes Alpes	7
	Montes Recti	9
	Montes Harbinger	11
Mountain Peaks	Mons Pico	8
Mons	Mons Piton	8
Faults	Rupes Cauchy	4
Rupes	Rupes Recta	8
Rilles	Rima Hyginus	6
Rimae	Rima Ariadaeus	6
	Rima Hippalus	10
Valleys	Vallis Alpes	7
Vallis	Vallis Schroteri	11