The Isabel Williamson Lunar Observing Program

by

The RASC Observing Committee

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Foreword to the Isabel Williamson Program

By David H. Levy

I think that the idea of a lunar observing program named for Isabel K. Williamson is unique, and one of the most original ideas to hit the RASC in a long time. The reason: Although the Moon is the brightest, most easily seen object in the night sky, it is often forgotten as a serious object for observing.

Any child will confirm my point, beginning with my own granddaughter, Summer, who pointed out the "Oon" to her mother when she was 11 months old. What she meant, I am certain, is that the Moon beckons us. It is close enough to touch, yet challenges us to seek her most detailed rilles, canyons, mountains, and craters. The Moon is a place of dreams.

And for me, the Moon is what Isabel Williamson got me interested in during my first visit to the RASC on October 8, 1960. On that evening my brother Richard and I climbed the steps and entered the observatory. There I encountered a number of people dressed in blue blazers emblazoned with RASC crests. One of them was Isabel Williamson, who greeted us at the door with a big smile.

Expecting to leave with a sheaf of papers, I received only one: the Sky & Telescope Lunar Map with its 325 lunar features. My assignment: to find on the Moon each of those features and draw a map. That project would take the clear nights of the next two years. I finally completed that map in 1964, and it is published in my Cambridge book "David Levy's Guide to the Night Sky."

As a new member, the next project I learned about was the Montreal Centre's Messier Club. For me, it was an adventure that would last five years, from 1962 to 1967, and involved searching for, finding, and recording notes on all of the 100+ objects in the catalogue of Charles Messier. Miss Williamson had founded this club during the 1940s, the first such observing club in all of North America.

For me, the Messier hunt evolved into comet hunting. In late 1965, in the afterglow of the brilliant sungrazing comet Ikeya-Seki, Miss Williamson introduced me to a new book she had just purchased for the Centre's library. Written by the comet hunter Leslie Peltier, it was called "Starlight Nights." I was captivated by that book, and forever thank her for showing me its quiet wisdom and spirituality.

During that time, meteor observing was a mainstay of the Centre's activities. Our most memorable night was August 12/13, 1966, the night of the maximum of the Perseid meteors that summer. Miss Williamson's lively account of that night appeared in Skyward's September 1966 issue: "There was the usual overcast sky when we left Montreal. (As one of the team remarked, 'we wouldn't feel comfortable if the sky were clear when we left on one of these jaunts.') We drove through the usual rain shower. We arrived at our destination and determinedly went about setting up the equipment, trying to ignore the heavy clouds. We went indoors for the usual briefing. [Miss Williamson began each meteor shower night with a careful and extensive briefing of what each observer was expected to do—and not do: “No flash pictures or you'll be shot at dawn!” She also told us about the "Order of the Hole of the Doughnut," awarded to observers who spot every hundredth meteor.] At 9:45 p.m. EDT one or two stars were visible and we decided to "go through the motions" for the benefit of newer members of the team. Light rain was actually falling at 10 p.m. when we took up our observing positions but a few stars were still visible. The first meteor was called within the first five minutes and two more in the next five, which encouraged us to continue. Then the sky began to clear. By 11:30 p.m. there wasn't a cloud in the sky and we enjoyed perfect observing conditions right through until dawn. In six hours of observation we recorded 906 meteors, thus breaking our record for all showers except the famous Giacobini-Zinner shower of 1946. It was a fantastic night."

The memories, the fun observing sessions, and (most of all) the friendships are a major part of my life. Miss Williamson, as she was known, was a definite and valued mentor in my observing, and I am delighted that her name is attached to this valuable project.

The Royal Astronomical Society of Canada
Presents

The Isabel Williamson Lunar Observing Program

Certificate Guidelines

Goals

Here is a summary of the goals for this certificate program:

1. Develop an appreciation for, and an understanding of, the lunar surface.
2. Develop an understanding of modern lunar geology and the forces that have shaped the Moon over its history.
3. Develop skills in observing detail.
4. Develop an understanding of how lunar phases and librations affect viewing specific features.

Requirements

The Isabel Williamson certificate is divided into two types of observations:

® - Required Observations; and
© - Challenge Observations.

A certificate is awarded for completing all of the **Required** objectives and activities. Most observers can complete these observations with a telescope of aperture 80 mm or larger. An additional letter of recognition will be presented to those who also observe one hundred or more of the optional **Challenge** features.

The program is designed to help you document your progress towards the certificate as you complete each observation. For successful observations, you may check off the "®" or "©" symbol as appropriate or use the check mark in the upper right corner if all the required observations for an objective are met. A basic recording form is provided on p. 50, as well as a drawing template on p. 49. They can both be photocopied as needed. You may also want to create your own logbook to record additional details of your observing session, such as lighting conditions, libration, observing location, instrument, and so on. Note that recording the date and time of each observation is required, though a general note stating the date and length of each complete observing session is acceptable. Other details and drawings are optional, although recommended. A suggested optional project for astro-photographers is to image each objective for further study, or as a memento.

The Isabel Williamson Lunar Observing Program can be completed in 6–12 months or longer, depending upon the dedication of the observer and favourable librations. For further information, see
www.rasc.ca/observing/williamson-lunar-observing-certificate

Program Organization

This program is organized into three parts:

I. Getting to Know the Moon.
II. Main Observing List.
III. Libration Challenge Features. (optional)

The first part, **Getting to Know the Moon**, consists of the first five lettered objectives that allow you to visualize and identify the major systems and features of the Moon, including the major impact basins. The detailed **Main Observing List** provides specific targets and observing notes for 135 lunar features and regions. The final section, **Libration Challenge Features**, provides ten objectives that are dedicated to objects near the lunar limb that are visible only during favourable librations, and require both luck and planning to observe. The grand total is 150 objectives for the entire program.

Equipment

All of the required (®) objectives should be visible through a telescope of aperture 80 mm or larger, although some of the challenge (©) features may need more aperture. Binoculars will be useful for familiarizing yourself with the major features, but they generally will not provide enough magnification to complete the program. The challenge observations may require magnifications up to 250x, and this normally implies an instrument at least 125 mm in diameter. A variable polarizing filter or Moon filter may also be necessary for viewing the bright lunar surface, especially near full Moon when the intensity can be uncomfortable for some observers.

Lunar Maps and Atlases

***Atlas of the Moon**,* by Antonin Rükl (revised, updated edition, Gary Seronik, Editor), is the official reference atlas for the Isabel Williamson Lunar Observing Program (this atlas is now out-of-print, but is available on the used market). Other atlases may be useful as well, especially the photographic types, such as those available at the Lunar and Planetary Institute. *Sky&Telescope's Field Map of the Moon* (available in correct-image and mirror-reversed versions) is an affordable and practical map to use at the telescope, with cartography by Rükl, although it does not contain the full detail of the Rükl atlas.

Resources

This program also provides an introduction to lunar geology and a high-level overview of various features and processes. For more detailed information you may wish to consult the RASC's ***Observer's Handbook*** or the following works:

Spudis, Paul D., ***The Once and Future Moon,*** available from the Smithsonian Institution Press. It contains an excellent overview of lunar geology and the findings of the Apollo missions.

Wood, Charles A., ***The Modern Moon: A Personal View,*** available from Sky Publishing. It provides a detailed review of lunar geology, as well as lunar features, organized into 18 geological regions.

A Lunar Geological Primer

Lunar History

The face of the Moon is made up of two general areas—the darker maria (filled basins excavated by huge impacts) and the highlands (lighter) areas where most craters are found. The lunar surface is ancient and almost all of the formations visible predate life on Earth (since they are more than 3 billion years)

Lunar geological time is divided into eras as follows:

- **Pre-Nectarian Era:** This era begins with the formation of the Moon and ends with the creation of the Nectaris Basin (~4.55 billion years ago to ~3.92 billion years ago.) Soon after the Moon's formation (thought to be from Earth's glancing impact with a Mars-sized planetoid) in-falling debris from the collision melted at least the upper part of the lunar crust and mantle to a depth of about 200 km. As the lava ocean cooled, light minerals (e.g. plagioclase, feldspar) precipitated out of the melt and rose to the surface. The materials became the light highlands that we see today and are principally comprised of the rock anorthosite.

- **Nectarian Era:** (~3.9 billion years ago to ~3.85 billion years ago) The Nectarian era is defined by the formation of the major basin systems of the Moon. Basins are the remains of gigantic impact craters that are 2–10 times the size of the ~175 km Chixuclub crater that resulted from an impact on Earth about 65 million years ago. Lava later flowed into many, but not all, of the maria and other basins that had been formed as a result of these impacts.

- **Lower Imbrian Era:** (~3.85 billion years ago to ~3.8 billion years ago) During this era the last major impact basins (Mare Imbrium and Mare Orientale) formed.

- **Upper Imbrian Era:** (~3.8 billion years ago to ~3.2 billion years ago) Most of the maria formed during this era, which was marked by intensive volcanic activity.

- **Eratosthenian Era:** (~3.2 billion years ago to ~1.1 billion years ago) This era was marked by a number of significant impacts, but major basin formation had ended, though some maria continued to form. Visually, the craters of this era have been slightly degraded.

- **Copernican Era:** (~1.1 billion years ago to present) The Copernican Era represents the most recent era, when a small number of impacts added to the major craters of the Moon. These craters are associated with distinctive ray systems that can be traced over much of the lunar surface. They are typically marked by crisp outlines and have minimal "over-cratering" by subsequent impacts.

Inner Structure of the Moon

- **Crust:** Immediately under the surface regolith of the highlands and the basalts of the lunar basins, the crust of the Moon extends to a depth of about 60 km and is made primarily of volcanic basalt similar to that found on the Earth.

- **Lithosphere / Upper Mantle:** The upper area of the lithosphere/mantle is solid rock and extends down about 90 km from the bottom of the crust to a depth of about 150 km, where it merges with the main section of the lithosphere. The lithosphere is a thick and quite sturdy layer of solid rock that extends down another 850 km to a depth of about 1000 km.

- **Asthenosphere / Lower Mantle:** This is a section near the core of the Moon that may be composed of partially molten rock.

- **Core:** The core of the Moon is thought to be mainly rock, unlike the core of the Earth, which is iron. Without an iron core, the Moon may be unable to generate an extensive magnetic field.

Lunar Surface Features

The various surface features visible on the Moon fall into four general categories – impact craters, crater features, volcanic features and tectonic features. All of these features have been modified over time by additional impacts and erosion processes.

1. Impact Craters

The vast majority of the craters on the lunar surface are impact craters. Early lunar selenographers (now known as lunar geographers) believed that the craters might have been volcanic in origin, in part due to their limited understanding of impact crater processes. The following table shows a progressive sequence of craters from the limit of telescopic resolution (~1 km) to the great basins. A representative example of each class is noted.

- **Simple Craters (e.g. Hortensius)** (1–15 km in diameter) – Simple craters have a bowl-shaped appearance and are generally very regular in shape. Depths are 1/5 to 1/6 of their diameters.

- **Intermediate Craters (e.g. Kepler)** (20–30 km diameter) – These larger craters have flat floors and scalloped walls where wall failure has resulted in the materials falling onto the crater floor. The flat floors reflect the solidification of impact melt that formed a new surface.

- **Complex Craters (e.g. Tycho, Copernicus)** (30–40 km diameter and larger) – These craters exhibit characteristic central peaks and wall terraces. The central peaks are formed during energetic impacts by the rebound of deep material after the pressure wave from the impact has passed. Central peaks can uplift material from the lunar mantle. Terraced walls formed by the collapse of the crater rim. Larger complex craters may have multiple central peaks.

- **Basins (e.g. Mare Imbrium, Mare Crisium, Mare Nectaris)** (200–500 km and greater in diameter) – In the largest examples of impact features on the Moon we see large flat expanses surrounded by concentric mountain rings rather than central peaks. The best examples (Mare Orientale and Mare Schrodinger) cannot be easily seen from Earth, but Mare Imbrium and Mare Crisium are the most accessible.

- **Secondary Craters** – (1–10 km diameter) – As a result of the formation of a major crater or basin, debris is ejected which then forms chains of craters or craters with distinctive elliptical shapes that point back towards the originator.

2. Main Crater Features

- **Rays** – The full Moon shows a beautiful overlapping series of rays. These rays represent light-coloured material thrown out by relatively recent impacts that have not yet been darkened by solar wind and cosmic rays to match the rest of the lunar surface.

- **Ejecta Blankets** – Many larger craters are surrounded by *ejecta blankets* that are made up of material thrown out by the impact. Ejecta blankets appear as rough-textured surfaces surrounding craters.

- **Central Peaks –** Generally located at the centre of a crater, these are mountain-like structures that are the result of rebound shock waves from an impact. They come in various sizes and there can be two or more peaks in one crater.

- **Terraced Walls –** These are features mainly present on the inner walls of craters that are the result of impacts, landslides and erosion. They are step-like structures that often appear as rings of increasing size.

3. Volcanic Features

Not all of the lunar surface has been shaped by impact events. Significant episodes of volcanism flooded much of the nearside with lava. Lunar lavas are mostly made of basalt and are rich in iron and magnesium-bearing minerals that provide the basaltic rocks with their distinctive darker colour.

From studies of the basalts found on the Moon, lunar scientists have determined that the thin lunar lavas once flowed much like motor oil on a kitchen table. As a result, most of the volcanic features on the Moon show very little relief and can be spotted only when they are very close to the terminator.

- **Domes** – Volcanic domes are visible in areas where lunar volcanism “made its last stand.” As the Moon cooled after its formation, volcanic activity slowed down and eventually ceased about one billion years ago. Volcanic domes are rare and interesting targets.

- **Rilles** – Three types of rilles occur on the Moon – sinuous, arcuate and straight (see “faults” below for arcuate and straight rilles). Sinuous rilles resemble dry riverbeds but are in fact lava channels or collapsed lava tubes. Long narrow rilles are likely to have always been open channels, while others display roofed and unroofed segments indicating an origin as a lava tube.

- **Dark Mantling Materials** – Many volcanic zones exhibit dark areas visible under favourable illumination of the local maria. These areas are places where volcanic ash erupted and coated the maria, or crater floors with fresh materials. Large areas of Dark Mantling Materials were formed by continuous eruptions (e.g. north of Rima Hyginus) while smaller areas were formed by intermittent eruptions (e.g. Alphonsus.)

- **Caldera** – A bowl-like structure sometimes seen at one end of a rille where subsurface lava boiled up and formed a pool, eventually draining down a rille or into a subsurface cavity.

The most recent episode of volcanism appears to have occurred near the Copernican crater Lichtenberg, where fresh mare materials overlie ejecta and rays from the crater. This may have occurred as recently as 800 million years ago and is still the subject of active investigation.

4. Tectonic Features

The Moon is much less geologically active than the Earth. Unlike Earth's crust, whose multiple overlapping and colliding crustal plates have built mountain ranges and destroyed seafloors, the Moon's crust is a single rigid plate. A number of lunar features result from the deformation of the crust and include compressional (shortening) and tensional (extension) features. Tectonic features are well illustrated around the Mare Humorum and Mare Serenitatis basins.

Tectonic features include:

- **Wrinkle Ridges** – A common landform on the basins, wrinkle ridges result when horizontal lavas are squeezed (shortened) and buckle. Wrinkle ridges are normally very low-relief landforms best seen near the terminator.

- **Faults or Rifts** – Faults or rifts result from extension of the crust to the point where a fracture results. Rifts are the common products of faulting where two faults run parallel to one another and a block of crust drops between them (e.g. Vallis Alpes.) The term scarp is also used for this type of feature (e.g. Rupes Recta).

- **Arcuate Rilles** – These are river-like structures that are concentric with formally active tectonic areas on the circular basins. Rilles often require favourable placement of the sunrise or sunset terminator for a good view. (e.g. Rimae Hippalus).

Erosion & Destruction

Many of the features on the Moon have been changed and eroded from their original "pristine" versions. The lunar highlands have been bombarded so thoroughly that they are saturated with craters of all sizes. Even the lunar basins, which appear to the observer to be relatively smooth, are in fact made up of broken and crushed *regolith* up to 20 metres deep. The regolith (overlying impact ejecta or space debris) in the lunar highlands can be quite deep in places.

All surface features on the Moon have been eroded, to varying degrees, by billions of years of meteoroid and micrometeoroid impacts that continue to this day. Even features that seem to have sharp edges, such as mountain ranges and relatively fresh craters, have in fact been eroded to gentle slopes by the constant, cosmic sandblasting.

These processes of erosion and destruction have affected much of the visible lunar face. Younger craters overlap older ones; ejecta blankets from younger impacts infill older craters, younger volcanic eruptions overlie older areas. Identification of the sequence of events of lunar history was established as early as the 1940s and 1950s by detailed examination of observatory photographs. The Apollo program has provided much detail about the composition of the lunar surface through on-site examinations and the analysis of returned samples. The Apollo program has also helped to determine the absolute ages of many lunar features and it provided close-up photos of many areas of the Moon that are difficult or impossible to see from Earth.

Lunar Geographical Feature Names

Early lunar geographers (or selenographers as they were once called) developed their own specific nomenclature to describe the various features that they mapped. These topographic feature names are based on the original Latin text.

Craters – mainly impact structures, but a few small ones are volcanic.

Catena – crater chain.

Darker lava covered areas known as basins or maria:

- Oceanus – ocean, largest lava covered area (e.g. Oceanus Procellarum.)
- Mare – sea, second largest lava covered areas (e.g. Mare Serenitatis.)
- Sinus – bay, third largest lava covered areas (e.g. Sinus Iridum.)
- Lacus – lake, fourth largest lava covered areas (e.g. Lacus Timoris.)

Note: While these lava basins generally do follow the above size criteria there are some instances where smaller lava areas have a larger type designation.

Dome – a hill-like structure caused by volcanism.

Dorsum – a wrinkle ridge.

Dorsa – a group of wrinkle ridges.

Mons – mountain.

Montes – mountain range or ranges.

Palus – marsh, areas with unusual textures (e.g. Palus Somni.)

Promontorium – promontory, a section of highland extending into a mare (basin).

Promontoria – two or more promontories.

Rima – a single rille.

Rimae – a group of rilles.

Rupes – scarp or fault

Vallis – valley.

Key to a Few Abbreviations Used

CS – Simple Crater
CC – Complex Crater
CI – Intermediate Crater
M – Mare
Mount – Mons or Montes (mountain or mountain range)
Rill – Rima or Rimae (rille or rilles)
WR – Dorsum or Dorsa (wrinkle ridge or ridges)

Libration

Libration is the *apparent* "wobbling" of the Moon that allows us to see up to 59% of its surface area from Earth. Libration in longitude (±8º) results form the nearly uniform axial rotation of the Moon combined with its varying speed along the elliptical lunar orbit. Libration in latitude (±7º) is caused by the tilt of the Moon's equator to its orbital plane. Dates and position angles of favourable libration appear in the annual *RASC Observer's Handbook* and in the annual *RASC Observer's Calendar*. It is important to note that both favourable libration and optimal position of the sunlight or sunset terminator are needed for successful observations. Although 59% of the lunar surface is technically visible, it is rarely possible to clearly recognize and accurately determine features beyond longitudes 90 degrees east and west or latitudes 90 degrees north and south.

Observing Tips

The surface of the Moon is an ever-changing panorama of new sites, and some of the most subtle features like dorsa, rimae, domes and catenae can be invisible at times for no apparent reason. They are elusive mainly because they are relatively small or low-lying objects compared to the major features like prominent craters or mountain ranges that are visible for longer periods during a lunar cycle. Do not be discouraged if some of the features are not visible the first or second time you look for them, because they are actually there, and they will pop into view when the conditions are favourable. Patience and persistence will result in successful observations, and as you gain experience you will become aware of the best times to look for certain features. Using higher magnifications and a solid telescope will also help a great deal, since very small features will easily disappear if the instrument is shaky.

The objectives in this program are listed in order from east to west by their coordinates in longitude. This means that each feature will generally rise or set chronologically as the terminator moves over the lunar surface, although slight deviations caused by libration will occur. The first few objectives listed along the eastern limb of the Moon can be observed during the waxing crescent phase, but are often best seen just after full Moon during the early waning gibbous phase. This is due to the difficultly of observing a slim waxing crescent when it is located low in the sky where the visibility and seeing are poor. Objects near the western limb of the Moon are often best seen just before full Moon rather than during the waning crescent phase when similar difficulties of visibility and seeing occur.

Acknowledgements

The Moon is unique among astronomical objects. It is close, easy to find, and shows rich detail in even the most meagre of instruments. The study of the Moon is very rewarding, but can be quite daunting to new observers. The Moon currently has over 1000 named features and many thousands more that are either unnamed or are given just lettered designations, such as secondary craters. Unlike other programs that simply supply a list of craters and other features, this program has been designed to provide a complete tour of the Moon. We have accomplished this by structuring the observing list in the form of detailed objectives that require the observer to look for more than just the title feature. By utilizing this approach, we have been able to highlight many notable objects and to present many interesting ‘challenge features.’

This program represents many months and years of research and was initiated and directed by Christopher Fleming, a past Chair of the RASC Observing Committee. Special recognition is given to Denis Grey who played a key role in organizing the project and to Terry Millard, who provided a great deal of expertise. We also recognize Simon Hanmer of the Geological Survey of Canada who did a comprehensive review of the lunar geology featured in the program and to Richard Wagner who made that possible. In addition, we acknowledge the contributions of experienced lunar observers Geoff Gaherty, Bruce McCurdy, Alister Ling, and Roger Fell, as well as others for their suggestions and encouragement. Thanks also to the late Leo Enright and Doug Joyce for their important editing contributions. David Chapman corrected, updated, and edited the second edition, with the assistance of Ken Backer, Chris Beckett, Roy Bishop, James Edgar, Paul Gray, Glen Harris, and Tenho Tuomi. Geoff Gaherty is also credited with recommending that the name of our program be a tribute to the dedicated observer Miss Isabel Williamson.

Isabel Williamson was an active member of the Montreal Centre from 1942 to 1971. In 1957 she challenged observers to observe a list of identified lunar features that were marked on a chart of the Moon. Several observers took her up on that challenge, including well-known comet hunter and author David Levy, who we thank for his excellent foreword on page vii. It is in the sprit of that original project that this new program was created and we hope that you enjoy exploring the Moon with us.

Sincerely,

RASC Observing Committee

Isabel Williamson Lunar Observing Certificate

Part One

Introducing the Moon

A – Lunar Phases and Orbital Motion	**Check □**

Recognizing and understanding the phases of the Moon is fundamental to lunar observing, and by understanding the Moon's various stages of illumination, the observer will know when to look for certain features. In addition, a clear understanding of our near neighbour's orbital motion will enable the observer to explain its unique movements across the sky as it revolves around Earth.

® During the course of this program observe and identify each of the following lunar phases: waxing crescent, first quarter, waxing gibbous, full Moon, waning gibbous, last quarter, and waning crescent. If this exercise has already been accomplished while doing the *Explore the Universe* Certificate program, a simple review is all that is required. For others a record of the date and time of each lunar phase seen is required. For more details about lunar phases check the RASC's Beginner's Observing Guide which has excellent information about phases.

® Observe Earthshine on a waxing or waning crescent Moon. Earthshine is a faint but noticeable glow on the unlit portion of the lunar disc that is caused by sunlight reflecting off the surface of Earth back to the Moon. The glow is most prominent during the early or late crescent phases, when from the lunar surface a nearly "full Earth" is in view that reflects a significant amount of sunlight back to the Moon.

® Observe the Moon's orbital motion by noting its position against the background stars or in relation to a terrestrial object, such as a nearby tree. On subsequent nights, repeat the observation at exactly the same time of day and note its change of position across the sky. You should notice a significant eastward movement that is caused by orbital motion.

B – Major Basins (Maria) & Pickering Unaided Eye Scale	**Check □**

The first thing an observer will notice when viewing the lunar surface is the large, dark regions that cover significant amounts of its surface area. They are called lunar basins or maria and they stand out visually, but are easier to identify using binoculars or a telescope at low power. These large dark areas are excellent markers for navigating the lunar surface and it is important to become familiar with them first. A full or nearly full Moon is the best time to observe the lunar basins or maria, although they can be seen at other times.

® Using unaided eyes and binoculars (or a telescope at low power) identify the majors basins on the Moon including Mare Crisium, Mare Fecunditatis, Mare Tranquillitatis, Mare Nectaris, Mare Serenitatis Mare Imbrium, Mare Nubium, Mare Humorum, and Oceanus Procellarum.

© Using binoculars, or a telescope at low power, identify these other notable dark lunar features: Mare Frigoris, Mare Vaporum, Sinus Medii, Sinus Aestuum, Mare Insularum, Sinus Iridum, Mare Cognitum, and Sinus Roris.

© To better understand the challenges faced by observers before the age of telescopes, test your visual acuity by determining your Pickering Number – how deep can you go with unaided eyes on the Moon? A template for this very challenging list is on page 46.

C – Ray System Extent Check □

Ray systems represent the ejecta deposits from recent impacts that have not been darkened by solar radiation. Overlapping ray systems help determine the relative ages of features.

® Under a full or nearly full Moon, observe the extent of the ray systems for Tycho, Copernicus, Kepler and other young craters across the lunar surface.

© Using the template provided on page 47 sketch the extent of the rays systems for Tycho, Copernicus and Kepler at or near full Moon.

D – Crescent Moon Less Than 24 Hours From New Check □

The crescent Moon is an important part of some religious observances today, and was for many cultures of antiquity. The theoretical limit of a visible crescent is approximately 12–14 hours under perfect conditions, before or after new Moon. A waxing crescent is seen at dusk in the western sky, while a waning crescent is seen at dawn in the eastern sky – how close can you come?

© During the course of your observing program, identify and note the waxing or waning crescent Moon and document your best sighting with the unaided eye. To calculate the age of the Moon, use the *RASC Observer's Handbook*, "Month by Month" chapter for times of new Moon, or use the *RASC Observer's Calendar*.

WARNING: While binoculars can help to spot a slim crescent Moon, it is very dangerous to use them near the Sun. Binoculars are **not** recommended if the Sun is above the horizon.

Date	Age in Hours	Location
______________	__________	________________________________
______________	__________	________________________________
______________	__________	________________________________

E – Binocular & Unaided Eye Libration Check □

Libration is the apparent "wobbling" of the Moon as observed from Earth (see p. 8), which allows us to "peek" around the limb and see up to 59% of its surface.

® Using binoculars, note the relative location of Mare Crisium from one part of a lunation to another. Other dark features near the limbs of the Moon can be used for this activity as well, such as Mare Frigoris to the north, Grimaldi to the west, Mare Australe to the southeast and Mare Humboldtianum to the northeast.

Important Note: East and west directions on the Moon are opposite to our view from Earth. If you can imagine yourself on the Moon looking back at the Earth, you should understand this anomaly.

© Without using binoculars, detect and sketch the libration of the Moon from one lunation to another using the template provided on p. 48.

Isabel Williamson Lunar Observing Certificate

Part Two

Main Observing List

1 – Mare Crisium – The "Sea of Crises" - 17.0 N 70-50 E	**Check □**
Origin: Impact and Volcanism **Size:** 570 km. **Rukl:** 38-27, 26-37 **Type:** Basin	

This spectacular lava-filled basin features impressive wall structures, and is actually oval-shaped but appears round because of its location near the lunar limb. Mare Crisium covers 20 degrees of the lunar surface, and may require various terminator angles for optimum views of all the features listed below. Some of these objects may be easier to see just after full Moon. For clarity this objective has been divided into eastern and western sections. Note that the ® symbol indicates required observations, while the © symbol indicates optional, challenge features.

Eastern Mare Crisium:

® In southeastern Mare Crisium observe the large promontory named Promontorium Agarum and note the area of the Luna 24 and Luna 15 landing sites. (Rukl 38)
© In northeastern Mare Crisium observe Dorsa Tetyaev and Dorsa Harker (Rukl 27) and in the southeastern area observe Mons Usov. (Rukl 38)

Western Mare Crisium:

® In northwestern Mare Crisium note the small craters Swift, Peirce, and Picard as well as the ruined, pre-mare crater Yerkes. (Rukl 26)
® In southwestern Mare Crisium observe the crater Greaves as well as the ruined pre-mare crater named Lick. (Rukl 37)
© At or near full Moon observe the lunar rays crossing Mare Crisium and note how they interact with its surface features.

2 – Eastern Basin Group (Crisium / Fecunditatis Area) – 1.0 N 69-58 E	**Check □**
Origin: Volcanic **Size:** Various **Rukl:** 38 **Type:** Mare-Basin, Sinus	

A number of small maria and a sinus in the region between Crisium and Fecunditatis. These features can be observed either during the waxing crescent phase, or the waning gibbous phase, just after full Moon. In addition, most basins can be seen whenever in sunlight.

® Identify Mare Undarum, the "Sea of Waves," a wishbone-shaped area with two main sections.
® Identify Mare Spumans the "Foaming Sea," a lake located south of Mare Undarum.
® Identify Sinus Successus, the "Bay of Success," a bay located west of Mare Spumans at the edge of Mare Fecunditatis.
© Observe the following craters: Condorcet, Firmicus, and Apollonius.

3 – Mare Anguis – The "Serpent Sea" – 22.0 N 67.0 E	Check □
Origin: Volcanic **Size:** 130 km. **Rukl:** 27 **Type:** Mare	

Small mare patch north of Mare Crisium that has less-well-defined borders. This area of the Moon is quite spectacular when observed just after full Moon, particularly during favourable libration. It can also be viewed during the waxing crescent phase, and while observing this area note the spectacular walls of Mare Crisium that are visible nearby.

® Observe Mare Anguis, a small mare section of one of the concentric rings from the Crisium impact. Note the remnants of Mare Crisium's wall around Anguis and to the west.
® On the northwestern edge of Mare Anguis, observe the elongated crater Eimmart.

4 – Vendelinus – 16.3 S 61.8 E	Check □
Origin: Impact **Size:** 147 km. **Rukl:** 60, 49 **Type:** CC	

Large, eroded pre-Nectarian crater located near the eastern limb of the Moon. This area can be seen during the waxing crescent phase or the waning gibbous phase, after full Moon.

® Observe Vendilinus and note the worn appearance of this old crater - especially the northern wall.
® Next to Vendelinus observe the crater Lamé and note its central peak. Also observe the chain of craters running north to south through Lamé.
® Observe the crater Holden on the southern edge of Vendelinus and Lohse (Rukl 49) on the northwestern edge.

5 – Langrenus – 8.9 S 60.9 E	Check □
Origin: Impact **Size:** 132 km. **Rukl:** 49 **Type:** CC	

An Eratosthenian aged crater with twin peaks, finely terraced walls and pronounced ejecta field. It stands out in an area that is heavily cratered. Note how older pre-Nectarian Vendelinus contrasts with younger Langrenus.

® Observe the central peaks, terraced walls, and ejecta field around this large crater.
® Observe the nearby trio of craters named: Atwood, Bilharz, and Naonobu, and farther north, look for the Luna 16 landing site located just west of the crater Webb.
© Note the contrast in appearance of the northern portion and southern portion of Langrenus' floor, perhaps caused by volcanic activity.
© Identify ejecta and secondary craters from Langrenus on the nearby Mare Fecunditatis.

6 – Petavius – 25.3 S 60.4 E	Check □
Origin: Impact **Size:** 177 km. **Rukl:** 59 **Type:** CC	

A lower Imbrian crater with a massive, complex central peak and floor uplift as indicated by rifts. This is an excellent example of a "floor fractured" crater.

® Observe this prominent crater and note its massive central peak.
® Observe the main section of Rimae Petavius on its southwestern floor. This is one of the most spectacular rilles visible within a lunar crater, and it is usually easy to spot.
® Note the crater Wrottesley next to Petavius.
© Observe the smaller sections of Rimae Petavius on its eastern floor.
© Note slight infilling by dark mantling materials that are evident along its walls.
© Trace the rille exiting the crater and ending in Hase to the south.

7 – Furnerius and Fraunhofer – 36.3 S 60.4 E	Check □
Origin: Impact **Size:** 125 km. **Rukl:** 69 **Type:** CC	

Furnerius is an old eroded crater with Nectarian ejecta on its floor. Compare this ancient crater with younger Petavius to the northeast.

® Observe Furnerius and look for Furnerius B on its floor. To the south look for the craters Fraunhofer and Fraunhofer A.
© Observe the very elusive Rima Furnerius on the floor of Furnerius.

8 – Geminus & Lacus Spei – 34.5 N 56.7 E	Check □
Origin: Impact and Volcanism **Size:** 86 km. **Rukl:** 16 **Type:** CC and Lacus	

Geminus is a classic complex crater with wall heights of 2.8 km in the west and 1.4 km in the east. Lacus Spei the "Lake of Hope" is the darkest of a series of "volcanic spots" in this region of the Moon.

® Observe Geminus and note its central peak, 1.46 km high. Compare with Tycho (same size.)
® Identify Lacus Spei, a small irregular upwelling of mare basalt that is possibly Imbrian Era.
© Between Geminus and Lacus Spei note the large crater Messala.
© To the east identify the craters Berosus and Hahn.

9 – Endymion & Mare Humboldtianum – 53.6 N 56.5 E	Check □
Origin: Impact and Volcanism **Size:** 125 km. **Rukl:** 7 **Type:** CC and Mare-Basin	

Prominent Nectarian age mare-filled crater with walls reaching 4.5 km. To the south, Endymion points to Mare Humboldtianum, also known as "Humboldt's Sea," a limb feature best seen during favourable libration.

® Observe Endymion, a major crater with a dark, flat floor that stands out in this area.
© Using Endymion as your pointer, look for Mare Humboldtianum during favourable libration in the northeastern quadrant of the Moon. Check also around full Moon.
© Observe the change in the lunar horizon or profile caused by libration and observe the interesting unnamed craters near Endymion.

10 – Snellius & Vallis Snellius – 29.3 S 55.7 E	Check □
Origin: Impact **Size:** S=83 VS=500. **Rukl:** 59 (69) **Type:** CC	

Impact feature associated with Mare Nectaris, likely caused by ejecta plowing out a valley.

® Observe Snellius and note the degraded walls, eroded peaks and lack of a sharp rim.
® Trace Vallis Snellius along its length from crater Borda southeast past Snellius.
© Note how Vallis Snellius is made up of overlapping craters.
© Identify the crater Santbech north of crater Borda.

11 – Cleomedes & Macrobius – 27.7 N 55.5 E	**Check □**
Origin: Impact **Size:** 126 km. **Rukl:** 26 **Type:** CC	
Prominent eroded craters to the west of Mare Crisium. ® Observe the prominent crater Cleomedes and note the secondary craters B & J on its floor as well as E & A on its northwestern wall. ® For Macrobius, a Lower Imbrian Era crater, observe its prominently terraced walls, rough floor and central peak. (You may need to wait for the terminator) © Observe the nearby craters Delmotte, Tralles, and Debes. © Observe the elusive Rima Cleomedes and the small, off-centre mount. © Note crater C superimposed on SW wall of Macrobius.	

12 – Stevinus – 32.5 S 54.2 E	**Check □**
Origin: Impact **Size:** 75 km. **Rukl:** 69 **Type:** CS	
Prominent circular crater with deep-terraced walls. ® Observe Stevinus and note its central peak and deep terraced walls. © To the northwest identify the crater Reichenbach, as well as several secondary craters forming a half-circle starting at Reichenbach F.	

13 – Mare Fecunditatis – The "Sea of Fertility" – 4.0 S 42-62 E	**Check □**
Origin: Impact and Volcanism **Size:** 990 km. **Rukl:** 48, 37, 49, 59 **Type:** Basin	
A mare consisting of two contiguous, nearly round areas of dark basaltic lavas.The northern part is three times larger than the southern and exhibits a number of dorsa. These lavas probably overlie an impact basin of pre-Nectarian age. Mare Fecunditatis covers 20 degrees of the lunar surface and may require various terminator angles for optimum views of all the features listed below. For clarity this objective has been divided into eastern, central, and western sections. ***Eastern Mare Fecunditatis*** ® In eastern Mare Fecunditatis observe the extensive system of wrinkle ridges, the most prominent of which are Dorsa Mawson, Dorsa Geikie, and Dorsum Cayeux. ***Central Mare Fecunditatis*** ® In central Mare Fecunditatis observe the spectacular craters Messier and Messier A caused by a low level impact (Rukl 48) as well as Dorsa Cato to the north (Rukl 37). ® Along the north-central edge of Mare Fecunditatis (Rukl 37) identify the craters Taruntius and Secchi as well as the relatively small and inconspicuous Montes Secchi. © Note the dark patches on the central peak of Taruntius. Is it volcanic? ***Western Mare Fecunditatis*** ® Along the western edge of Mare Fecunditatis (Rukl 48) identify the small crater Lubbock, located in a prominent highland area. ® Along the southwestern edge of Mare Fecunditatis (Rukl 48) observe the interesting, elongated crater Goclenius, as well as the prominent crater Colombo a little farther south. Note also the large crater Gutenberg that had a chunk of its wall destroyed by an overlapping impact. © Under low Sun angle, note the many ghost craters in western Mare Fecunditatis. © Observe several rilles in this area and clefts on the floors of Goclenius and Gutenberg.	

14 – Vallis Rheita – 42.0 S 51.0 E	Check □
Origin: May have formed with Nectaris Basin **Size:** 500 km in length **Rukl:** 68 **Type:** Valley	

A spectacular lunar valley that is the longest and widest visible from Earth.

® Identify Vallis Rheita, a long, wide valley that is interrupted by several overlapping craters. Next to the valley, note the prominent crater Rheita, featuring a distinctive central peak.
© Observe the elongated crater formation located northeast of the crater Rheita.
© Toward the southeast, look for the craters Young and Young D as well as the eroded craters Mallet and Mallet A. To the northwest, identify the crater Neander (you may need to wait for the terminator to see Neander).

15 – Promontoria Lavinium & Olivium – 15.0 N 49.0 E	Check □
Origin: Impact **Size:** N/A **Rukl:** 26 **Type:** Promontory	

The western edge of Mare Crisium contains these two compelling promontories.

® Trace Promontoria Lavinium and Olivium along the outer edge of two eroded craters. The outer walls of those two eroded craters were once known as "O'Neil's Bridge or Arch."
© Note Dorsum Oppel concentric to the centre of Mare Crisium. It may be a remnant of an inner ring.

16 – Franklin & Cepheus – 38.8 N 47.7 E	Check □
Origin: Impact **Size:** 56, 40 km **Rukl:** 15 **Type:** CS	

Fine duo of craters located to the northeast of Lacus Somniorum.

® Observe Franklin and note its terraced walls and central peak.
® Observe Cepheus and note Cepheus A on its eastern wall.

17 – Steinheil and Watt – 48.6 S 46.5 E	Check □
Origin: Impact **Size:** 67, 66 km **Rukl:** 76, 68 **Type:** CS	

Two nearly equal sized craters sharing one wall.

® Within Steinheil look for deep-terraced walls and a smooth floor. Within the crater Watt, look on its floor for linear detail that may be ejecta from the Steinheil impact.
© To the east look for the crater Mallet J.

18 – Palus Somni and Proclus – 14.0 N 45.0 E	Check □
Origin: Tectonic **Size:** 140 km **Rukl:** 37, 26 **Type:** Palus, Crater and Ray System	

Palus Somni, the " Marsh of Sleep," is a dark continental area west and south of Proclus. Its area is defined by an oblique impact that created a differential ray system. The unique character of this area is often best seen after full Moon.

® Identify Palus Somni and the crater Proclus.
© Sketch the extent of the differential rays east and west from Proclus, using the general drawing templates provided. These features may be more prominent at, or after, full Moon.

19 – Newcomb – 29.9 N 43.8 E	Check □
Origin: Impact **Size:** 39 km **Rukl:** 25 **Type:** Cl	
Named for noted Canadian astronomer Simon Newcomb, whose name is also honoured on the RASC's Simon Newcomb Award. ® Identify the crater Newcomb located near the edge of Montes Taurus and the secondary craters Newcomb A, J, and G next to it.	

20 – Metius and Fabricius – 40.3 S 43.3 E	Check □
Origin: Impact **Size:** 88, 78 km **Rukl:** 68 **Type:** CS	
These two prominent craters are nearly equal in size and structure with deep walls. ® Look for detail on the floor of Fabricius, and look for Metius B on the floor of Metius. © Northwest of Fabricius, look for the disintegrated craters Brenner and Brenner A.	

21 – Sinus Concordiae – The "Bay of Concord" – 11.0 N 43.0 E	Check □
Origin: Volcanic **Size:** 160 km **Rukl:** 37 **Type:** Bay	
Small bay, noticeably darker than the mare to the west. ® Note this small bay and trace the transition to Palus Somni. This area of the Moon is often best observed at, or just after, full Moon.	

22 – Janssen – 44.9 S 41.0 E	Check □
Origin: Impact **Size:** 250 km **Rukl:** 68, 67 **Type:** CS	
Large crater with a 140 km system of rilles on its floor. ® Look for detail and secondary craters on the floor of Janssen. To the west observe the crater Lockyer and look for several sharply defined, younger craters in this area. © Observe the system of rilles on Janssen's floor.	

23 – Montes Pyrenaeus – 14.0 S 41.0 E	Check □
Origin: Impact **Size:** 250 km **Rukl:** 48, 47, 58 **Type:** Mount	
Near the crater Bohnenberger (33 km) Montes Pyrenaeus appears as a ridge forming part of an inner ring of the Mare Nectaris. ® Trace the Pyrenees along their length from south of Bohnenberger (Rukl 58) to the crater Gutenberg. (Rukl 48)	

24 – Atlas and Hercules – 46.7 N 44.4 E	Check □
Origin: Impact **Size:** 69 km **Rukl:** 15, 14 **Type:** CC	

Two prominent craters that share the same region. There is some debate about the age of Atlas, but it is probably Upper Imbrian while Hercules is Eratosthenian.

® Compare Atlas and Hercules. Note that Atlas, perhaps due to infilling, is only half the depth of Hercules and is the older of the two.
® In Atlas, note the terraced walls with noticeable landslips and a complex floor.
© Note Hercules G within Hercules, and note how the ejecta from G has brightened the floor around it. (You may need to wait for the terminator)
© In Hercules, note its terraced walls, and to the south, a small area of old floor that is considerably darker.
© Within Atlas, observe the five volcanic rilles, and the dark mare material in the north and southeast, as well as the central hills.

25 – Mare Nectaris – The "Sea of Nectar" – 15.0 S 40-30 E	Check □
Origin: Impact and Volcanism **Size:** 350 km. **Rukl:** 58, 47 **Type:** Basin	

The smallest of the major circular maria, at 350 km across, it formed about 3.92 billion years ago. Even though Mare Nectaris is relatively small compared to other large basins, it still covers over 10 degrees of the lunar surface and may require various terminator angles for optimum views of all the features listed below.

® Note the presence of wrinkle ridges, mainly in the eastern areas of Mare Nectaris, but the absence of arcuate rilles. The absence of rilles may relate to the relative thinness of lava in this mare.
© Note the craters Bohnenberger at the southeastern edge, Rosse in the south-central area, and Beaumont at the southwestern edge (Rukl 58).
© In the northern area of Mare Nectaris (Rukl 47) observe the eroded and flooded crater Daguerre.

26 – Rupes Cauchy & Cauchy Domes – 7-12 N 39-35 E	Check □
Origin: Tectonic and Volcanic **Size:** Various **Rukl:** 36, 37 **Type:** Domes	

Impressive area of the Moon that features a prominent scarp, two amazing domes, and a rill.

® Locate the small well-defined crater Cauchy, and nearby look for the striking Rupes Cauchy, a scarp that rivals Rupes Recta (the "Straight Wall"). Try to observe this area both at sunrise (before full Moon) and sunset (after full Moon).
® Observe the two spendid domes Cauchy ω (Omega) and Cauchy T (Tau) located south of Rupes Cauchy.
© Observe Rima Cauchy located just north of the crater Cauchy.
© Look for the distinct summit crater on Cauchy ω (Omega) dome.

27 – Sinus Amoris – The "Bay of Love" – 19.0 N 38.0 E	Check □
Origin: Volcanic **Size:** 250 km **Rukl:** 25 **Type:** Bay	

Long, slightly troughed, gentle drop in elevation to Mare Tranquillitatis. The flow of lava seems to have been from west to east, from the area around Maraldi, and then southward.

® Note Montes Taurus region to the north (similar to Southern Highlands) and observe the crater Romer.
® Observe the flooded crater Maraldi and Mons Maraldi just south of it.
® Note prominent craters Hill and Carmichael to the east.

28 – Capella and Vallis Capella – 7.6 S 34.9 E **Check □**

Origin: Multiple linear impacts **Size:** Crater 49 km, Vallis 110 km **Rukl:** 47 **Type:** CC &Valley

Interesting crater with a valley running through it on the northern edge of Mare Nectaris.

® Note the valley running through Capella and the large central peak of the crater.
® Observe the crater Isidorus just to the west, and note how Capella is superimposed upon it.
© Try to count eight or more craters along Vallis Capella.
© Observe the bright, haloed crater Censorinus located further north at the edge of Mare Tranquillitatis. Re-observe it at several lunar phases and note its changing appearance.

29 – Fracastorius – 21.2 S 33.0 E **Check □**

Origin: Impact **Size:** 124 km **Rukl:** 58 **Type:** CC

Since this crater transects the Nectarian Basin wall, it formed after the Nectarian Basin impact but before the area was flooded with lava.

® Observe Fracastorius and note the degraded northern wall flooded by Nectarian lava.
© Observe the small craters L and M, and the rille running east to west across the crater.

30 – Hommel – 54.6 S 33.0 E **Check □**

Origin: Impact **Size:** 125 km **Rukl:** 75 **Type:** CC

Extremely complex crater with several overlapping structures.

® Look for a large crater significantly covered by the overlapping secondary craters Hommel A,B,C,D,H, and P.
® To the north of Hommel, note the crater Pitiscus and identify the prominent duo Vlacq and Rosenberger to the east.
© Farther east look for Biela, and to the southeast look for Nearch and Hagecius. Identify the smaller secondary craters next to Hommel designated Hommel Q,S, and J.

31 – Piccolomini – 29.7 S 32.2 E **Check □**

Origin: Impact **Size:** 88 km **Rukl:** 58, 68 **Type:** CC

Piccolomini is thought to be an Upper Imbrian Era crater superposed on Rupes Altai and on secondary craters related to the Imbrium Basin (most of the smaller, older craters nearby).

® Observe Piccolomini and note its terraced walls and massive central peak.
© Note the slumped area on the southern wall of Piccolomini.

32 – Wohler – 38.2 S 31.4 E **Check □**

Origin: Impact **Size:** 27 km **Rukl:** 67 **Type:** CI

Slightly elongated intermediate crater with a smooth floor.

® Observe Wohler, and to the northeast identify the craters Stiborius and Stiborius C.
© To the southwest observe the craters Nicolai and Spallanzani (you may need to wait for the terminator).
© Note also many disintegrated craters in the area.

33 – Posidonius – 31.8 N 29.9 E — Check □

Origin: Impact **Size:** 95 km **Rukl:** 14 **Type:** CC

Flooded crater from the Upper Imbrian Era. The interior ring is higher than the lunar mean surface in the eastern portion. It has very irregular terrain.

® Observe Posidonius and note the presence of hills (that may be volcanic) throughout the interior Also look for newer Posidonius A on the floor of Posidonius located just west of centre.
® Observe the nearby crater Chacornac located just to the southeast.
© Observe as many of the five separate rimae within Posidonius as you can. These are possibly what happens when a large impact occurs on the edge of an already fractured basin. Three rimae run NW to SW; two others run from NE to SW. Note also the same situation occurs in the crater Chacornac, which abuts to the southeast.
© Observe the crater Chacornac A on floor of Chacornac and the rilles on its northern floor.

34 – Dorsa Aldrovandi and Mons Argaeus – 24.0 N 29.0 E — Check □

Origin: Tectonic and Impact **Size:** 120 km Dorsa **Rukl:** 24 **Type:** WR

Note darkened area of Mare Serenitatis in this vicinity, especially when the Sun is high.

® Identity Dorsa Aldrovandi, a wrinkle ridge caused by the subsidence of Mare Serenitatis.
® Identify Mons Argaeus.
® Observe the eroded crater le Monnier and note the area of the Luna 21 landing site within it.
© At high power observe the small crater chain named Catena Littrow and also Rimae Litrow (Rukl 25.) In addition, find Mons Vitruvius (Rukl 25) and the Apollo 17 landing site next to it.
© Under excellent seeing, identify broken areas (perhaps scarps) in the northern section of Dorsa Aldrovandi.

35 – Jansen – 13.5 N 28.7 E — Check □

Origin: Impact and Volcanic **Size:** 23 km **Rukl:** 36 **Type:** CC

Jansen is a low, mare-flooded crater. It dates from the pre-Nectarian Era.

® Observe the flooded crater Jansen, and note that its floor is darker than the surrounding mare.
© Observe the tiny crater designated Y on Jansen's floor.
© Identity the craters Sinas and Maskelyne to the south and Dorsa Barlow to the east.

36 – Lacus Mortis and Burg – 45.0 N 27.0 E — Check □

Origin: Volcanic and Impact **Size:** 150 km, 40 km **Rukl:** 14 **Type:** Lacus, CC

Lacus Mortis, the "Lake of Death," is an ancient crater flooded by lava and is almost hexagonical in shape.

® Observe Lacus Mortis, an almost circular area that is the remnant of a large, ancient, eroded crater.
® Identify the prominent crater Burg and note its deep walls and central peak.
® Note the two craters Plana and Mason at the southeastern edge of Lacus Mortis and Lacus Somniorum, the "Lake of Dreams," to the south.
© Observe Rimae Burg, an impressive feature, located on the western floor of Lacus Mortis.

37 – Theophilus (Sinus Asperitatis & Mare Nectaris Area) – 11.4 S 26-22 E Check □

Origin: Impact **Size:** 100 km **Rukl:** 46 **Type:** CC

The three craters, Theophilus, Cyrillus, and Catherina, all about 100 km in diameter, form a trio bordering the edge of Mare Nectaris.

® Observe Theophilus, a Tycho-like crater of late Eratosthenian age. Under ideal conditions, some of its rays are still visible over the Sinus Asperitatis.
® Observe the characteristic terraced walls, flat floor, and broad central peak.
® Note the continous ejecta deposit from the rim outward for about 15 km.
® Note the crater Madler just east of Theophilus.
© Note the impact melt that gathered in small "ponds" around the northern, outer wall.

38 – Cyrillus (Sinus Asperitatis & Mare Nectaris Area) – 13.2 S 26-22 E Check □

Origin: Impact **Size:** 98 km **Rukl:** 46 **Type:** CC

Cyrillus is older than Theophilus, which overlaps its eastern wall, and is more eroded.

® Observe Cyrillus and note its twin central peaks, degraded walls, and the fact that Theophilus cuts into it. Also note the secondary crater designated A on its western wall.
® Observe nearby Mons Penck.
© Observe the craters Ibn Rushd and Kant to the northwest.
© Observe the small third central peak.
© Observe the arcuate ridge on the eastern floor and the narrow rille southeast of the peak.

39 – Catharina (Sinus Asperitatis & Mare Nectaris Area) – 18.0 S 26-22 E Check □

Origin: Impact **Size:** 100 km **Rukl:** 57 **Type:** CC

Catharina is the oldest of the three features with five craters superposed on it. Probably pre-Imbrian, since elongated craters on its northeast rim are aligned with Mare Imbrium.

® Observe Catharina and note the large ghost crater Catharina P within it.
© Observe the two elongated secondary craters Catharina B and G on its northeastern wall.
© Observe the secondary craters Catharina C, K, A, F, S, and D, and the small craters inside Catharina P.

40 – Rupes Altai – 16–29 S 30–21 E Check □

Origin: Tectonic **Size:** 480 km. **Rukl:** 57,59, 46 **Type:** Scarp

This incredible scarp is the continuous southwestern outer rim of the Nectaris Basin. Spectacular at low Sun, it varies from 3.5-4 km high, but tapers off and is more broken southward toward crater Piccolomini and northward past crater Borda.

® Observe the most prominent section of Rupes Altai, located to the south and southwest of Catharina, and re-observe it during other lighting angles.
® Trace a partial inner ring by noting the short ridge joining Cyrillus and Catharina and compare it to the area on the opposite shore between craters Colombo and Santbech.
© Craters Tacitus, Kant, and Hypatia lie on the northern less-well-defined rim. Trace this scarp along as much of its length as you can observe.

41 – Mare Serenitatis – The "Sea of Serenity" – 28.0 N 25.3 E	**Check □**
Origin: Impact and Volcanic **Size:** 707 km. **Rukl:** 24, 13, 14 **Type:** Basin	

Nectarian Era impact basin predating Mare Imbrium, filled with Imbrium Era mare material, very titanium rich. It is rich in dorsa and rimae. The second strongest subsurface Mass Concentration or Mascon on the near side is centred under the Mare Serenitatis.

® Observe the impressive Dorsa Smirnov and Dorsa Lister, and note the nearly circular structure formed by Dorsa Lister that extends around to and north of the crater Bessel in central Mare Serenitatis.
® Note the albedo difference between the area of Dorsa Aldrovandi and the main Mare Serenitatis area. Can you detect any darkened areas?
© Punctuated by the small crater Very, note how the north end of Dorsa Smirnov seems to form part of a wall of a ghost crater. Best viewed under low lighting conditions.
© Observe Dorsum Nicol located to the south of Dorsa Lister and Dorsum Azara that extends north and south of the crater Sarabhai.

42 – Sinus Asperitatis – The "Bay of Asperity" – 6.0 S 25.0 E	**Check □**
Origin: Impact and Volcanic **Size:** 180 km **Rukl:** 46, 47 **Type:** Bay	

Joins Mare Tranquillitatis to Mare Nectaris just to the north of Theophilus.

® Note the roughness of this area at low Sun angle and the unusual shape of crater Torricelli (Rukl 47) caused by an intersecting elongated crater.
© Note the open wall of Torricelli that was obliterated by the overlapping impact.

43 – Plinius – 15.4 N 23.7 E	**Check □**
Origin: Impact **Size:** 43 km **Rukl:** 24 **Type:** CC	

Complex crater with multiple central mountains, appearance changes considerably under different lighting conditions.

® Observe Plinius, a well-defined Eratosthenian Era crater, and note its central peak.
© Look for the ejecta blanket surrounding Plinius, as well as irregular hills on its northern floor.
© Note the arcuate rilles (including Rimae Plinius) located north of Plinius and their darker surrounding area. The darker areas highlight lava flows that predate the brighter lava of the sunken inner parts of the Mare Serenitatis Basin.
© Note also Promontorium Archerusia and the crater Dawes.

44 – Lamont, Arago, & Ross – 5.0 N 23.2 E	Check □
Origin: Impact and Volcanic **Size:** 75 km (Lamont) **Rukl:** 35 **Type:** CI	

Lamont is a large, ruined ghost crater near the centre of Mare Tranquillitatis. It is best viewed under low lighting; Apollo 11 landing site is to the south. Arago features two nearby domes designated α (Alpha) and β (Beta) that are impressive to view when visible.

® Identify Arago and Ross, two nearly equal-sized, sharp-edged craters located in western Mare Tranquillitatis.
® Observe Lamont, a large completely flooded ghost crater located southeast of Arago.
® Note the nearby craters Ritter and Sabine located to the southwest, as well as Sinus Honoris, the "Bay of Honour," to the northwest.
© Observe the two fascinating domes designated α (Alpha) and β (Beta) that are located to the north and west of Arago.
© Under low lighting look for summit pits on the Arago domes.
© Note the small offset peak in the 2.5-km-deep Ross and various details within Arago, including a small darkened area on the northeast corner of its floor.
© Locate the craters Armstrong, Aldrin, and Collins near the Apollo 11 landing site to the south.

45 – Moltke & Rimae Hypatia – 0.6 S 24.2 E	Check □
Origin: Impact and Tectonic **Size:** 6.5 Km and 180 km in length **Rukl:** 46, 35 **Type:** Crater and Rill	

Impressive small crater that has a bright halo near the time of full Moon. Rimae Hypatia is a group of rilles (grabens) surrounding Mare Tranquillitatis. These parallel rilles form a shallow graben.

® Observe the circular crater Moltke located off the tip of a prominent highland area that extends into Mare Tranquillitatis.
© Observe Rimae Hypatia, a clearly visible feature during times of favourable lighting angles. In addition to the main section, there are two difficult-to-see extensions that may be visible. Rimae Hypatia extends from the crater Sabine, past Moltke, and along the southern edge of Statio Tranquillitatis, the site of the Apollo 11 landing.
© Observe the two small craters found along the rille to the left and right of the crater Moltke.

46 – Zagut, Rabbi Levi, & Lindenau – 32.0 S 22.1 E	Check □
Origin: Impact **Size:** 84, 81, 53 **Rukl:** 67 **Type:** CC	

Interesting group of craters located in a crowded and somewhat difficult area to navigate.

® Observe these three craters, and within Zagut, look for two younger craters designated A and E. Within Rabbi Levi, observe a close group of five secondary craters. Within Lindenau, look for interesting detail on its floor.
® To the northeast look for the fine crater Rothmann and to the west look for the crater Celsius named for Anders Celsius, inventor of the centigrade temperature scale.

47 – Delambre – 1.9 S 17.5 E	Check □
Origin: Impact **Size:** 52 km **Rukl:** 46 **Type:** CC	

Note the sharp rim and terraced walls of Delambre. Try to see this crater at a high Sun angle.

® Observe the fine crater Delambre located near the edge of Mare Tranquillitatis and not too far from Statio Tranquillitatis, the landing site of Apollo 11 in 1969. (Rukl 35)
® Observe the twin craters Theon Senior and Theon Junior, located just to the west of Delambre.
© Note the small crater Delambre D located on the north wall of Delambre.

48 – Aristoteles & Eudoxus – 50.2 N 17.4 E	Check □
Origin: Impact **Size:** 87 km, 67 km **Rukl:** 5, 13 **Type:** CC	

Spectacular pair of craters located at the edge of Mare Frigoris, the "Sea of Cold." These two prominent craters can be easily identified using binoculars.

® Observe the impressive crater Aristoteles and note its relatively smooth floor and terraced walls.
® Observe Eudoxus, a deep, complex crater with steeply terraced walls that range from 1 km high in the north to 4.3 km in the southeast.
® Compare Eudoxus, a Copernican age crater, with the Eratosthenian age crater, Aristoteles. Compare also with the young crater Tycho (you may need to wait for the terminator).
® Note the eroded crater Mitchell and the flooded crater Egede on either side of Aristoteles and the younger crater Galle in Mare Frigoris.
© Observe the two small central peaks in Aristoteles and the multiple central uplifts in Eudoxus.
© At higher powers identify secondary impact craters from Aristoteles, the distant craters Sheepshanks and Sheepshanks C, and the craters C. Mayer and Arnold.

49 – Sacrobosco and Playfair – 23.7 S 16.7 E	Check □
Origin: Impact **Size:** 98 & 48 km **Rukl:** 56 **Type:** CC	

Sacrobosco is a pre-Nectarian crater and Playfair is Nectarian. The eroded Playfair G (94 km), directly west of Playfair, is pre-Nectarian, since it is covered by deposits of probably Nectarian age. Sacrobosco and Playfair are located at widely separated longitudes, so you may need to wait for the terminator to observe them both at the same time.

® Compare the appearance of Playfair with Sacrobosco and Playfair G (You may need to wait for the terminator) and note how the older craters are eroded by Nectarian deposits.
© Note the two craterlets in Playfair and the four craterlets in Playfair G.

50 – Maurolycus and Barocius – 41.8 S 14.0 E	Check □
Origin: Impact **Size:** 114 & 82 km **Rukl:** 66 **Type:** CC	

Large structures with underlying and overlapping impact scars.

® Look for terraced walls and detail on the floors of these big craters.
© To the south look for the craters Breislak and Clairaut and to the northeast look for Buch and Büsching.

51 – Gemma Frisius – 34.2 S 13.3 E	Check □
Origin: Impact **Size:** 88 km **Rukl:** 66 **Type:** CC	

This crater features an unusually high wall of over 5 km.

® Observe Gemma Frisius, and at its northeast corner identify the crater Goodacre.
® Just over the western wall look for a trio of the three craters D, G, and H.
© To the northwest try to identify the disintegrated crater Poisson.

52 – Montes Haemus & Mare Serenitatis Lacus Group – 17.0 N 13.0 E	Check □
Origin: Impact & Volcanic **Size:** 400 km (Montes Haemus) **Rukl:** 23,22 **Type:** Mount and Lacus	

Raised edge of Mare Serenitatis Basin, overlain with ejecta from the Mare Imbrium and flooded by basaltic lavas. These Upper Imbrian age lowlands near Mare Serenitatis are separated into multiple Lacus or "Lakes."

® Observe Montes Haemus and note linear nature of their structure and the high massif northwest of crater Menelaus. Its height is 4.2 km.
® Note members of the lacus group including the following: Lacus Hiemalis, the "Winter Lake"; Lacus Lenitatis, the "Lake of Tenderness"; Lacus Gaudii, the "Lake of Joy"; Lacus Doloris, the "Lake of Suffering"; Lacus Odii, the "Lake of Hate"; and Lacus Felicitatis, the "Lake of Happiness." (last one: Rukl 22.)

53 – Rima Ariadaeus – 7.0 N 13.0 E	Check □
Origin: Tectonic **Size:** 220 km **Rukl:** 34 **Type:** Rill	

Wide, prominent rima, exceptional object when close to the terminator. It is a classic graben formed by separation of the lunar surface and down-dropping of material. This rima has a very notable fault structure apparent in its make-up: it consists of a series of offset segments; at least one offset may well be visible.

® Observe Rima Ariadaeus and note where it passes under other features that have subsided with it.
® Note the large eroded crater Julius Caesar to the northeast.
® Observe the parallel connection with Hyginus rille to the west.

54 – Abulfeda & Catena Abulfeda – 17.0 S 13-21 E	Check □
Origin: Impact **Size:** 62 km (crater), 210 km in length (catena) **Rukl:** 45, 56, 57 **Type:** Crater, Catena	

This long crater chain begins at Abulfeda and continues to Rupes Altai. The origin of this chain, which is radial to no known basin or crater, is unclear.

® Observe the Nectarian Era crater Abulfeda and note its flat floor.
® Starting at the southern edge of Abulfeda, trace the Catena Abulfeda crater chain along its entire length extending to Rupes Altai.
© Note the variation in size of the craterlets along this catena.
© Observe the very small secondary craters covering the north wall of crater Abulfeda.
© Try to identify four craterlets that begin the Catena on the south wall of Abulfeda.

55 – Abenezra & Azophi – 22.0 S 12.0 E	Check □
Origin: Impact **Size:** 42 & 48 km **Rukl:** 56 **Type:** CC	

Two craters, part of a group that is useful for orientation in this heavily bombarded area of the lunar surface.

® Identify these two craters that are part of a group: Apianus, Playfair, Azophi, Abenezra, Geber, and Almanon.
© Note the freshness of these craters in this area (Abenezra is the younger of the two since its rim overlaps Azophi's.) Note the different appearance of their floors.
© Note the three small craters in Azophi.

56 – Dorsum von Cotta & Dorsum Buckland – 24.0 N 12.0 E **Check □**

Origin: Tectonic **Size:** 220 & 159 km **Rukl:** 23 **Type:** WR

Prominent wrinkle ridges at the southeastern edge of Mare Serenitatis caused by subsidence.

® Note these two prominent dorsa, von Cotta and Buckland, located just to the north of the crater Sulpicius Gallus.
® To the southeast identify crater Menelaus.
© Look for two nearby dorsa named Owen and Gast, for Rimae Sulpicius Gallus at the edge of Montes Haemus, and for Rimae Menelaus to the east of crater Menelaus (Rukl 24).

57 – Linné – 27.7 S 11.8 E **Check □**

Origin: Impact **Size:** 2.4 (actual crater); bright halo larger **Rukl:** 23 **Type:** CS

The actual crater is a small difficult object, but the bright halo around it is easy to spot. Linné has been described as a crater, cloud, crater-cone, or pit in a depression. The true nature of this bright and simple crater was settled using Apollo photos.

® Observe the bright halo around Linné.
® Observe from low light and re-observe during first quarter and full Moon.
© Try to resolve the small 2.4 km crater at the core of the bright area.

58 – Cuvier – 50.3 S 9.9 E **Check □**

Origin: Impact **Size:** 75 km **Rukl:** 74 **Type:** CS

Crater with a smooth floor. Cuvier (Rukl 74) is located almost due south of the prominent crater Maurolycus (Rukl 66) in a heavily cratered area of the Moon that is an interesting challenge to navigate.

® Observe Cuvier and look for a notable pattern of five craters Q, F, A, E, and B located just to the southeast of it.
© To the east and southeast look for the craters Baco, Asclepi, and Tannerus.
© Farther southeast look for Mutus and Manzinus (more easily seen during favourable libration), and to the south look for Jacobi and Kinau.

59 – Manilius – 14.5 N 9.1 E **Check □**

Origin: Impact **Size:** 39 km **Rukl:** 23,34 **Type:** CC

Deep (3.2 km) terraced crater with high (2.6 km) central peak. Eratosthenian-age crater.

® Observe crater Manilius, a fairly large crater, located in a relatively crater-free area.
© Look for radial banding on the crater floor and its offset central peak.
© Under high Sun conditions, note ray material out across Mare Serenitatis.

60 – Montes Caucasus – 39.0 N 9.0 E **Check □**

Origin: Impact **Size:** 445 km in length **Rukl:** 13 **Type:** Mount

A continuation of the Montes Apennines, and part of the original edge of the Mare Imbrium impact basin.

® Observe this impressive mountain range and identify the crater Calippus.
© Observe the area east of the southernmost end of this range, which has well -separated volcanic domes visible under low-light conditions.

61 – Rima Hyginus – 7.8 N 6.3 E	Check □

Origin: Tectonic **Size:** 220 km **Rukl:** 34 **Type:** Rill

One of the most impressive of the many rimae on the lunar surface. It extends from Rima Ariadaeus in the east to Rimae Triesnecker in the west.

® Observe Rima Hyginus and note the crater Hyginus about midway along its path.
® South of its eastern tip observe the large craters Agrippa and Godin.
© Observe the small crater on the northern edge of the crater Hyginus.

62 – Stofler and Faraday – 41.1 S 6.0 E	Check □

Origin: Impact **Size:** 126 km, 70 km **Rukl:** 65, 66, 73 **Type:** CC

Large pre-Nectarian crater with overlapping Imbrian Era crater.

® Look for terraced walls on the western end of Stofler and several secondary craters nearby.
® Note the two distinct craters on either side of its companion crater Faraday.
® To the south of Stofler observe the notable, oval-shaped crater Licetus, and the odd-shaped crater Heraclitus (Rukl 73)
® To the north observe the two craters Fernelius and Kaiser and note other unnamed craters.

63 – Airy, Argelander, & Vogel – 16.5 S 5.8 E	Check □

Origin: Impact **Size:** 37 km, 34 km, 27 km **Rukl:** 56 **Type:** CC

Relatively prominent features in the otherwise difficult-to-navigate Southern Highlands to the west of crater Abulfeda.

® Observe this trio of craters located in the Southern Highlands.

64 – Rimae Triesnecker – 5.0 N 5.0 E	Check □

Origin: Tectonic **Size:** 200 km in length **Rukl:** 33 **Type:** Rill

This impressive but unusual system of rilles does not appear to be related to subsidence.

® Note the impact crater Triesnecker that is located just west of the rille system.
® Observe Rimae Triesnecker, a group that runs generally north and south of the crater Triesnecker.
® To the south of Rimae Triesnecker identify the eroded crater Rhaeticus. To the southeast, note Sinus Medii, the "Central Bay," where zero degrees longitude can be found (you may need to wait for the terminator).
© Identify craters Murchison, Pallas, Bruce, and Blagg, and also the Surveyor 4 and 6 landing sites.

65 – Hipparchus – 5.5 S 4.8 E	Check □

Origin: Impact **Size:** 150 km **Rukl:** 44, 45 **Type:** CC

A pre-Nectarian crater with badly disintegrated walls and a square-like shape, perhaps due to pre-existing faults.

® Observe crater Hipparchus and note smooth floor and linear scars on walls, caused by Mare Imbrium ejecta.
® Note the craters Horrocks, Halley, and Hind.
© Under low Sun conditions, observe two buried craters on the floor of Hipparchus, about 4 degrees west of Horrocks.
© Observe the craters Seeliger and Reaumur. (Rukl 44)

66 – Albategnius – 11.3 S 4.1 E **Check □**

Origin: Impact **Size:** 136 km **Rukl:** 44, 45 **Type:** CC

This is a Nectarian age crater that still retains an off-centred peak.

® Observe Albategnius, and note the scar outside the eastern wall and also note in this area various oval-shaped craters caused by ejecta from the Mare Imbrium impact.
® Note the crater Klein located within crater Albategnius.
© Observe a saucer-shaped depression on the floor of crater Albategnius; it may be seen only under low light conditions.

67 – Werner & Aliacensis – 28.0 S 3.3 E **Check □**

Origin: Impact **Size:** 70 km, 80 km **Rukl:** 55, 65 **Type:** CC

Prominent craters near the Moon's prime meridian at the edge of the Southern Highlands.

® Observe the two impressive craters Werner and Aliacensis, and note their deeply terraced walls. Also note that deposits from crater Werner have degraded the appearance of crater Aliacensis, which is a Nectarian Age crater with a diameter of 80 km.
® Compare the Eratosthenian Age crater Werner with the crater Tycho (you may need to wait for the terminator), a nearly equal-sized crater. Also note their sharp-rimmed walls that are often a feature of younger craters.
© Note crater Werner D on the north wall of crater Werner, and also the small off-centre peaks in both crater Werner and crater Aliacensis.

68 – Montes Alpes & Vallis Alpes – 46.0 N – 3.0 E – 3.0 W **Check □**

Origin: Impact and Volcanic **Size:** 250 km in length (Montes Alpes) **Rukl:** 12, 4 **Type:** Mount and Valley

Spectacular boundary of the Mare Imbrium Basin, with heights from 1.8 to 2.4 km ranging up to 3.6 km for the great Mont Blanc. The impressive Vallis Alpes runs perpendicular to the prominent Montes Alpes, making this one of the most picturesque areas on the Moon.

® Observe Montes Alpes and note the shadows extending from the mountains. The shadows are used to measure their heights.
® Observe Vallis Alpes – a wide rift valley, 180 km in length, that links Mare Frigoris and Mare Imbrium.
® Just south of Montes Alpes observe the crater Cassini and the two small craters within it designated A and B. Also note the crater Theaetetus southeast of Cassini.
© Identify the two notable promontories – Promontorium Agassiz & Deville as well as Mont Blanc. © Using a large telescope and high power try to resolve the narrow, sinuous volcanic rille running along the centre of the floor of Vallis Alpes.

69 – Aristillus & Autolycus – 33.9 N 1.2 E **Check □**

Origin: Impact **Size:** 55 km **Rukl:** 12 **Type:** CC

Two outstanding craters in Mare Imbrium that contrast nicely in size. They are both Copernican Era impacts with Aristillus featuring a notable ejecta blanket.

® Note crater Aristillus and its ejecta blanket. Compare it with crater Autolycus to the south.
® At full Moon, trace the prominent rays of Aristillus.
® Observe Sinus Lunicus to the west and the Luna 2 landing site next to Autolycus.
© Note the very small secondary craters near Aristillus designated A, B, C, and D.

70 – Montes Apenninus & Apennine Bench – 20.0 N - 10.0 W – 6.0 E **Check □**

Origin: Impact and Tectonic **Size:** 600 km in length (Monte Apenninus) **Rukl:** 22, 21 **Type:** Mount

Spectacular mountain range with heights to 5000 metres, best seen at first and last quarter.

® Note this spectacular mountain range formed by the impact that created the Imbrium Basin.
® Trace the continuation of the Montes Apenninus into the Montes Carpatus and the Montes Alpes.
© Observe the following: Mons Hadley and Mons Hadley Delta, Mons Bradley, Mons Huygens, Mons Ampère, and Mons Wolf. (Rukl 21)
© Note the Apennine Bench, a lightly hued area that is probably igneous rock that erupted after the basin formed, but escaped flooding by later lava flows.
© Identify the curve of Rima Hadley near the Apollo 15 landing site. (It requires low sun angles and magnifications of over 200x.)

71 – Walther – 33.0 S 0.7 E **Check □**

Origin: Impact **Size:** 132 km **Rukl:** 65 **Type:** CC

Large, prominent, Nectarian Era crater.

® Observe crater Walther (Walter before 1979), and look for terraced walls and an off-centre peak and the overlapping craters located on the northeastern part of its floor.
® Note overlapping craters on crater Walther's eastern wall and the nearby crater Nonius.
© Look for a ray across crater Walther at sunrise or sunset.

72 – Huggins, Nasireddin, & Miller – 40.0 S 0.0 W **Check □**

Origin: Impact **Size:** 65 km, 52 km, 75 km **Rukl:** 65 **Type:** CC

A fine trio of craters featuring nearly equal sizes and structures, located in a rich area of many craters.

® Look for central peaks in this trio of craters, and to the west look for the large crater Orontius.
® To the southwest look for the craters Saussure and Proctor.

73 – Regiomontanus & Purbach – 28.4 S 1.0 W **Check □**

Origin: Impact **Size:** 126x110 km, 118 km **Rukl:** 55 **Type:** CC

Regiomontanus is a pre-Nectarian Era crater. Note its severely eroded walls and elongated shape. Purbach is a prominent pre-Nectarian crater with a poorly defined and eroded western wall.

® Observe crater Regiomontanus and note the crater pit, Regiomontanus A, located on the central peak. This was once believed to be evidence of volcanism.
® Observe the nearby crater Purbach and note the overlapping crater on its northwestern wall and interesting detail on its floor.

74 – Arzachel – 18.2 S 1.9 W	Check □
Origin: Impact **Size:** 97 km **Rukl:** 55 **Type:** CC	

Arzachel is a spectacular Imbrian Era crater with sharply defined, deep-terraced walls. It makes a nice trio with Alphonsus and Ptolemaeus to the north.

® Observe Arzachel and note the broad inner wall, off-centre peak, and the depression valleys on the southeastern and southwestern walls. The valleys are designated E and F.
® Observe the nearby crater Alpetragius and note that its central peak occupies most of its floor.
® Observe the nearby craters Thebit and Thebit A.
© Observe the low hills on the south and southwestern floor of Arzachel.
© Observe the arcuate rille on the floor of Arzachel. At sunset this rille casts a shadow eastward, indicating it is higher to the west and may be a fault.

75 – Ptolemaeus & Alphonsus – 12.0 S 2.0 W	Check □
Origin: Impact **Size:** 153 km, 100 km **Rukl:** 44 **Type:** CC	

Very prominent craters easily visible through binoculars. Older Ptolemaeus (pre-Nectarian) and younger Alphonsus (Nectarian) are visible on the terminator at the same time.

® Observe these two impressive craters and look for a central peak in Alphonsus; also note the crater Herschel just to the north of Ptolemaeus.
® In Ptolemaeus note its smooth floor and the sharply defined small crater Ammonius on its northeastern floor. It is one of only a few such named craters within a larger one.
© On the floor of crater Alphonsus, note three distinct dark patches. They are recognized as ash deposits from fire fountains that occurred after the crater was formed.
© Observe the crater Flammarion and Rima Flammarion.

76 – Goldschmidt – 73.0 N 2.9 W	Check □
Origin: Impact **Size:** 120 km **Rukl:** 4 **Type:** CC	

Part of the North Polar Region, this crater and its surrounding area are more easily observed during favourable librations.

® Observe crater Goldschmidt, which is very prominent during favourable libration, but more challenging to observe at other times, especially when there is negative libration in that area.
® Note the younger crater Anaxagoras overlapping Goldschmidt’s western wall.
© South of crater Goldschmidt and between crater Archytas and crater W. Bond, observe the valley radial to the Mare Imbrium impact.
© Identify post-Imbrian Era craters in and around Goldschmidt.
© Note marked infilling of Goldschmidt and surrounding craters by Mare Imbrium impact ejecta.

77 – Montes Spitzbergen & Mons Piton – 35.0 N 5.0 W	Check □
Origin: Impact **Size:** 60 km length **Rukl:** 12 **Type:** Mounts	

Picturesque small mountain range and an isolated mountain in Mare Imbrium. These peaks are interpreted to be relics of inner impact basin rings, and their shadow lengths are used to measure their heights.

® Identify Montes Spitzbergen, a group of mountains that is the remnant of the Mare Imbrium formation. Peaks rise to 1500 m.
® Note higher Mons Piton to the northeast rising 2250 m.
© Observe the nearby craters Piazzi Smyth and Kirch and the tiny craters A & B near Piton.

78 – Archimedes & Montes Archimedes – 26.0 N 5.0 W	Check □
Origin: Impact **Size:** 140 km **Rukl:** 22 **Type:** Flooded crater and basin remnant.	

Crater Archimedes is an impact structure that was flooded from the interior by Imbrian Age lava. Montes Archimedes is a notable mountainous area just south of crater Archimedes.

® Observe the prominent, flooded crater Archimedes. Also, observe Montes Archimedes, which is a possible remnant inner ring of the Imbrium Basin.
® Note linear features on the slopes of Montes Archimedes carved by ejecta from the Imbrium impact.

79 – Deslandres – 32.5 S 5.2 W	Check □
Origin: Impact **Size:** 234 km **Rukl:** 65, 64 **Type:** CC	

A very large, pre-Necterian Era, disintegrated crater.

® Observe Deslandres, one of the largest craters on the Moon, and look for the eroded crater Lexell (Rukl 65) on its southeastern edge and the prominent, younger crater Hell (named for astronomer Maximilian Hell) on its western edge. (Rukl 64)
© Look for a line of very small craters on the eastern floor of crater Deslandres (Rukl 65) and also look for the central peak in crater Hell (Rukl 64).

80 – Moretus & South Polar Region – 70.6 S 5.5 W	Check □
Origin: Impact **Size:** 114 km **Rukl:** 73 **Type:** CC	

Moretus dominates this jumbled terrain. Gigantic South Polar Basin is just beyond this area on the far side of the Moon.

® Moretus is an impressive circular Eratosthenian Era crater located in the southern region of the Moon, near the central meridian.
® Look for deep-terraced walls and a prominent central peak. To the northwest look for the craters Cysatus and Gruemberger.
© To the northeast and east look for the craters Curtius, Zach, Pentland, and Simpelius; to the south observe the remote craters Short and Newton.

81 – Maginus – 50.0 S 6.2 W	Check □
Origin: Impact **Size:** 163 km **Rukl:** 73 **Type:** CC	

Large, prominent, pre-Nectarian Era crater.

® Look for details on the floor of Maginus and identify the secondary crater Maginus A on its northeastern floor.
® Note a trio of craters on its northwestern wall and Maginus C on its southwestern wall.
© To the east look for Heraclitus and Lilius and to the southeast look for Deluc.

82 – Davy & Catena Davy – 11.0 S 7.0 W	Check □
Origin: Impact **Size:** 35 km **Rukl:** 43 **Type:** Crater and Catena	

Notable crater with a nearby chain of very small craters likely caused by a fragmented comet or asteroid impacting the Moon.

® Observe the crater Davy and the secondary crater Davy A that overlaps its southeastern wall.
® Note the craters Lalande and Mosting to the north.
© At high power observe Catena Davy, a line of tiny craters located to the northeast of Davy.

83 – Rupes Recta – 22.0 S 7.0 W	Check □

Origin: Tectonic **Size:** 110 km in length **Rukl:** 54 **Type:** Scarp

The famous "Straight Wall" is one of the most interesting features on the Moon.

® Observe Rupes Recta, a gentle vertical slope rising 2.5 km. It is dramatic at the time of low Sun angles – dark at sunrise and light at sunset.
® Note the sharply defined fresh crater Birt just to the west.
® Note distinctive Promontorium Taenarium protruding into Mare Nubium, just off the northern tip of Rupes Recta
© Observe crater Birt A and Rima Birt.

84 – Mons Pico & Montes Teneriffe – 48.0 N 9.0-13.0 W	Check □

Origin: Impact **Size:** 110 km, 11x25 km **Rukl:** 11 **Type:** Mount

Isolated mountains in Mare Imbrium that may be the remnants of an inner wall of the Mare Imbrium Basin.

® Observe isolated Mons Pico and Mons Pico β (beta) to the south; also, observe Montes Teneriffe.

85 – Plato – 51.6 N 9.3 W	Check □

Origin: Impact and Volcanic **Size:** 101 km **Rukl:** 3 **Type:** CC

Spectacular dark-floored crater on the margin of Mare Imbrium south of Mare Frigoris. It is older than Mare Imbrium. Plato's dark floor is basin-like and visible whenever it is in sunlight.

® Observe Plato, an amazing crater with an extremely smooth floor. The floor has no visible features at low to medium power.
® Observe the craters Fontenelle and Philolaus to the north.
© Note crater Plato in relation to Mare Imbrium and the contrast with the Mare Imbrium ejecta.
© Note irregular rim features through shadows cast at different Sun angles during a lunation.
© Note up to five tiny craters on the floor of crater Plato (high power, a large-aperture telescope, and excellent "seeing" conditions are required).

86 – Tycho – 43.3 S 11.2 W	Check □

Origin: Impact **Size:** 85 km **Rukl:** 64 **Type:** CC

One of the youngest craters on the Moon, Tycho is inconspicuous during most of the lunar day, but comes into its own at the full Moon where its rays can be traced over much of the lunar surface. The Tycho impact may have occurred as recently as 100 million years ago!

® Look for a prominent central peak, deep terraced walls, and the nearby craters Street and Pictet.
© To the north and northeast, look for the Surveyor 7 landing site, the large disintegrated crater Sasserides, and several secondary craters nearby.

87 – Eratosthenes – 14.5 N 11.3 W	Check □

Origin: Impact **Size:** 58 km. **Rukl:** 21,32 **Type:** CC

This prominent crater is post-Imbrian Era, but pre-Copernican and lends its name to the Eratosthenian Era. It can be found at the southern tip of Montes Apenninus.

® Observe crater Eratosthenes and note its central peak and deeply terraced walls.
® Trace its ejecta blanket south through Sinus Aestuum.
® Observe Sinus Aestuum, the "Bay of Billows."

88 – Gauricus and Wurzelbauer – 33.8 S 12.6 W	Check □
Origin: Impact **Size:** 79 km, 88 km **Rukl:** 64 **Type:** Eroded Craters	

Heavily eroded craters in the southern highlands region contrast with younger craters nearby.

® Look for hilly terrain on the floor of Wurzelbauer that may be ejecta from other impacts, and observe several smaller, younger craters nearby. Also, to the southeast look for the circular crater Ball featuring a distinct central peak.

89 – Timocharis – 29.0 N 13.0 W	Check □
Origin: Impact **Size:** 34 km **Rukl:** 21 **Type:** CC	

Prominent crater located near the middle of Mare Imbrium.

® Observe crater Timocharis and note the inner crater that has obliterated the central peaks (you may need to wait for the terminator to see the inner crater).
® Observe the simple craters Feuillée and Beer to the east and crater Heinrich to the southwest.
© Identify Dorsum Higazy to the west of crater Timocharis.
© Observe Dorsum Grabau located to the north of crater Timocharis and the crater Landsteiner near it (Rukl 11).

90 – Pitatus – 29.8 S 13.5 W	Check □
Origin: Impact **Size:** 97 km **Rukl:** 54, 64 **Type:** CC	

Large Nectarian Age crater with fractured walls.

® Observe this big crater located at the southwestern edge of Mare Nubium and note its off-centred peak and eroded walls.
© Look for the elusive Rimae Pitatus winding across the floor of crater Pitatus.

91 – Stadius – 10.5 N 13.7 W	Check □
Origin: Impact **Size:** 69 km **Rukl:** 32 **Type:** CC	

Ghost crater, subtle circular depression edged with incomplete low walls and crater pits.

® Observe crater Stadius, a slightly larger but much less prominent feature than nearby crater Eratosthenes. It is located roughly one crater diameter to the southwest of Eratosthenes.
® Note the dark patches on the floor of Mare Insularum to the south.
® Observe the prominent but anonymous mountain massif between the craters Stadius and Eratosthenes.

92 – Clavius – 58.4 S 14.4 W	Check □
Origin: Impact **Size:** 225 km **Rukl:** 72, 73 **Type:** CC	

Exceptionally large crater seen at its best near the time of first quarter and last quarter Moon. It is also visible in binoculars.

® Identify this very large, prominent Nectarian Era crater that has several interesting secondary craters within it that are suitable for testing telescope optics.
® Observe a unique half-circle of progressively smaller craters starting at crater Rutherfurd.
© On the northeastern wall look for the overlapping crater named Porter, and on the floor of crater Clavius see how many of the very small craters you can identify.

93 – Fra Mauro Formation – 6.0 S 17.0 W	Check □
Origin: Impact **Size:** 95 km **Rukl:** 42, 43 **Type:** Ejecta blanket	

Eroded crater partially filled by ejecta blanket from the Mare Imbrium impact. The Apollo 14 landing site is just south of Fra Mauro crater.

® Observe the eroded and almost flooded crater Fra Mauro and note the Apollo 14 landing site just to the north of it.
® Note heavily eroded craters Parry and Bonpland to the south.
© Note Rimae Parry.
© Observe Dorsum Guettard to the southwest of crater Bonpland.

94 – Montes Recti – 48.0 N 20.0 W	Check □
Origin: Impact **Size:** 90 km in length **Rukl:** 11 **Type:** Mount	

Picturesque small mountain range in Mare Imbrium that may be the remnant of an inner ring of the Mare Imbrium Basin.

® Observe this mountain range and note the irregular shapes at the base of these mounts.

95 – Copernicus – 9.7 N 20.0 W	Check □
Origin: Impact **Size:** 93 km. **Rukl:** 31 **Type:** CC	

A prominent crater that is the prototype of the Copernican geological period. Copernicus features spectacular central peaks and is surrounded by both a prominent ejecta blanket and numerous secondary craters. The impact that formed Copernicus occurred about one billion years ago. It is easily visible in binoculars, particularly when near the terminator, and is by far the most prominent feature in the otherwise mostly flat Mare Insularum.

® Observe crater Copernicus and note its extensive ejecta blanket, deep terraced walls, and multiple central peaks.
® Observation at full Moon shows full extent of ray system, which overlaps that of Kepler to the west.
© Worthy of repeated observation at both sunrise and sunset (~1.5 days after first and last quarter respectively.) Observe over a period of hours to watch the sunlight gradually illuminate subtle detail of the terraced inner walls and the complex outer rim, which soars nearly 1 km above the surrounding terrain.
© Compare the ray system to that of Tycho, which features a few very long rays. Copernicus has a large number of shorter, overlapping rays, leaving the impression of a squashed tarantula.

96 – Mare Imbrium / Eratosthenes / Copernicus System	Check □
Origin: Impact and Volcanic **Size:** Various **Rukl:** 19-22, 9-12, 31 **Type:** Various	

This area of the Moon illustrates the overall ages of the major systems. You can trace out the relative ages of each by noting which crater is overlain on the other. Note these features:

® Mare Imbrium lavas fill crater Archimedes; so they are post-impact, but pre-Mare Imbrium.
® The crater Eratosthenes is post-Mare Imbrium, but pre-Copernican.
® The crater Copernicus is the most recent major impact in this area, and overlies older structures.
® The ejecta blanket surrounding Mare Imbrium is the oldest part of this system and dates back to the Imbrium impact itself. It is especially noticeable in some areas e.g. in the area of the crater Julius Caesar (Rukl 34).

97 – Wilhelm & Heinsius – 41.1 S 20.8 W	Check □
Origin: Impact **Size:** 107 km, 64 km **Rukl:** 64 **Type:** CC	
Prominent large and medium-size craters located to the west of craterTycho. ® Look for several smaller craters overlapping the outer walls of Wilhelm. Also look for the craters Heinsius A, B, and C located on Heinsius' southwestern wall. ® Observe the significantly eroded crater Montanari.	

98 – Blancanus & Scheiner – 63.6 S 21.5 W	Check □
Origin: Impact **Size:** 105 km, 110 km **Rukl:** 72 **Type:** CS	
Two notable craters located near crater Clavius. ® Look for deep terraced walls in crater Blancanus and some small detail on its floor. In crater Scheiner look for several secondary craters across its floor (you may need to wait for the terminator). © To the southwest of Scheiner try to find the remote craters Wilson and Kircher.	

99 – Longomontanus – 49.5 S 21.7 W	Check □
Origin: Impact **Size:** 145 km **Rukl:** 72 **Type:** CS	
Very large prominent Nectarian Era crater in heavily impacted region. ® Note unusual wall structure, mainly caused by numerous secondary impacts. Also note the small off-centre peak. ® Observe several secondary craters in the northwestern area of this crater's floor.	

100 – Bullialdus – 20.7 S 22.2 W	Check □
Origin: Impact **Size:** 61 km **Rukl:** 53 **Type:** CC	
An exceptional Eratosthenian Era crater. ® Observe the spectacular crater Bullialdus and note its prominent ejecta blanket. ® Note the craters Bullialdus A and B to the south and the crater König to the southwest.	

101 – Kies, Mercator, & Campanus – 26.3 S 22.5 W	Check □
Origin: Impact **Size:** 44 km **Rukl:** 53 **Type:** CC	
Kies is a flooded crater with a nearby volcanic dome designated π (Pi). Mercator and Campanus are two nearly equal-sized craters located at the edge of Mare Nubium. ® In Mare Nubium, directly south of crater Bullialdus, observe the lava-filled crater Kies. ® Observe crater Mercator and Rupes Mercator, which together form the southwestern edge of Mare Nubium. © Under a low sun, observe the volcanic dome just west of crater Kies designated π (Pi). © Note crater Campanus and the unnamed rille running between it and crater Mercator.	

102 – Mare Cognitum & Kuiper – 9.8 S 22.7 W	Check □

Origin: Impact **Size:** 6.8 km **Rukl:** 42 **Type:** Mare and CS

Mare Cognitum, the "Known Sea," was named in 1964 to mark the successful flight of the Ranger 7 spacecraft, which sent back the first detailed television pictures of the lunar surface. Kuiper, located in central Cognitum, is an excellent example of a small, simple crater.

® Identify the Mare Cognitum basin, and note the area where the Ranger 7 spacecraft landed.
® Observe small crater Kuiper in central Mare Cognitum and note crater Darney to the south.
© Note the low wrinkle ridges in Mare Cognitum.
© Identify Mons Moro.

103 – Reinhold & Lansberg – 3.3 N 22.8 W	Check □

Origin: Impact **Size:** 48 km, 39 km **Rukl:** 31**,** 42 **Type:** CS

Two fine craters located in Mare Insularum. Note their deep terraced walls and compare them with the great crater Copernicus located farther north.

® Observe crater Reinhold, a prominent crater with an ejecta blanket, and 3260-metre-deep terraced walls.
® Observe crater Lansberg and note its ejecta blanket, central peak, and 3110-metre-deep terraced walls.
© Observe the two tiny central peaks in crater Reinhold.
© Identify the Luna 5 landing site southeast of crater Lansberg (Rukl 42).

104 – Dorsum Zirkel and Dorsum Heim – 31.0 N 23-32 W	Check □

Origin: Tectonic **Size:** 130 and 210 km in length **Rukl:** 10, 20 **Type:** WR

Tectonic ridges formed by the subsidence of Mare Imbrium. These two features cover 9 degrees of the lunar surface and may require various terminator angles for optimum view.

® Trace Dorsum Zirkel (Rukl 20) and note the prominent Eratosthenian Era crater Lambert located near the dorsum. Lambert displays a significant ejecta blanket and interesting detail on its floor.
® Observe Mons La Hire, located to the northwest of crater Lambert, and the crater Pytheas to the south. Note the very bright northern wall of crater Pytheas.
® To the west observe Dorsum Heim (Rukl 10) a large prominent ridge in western Mare Imbrium that is easily visible when near the terminator (you may need to wait for the terminator).
© Note the ghost crater Lambert R just south of crater Lambert.
© Observe the section of dorsum extending southeast from crater Lambert that appears to be a continuation of Dorsum Zirkel.

105 – Montes Carpatus – 15.0 N 25.0 W	Check □

Origin: Impact **Size:** 500 km in length **Rukl:** 20, 31 **Type:** Mount

Picturesque mountain range located just north of crater Copernicus at the edge of Mare Imbrium.

® Observe this range and note its conflicting structure that was caused by various nearby impacts.
© Note effects of nearby basin impacts and erosion, and the herringbone patterns of secondary craters from Copernicus near the eastern edge of Montes Carpatus.
© Observe Rima Gay-Lussac located along the southern edge of Montes Carpatus. (Rukl 31)

106 – Sinus Iridum – The "Bay of Rainbows" – 45.0 N 25-37 W	Check □

Origin: Impact and Volcanic **Size:** 260 km. **Rukl:** 9,10 **Type:** CC

Massive, spectacular, flooded crater on the edge of Mare Imbrium. It combines the high mountains of Montes Jura with a missing southeastern rim & two prominent "capes." Sinus Iridum covers more than 10 degrees of the lunar surface and may require various terminator angles for optimum views of all the features listed.

® Observe the half-circle structure of Montes Jura and note the post-Iridum Age crater Bianchini on its northern wall.
® Observe Promontoria Heraclides and LaPlace, projecting into Mare Imbrium at both the eastern and western tips of Montes Jura.
® Note the post Imbrium Age craters Helicon and le Verrier located to the southeast of Sinus Iridum in Mare-Imbrium and crater C. Herschel to the southwest.
© Note post-Iridium Age craters Sharp and Mairan (Rukl 9) and compare them with the pre-Iridum Age crater Maupertuis to the north.
© Identify the Luna 17 landing site located to the southwest of Promontorium Heraclides.

107 – Klaproth & Casatus – 69.7 S 26.0 W	Check □

Origin: Impact **Size:** 119 km, 111 km **Rukl:** 72 **Type:** CS

Double crater located near the southern edge of the Moon.

® Note plain barren floor of crater Klaproth, and within crater Casatus look for the two distinct secondary craters Casatus C and J. (You may need to wait for the terminator to see the secondary craters.)

108 – Palus Epidemiarum – The "Marsh of Epidemics" – 32.0 S 27.0 W	Check □

Origin: Flooded lava plain **Size:** 300 km **Rukl:** 63, 62, 53, 54, **Type:** Palus

One of only a few lava-flooded areas located in the southern highlands of the Moon. It has an irregular shape, a dark floor, and two rille systems.

® Identify Palus Epidemiarum and along its southern wall look for the disintegrated crater Capuanus. Also, observe the simple crater Ramsden in western Palus Epidemiarum.
® Observe Rima Hesiodus that extends from within Palus Epidemiarum over to the crater Hesiodus, which is located next to the crater Pitatus. Use maps 63, 53, and 54 to trace its entire length.
© Identify Rimae Ramsden that is located within Palus Epidemiarum. Also, identify the craters boardering Palus Epidemiarum named Cichus, Weiss, Dunthorne, and Lepaute. (This last crater is on Rukl 62.)

109 – Lacus Timoris – The "Lake of Fear" – 39.0 S 28.0 W	Check □

Origin: Flooded lava plain **Size:** 130 km **Rukl:** 63 **Type:** Lacus

A small feature located in the mostly cratered southern highlands. It is long and narrow with a dark floor and inlets.

® Observe this feature and note the slightly irregular crater Epimenides located just south of it, and to the northeast look for crater Haidinger and other secondary craters.
® Note mountainous areas surrounding this feature.
© To the southwest observe the large overlapping trio of craters: Hainzel, Hainzel A, and Hainzel C.

110 – Montes Riphaeus – 6–10 S 28 W	**Check □**
Origin: Impact **Size:** 150 km in length **Rukl:** 41, 42 **Type:** Mount	
Picturesque mountain range located between Oceanus Procellarum and Mare Cognitum. These mountains are quite impressive when viewed near the terminator. ® Observe Montes Riphaeus (Rukl 42) and note the bright, haloed crater Euclides just to the west. (Rukl 41) © Observe the large dome located north of crater Euclides next to the crater designated D (Rukl 41).	

111 – Hortensius & Hortensius Domes – 7.0 N 28.0 W	**Check □**
Origin: Impact and Volcanism **Size:** 14.6 km crater and various domes **Rukl:** 30 **Type:** CS and Domes	
A fine sharp-rimmed crater (2860m deep) with a fascinating group of domes nearby. The domes are quite obvious under the right lighting conditions, but are elusive at other times. ® Observe the crater Hortensius and a group of 5 or 6 domes located a short distance north. The domes are best seen at low illumination about 2.5 days after first or last quarter. ® Note Mare Insularum, the "Sea of Isles," featuring many island-like highlands. © Using high power, observe the ~1 km summit craters on the Hortensius Domes–visible under ideal conditions.	

112 – Mare Insularum Volcanic Complex – 10.0 N 31.0 W	**Check □**
Origin: Volcanic **Size:** Various domes **Rukl:** 30, 19 **Type:** Domes	
Volcanic dome complex, smaller than crater Hortensius, in the northern reach of Mare Insularum. ® Note the simple craters Milichius and Milichius A located in Mare Insularum, and the nearby dome designated Milichius π (Pi). © Observe the crater T. Mayer (Rukl 19) and the nearby domes shown on Chart 30 and designated T. Mayer α (Alpha) and ζ (Zeta) © At low sun angles and using high power, observe the summit craters on T. Mayer α (Alpha) and ζ (Zeta). © Look for a group of lower, less defined domes in the vicinity of the T. Mayer domes.	

113 – Promontorium Kelvin & Rupes Kelvin – 27.0 S 33.0 W	**Check □**
Origin: Impact and Tectonic **Size:** 150 km **Rukl:** 52 **Type:** Promontory and Scarp	
A large, well-defined promontory in Mare Humorum and a scarp located nearby on the edge of the same Mare. ® Observe Promontorium Kelvin and the less-well-defined Rupes Kelvin located just south. ® Observe Rimae Hippalus running north to the degraded crater Hippalus. ® Note extensive system of wrinkle ridges visible at low sun angles in eastern Mare Humorum. © Note the large ruined crater Agatharchides to the north.	

114 – Mons Delisle & Mons Vinogradov – 26.9 N 36.0 W	**Check □**
Origin: Impact **Size:** 30 km, 25 km **Rukl:** 19 **Type:** Mounts	
Picturesque, small, isolated mountains in Mare Imbrium. ® Observe the crater Delisle and Mons Delisle to the southwest. ® Observe the crater Diophantus and Mons Vinogradov to the south of it.	

115 – Kepler & Encke – 8.1 N 38.0 W	Check □
Origin: Impact **Size:** 32 km, 29 km **Rukl:** 30 **Type:** CC	

Recent impact crater Kepler (32 km), with its uneven floor and bright ray system, contrasts with older crater Encke of nearly the same size.

® Observe craters Kepler and Encke and note how much shallower crater Encke is. Kepler is 2570 m deep, while Encke is just 750 m.
® At the time of full Moon, observe to its full extent the ray system emanating from crater Kepler, a ray system that overlaps that of the crater Copernicus.
© Sketch the extent of crater Kepler's ray system.
© Note tiny crater Encke N on the western wall of crater Encke.

116 – Gassendi – 17.5 S 39.9 W	Check □
Origin: Impact/Tectonic **Size:** 110 km **Rukl:** 52 **Type:** CC, Rill	

Nectarian Era, eroded crater with extensive system of rimae on its floor.

® Observe crater Gassendi and its central peaks.
© Observe the extensive system of rilles visible at low Sun angles.

117 – Mons Gruithuisen Gamma (γ) & Delta (δ) – 36.3 N 40.0 W	Check □
Origin: Volcanic **Size:** 20 km each **Rukl:** 9 **Type:** Domes	

Impressive twin-shield volcanoes on boundary between Mare Imbrium and Oceanus Procellarum.

® Observe these two unique, large domes and the 16 km-wide crater Gruithuisen nearby.
© Detect the summit pit or crater at the top of Mons Gruithuisen Gamma.
© Farther to the northwest (you may have to wait for the terminator) observe the small dome designated Mairan T, located in Sinus Roris and to the west of the crater Mairan. With high power and under ideal conditions, the summit crater can be resolved.

118 – Schiller & the Schiller-Zucchius Basin – 51.8 S 40.0 W	Check □
Origin: Impact **Size:** 179x71 km **Rukl:** 71 **Type:** CC and Basin	

A crater that is very elongated, perhaps as a result of a very-low-angle impact or the merging of two crater structures. The Schiller-Zucchius Basin is the remains of a very large, ancient impact.

® Observe Schiller, a distinctive, long, fairly wide crater featuring some detail on its western floor.
® To the northwest look for the crater Bayer, and to the southeast, note the circular craters Rost and Weigel.
© To the south of crater Schiller look for a vast (325 km) basin bounded by the craters Schiller, Zucchius, and Phocylides. (Rukl 70)

119 – Montes Harbinger – 27.0 N 41.0 W	Check □
Origin: Impact **Size:** 90 square km **Rukl:** 19 **Type:** Mount	

Isolated mountain groups that may be the remnants of the southwestern boundary of Mare Imbrium.

® Identify the three main peaks of Montes Harbinger.
© Observe the nearby eroded crater Prinz.

120 – Letronne and Flamsteed – 10.6 S 42.4 W	Check □
Origin: Impact **Size:** 119 km, 21 km **Rukl:** 40 **Type:** CI	

Letronne is a possible upper-Imbrian Age crater, whereas crater Flamsteed is Eratosthenian in age.

® Identity Letronne, a large, eroded crater located just to the east of Billy and Hansteen.
® Identify the crater Flamsteed named for John Flamsteed, the first English Astronomer Royal and author of a star-numbering system that is still in use today.
© Observe Dorsa Rubey and the Surveyor 1 landing site area located in the large ghost crater, designated Flamsteed P.

121 – Rupes Liebig – 24.3 S 46.0 W	Check □
Origin: Tectonic **Size:** 180 km in length **Rukl:** 51 **Type:** Fault	

Notable subsidence fault, linked to Mare Humorum.

® Identify Rupes Liebig, an impressive fault similar to the famous Rupes Recta (the Straight Wall).
© Observe the large eroded crater Doppelmayer and Rimae Doppelmayer (Rukl 52)

122 – Aristarchus Plateau & Vallis Schröteri – 23.7 N 47.7 W	Check □
Origin: Impact and Tectonic **Size:** 40 km, 160 km length **Rukl:** 18 **Type:** CC and Valley	

Aristarchus is a bright, complex crater that is a little older than crater Tycho, and is located near the edge of a unique plateau that rises 2 km over Oceanus Procellarum. Vallis Schröteri was a lava tunnel that carried lava from the highland plateau to the adjacent basin.

® Observe crater Aristarchus and note the bright mare material excavated from beneath Mare Procellarum and the notable rays to the south and west. Note overall diamond shape and the darker hues of the plateau relative to Oceanus Procellarum.
® Trace Vallis Schröteri – the largest volcanic rille on the Moon – along its length to the north and east.
® Observe Montes Agricola, a small mountain range to the North.
© Note heavily fractured and faulted Rupes Toscanelli area, and trace it north to crater Toscanelli. Also, observe the three rilles of Rimae Aristarchus.
© Note "Cobra Head" formation at the southern end of Vallis Schröteri, near Herodotus. It may be a volcanic caldera.
© Note Mons Herodotus, and the various hills and dark features on the plateau.

123 – Mersenius & Rimae Mersenius – 21.5 S 49.2 W	Check □
Origin: Impact and Tectonic **Size:** 84 km **Rukl:** 51 **Type:** CC and Rill	

Prominent, flooded crater with numerous small craters on its floor that are likely related to the Mare Imbrium impact.

® Observe crater Mersenius and note how the floor of this crater is bowed upward and fractured, perhaps because of a rebound shockwave or past tectonic activity.
® Observe Rimae Mersenius, a wide, easily visible set of rilles that begin east of the crater and run north for 230 km. These rilles are often more prominent when the terminator is a little farther east, before crater Mersenius comes into full view.

124 – Billy and Hansteen – 13.8 S 50.1 W	Check □
Origin: Impact **Size:** 46 km, 45 km **Rukl:** 40 **Type:** CI	

Flooded crater with a dark flat floor contrasts with a similar-sized crater with a rough floor.

® Compare crater Billy, that has a flat dark floor, with nearby crater Hansteen that is only one km smaller, but with different features.
® To the north of crater Billy, observe Mons Hansteen, a roughly triangular mountain massif that is very bright under high illumination.

125 – Zucchius, Bettinus, & Kircher – 61.4 S 50.3 W	Check □
Origin: Impact **Size:** 64 km, 71 km, 73 km **Rukl:** 71 **Type:** CS	

Trio of nearly equal-sized craters.

® Identify this group of craters that form an excellent landmark pointing to the immense crater Bailly (Libration Challenge Object #8).
® Note the crater Segner, located next to crater Zucchius, making this actually a four-crater group.

126 – Marius & Marius Hills – 12.5 N 54.0 W	Check □
Origin: Volcanic **Size:** 200x300 km **Rukl:** 29, 28 **Type:** Domes	

Extensive field, within an area of about 200x300 km, of low volcanic domes west of the crater Marius. It is best seen at low illumination and near the terminator (~4 days after first or last quarter). (See Rűkl photo 30.)

® Observe crater Marius, a regular flooded crater 41km in diameter, and the Marius Hills, a striking group of low-lying hills and domes to the west of it.
® Identify Reiner, an Eratosthenian-age crater with a diameter of 30 km.
© Observe the central peak in crater Reiner.
© To the north, observe Rima Marius, a feature with a total length of about 250 km.
© Note Rima Galilaei, a sinous rille (180 km) at the western boundary of the Marius Hills (Rukl 28).

127 – Schickard & Lacus Excellentiae – 44.4 S 54.6 W	Check □
Origin: Impact and Volcanic **Size:** 227 km, 150 km **Rukl:** 62 **Type:** CC and Lacus	

Pre-Nectarian Era crater with subtle variations on its floor. Crater Schickard contains bright spots of high albedo and several secondary craters. Lacus Excellentiae, the "Lake of Excellence," lies near Schickard.

® Identify the enormous crater Schickard and look for several smaller, younger craters on its southwestern floor.
® Observe the less-well-defined Lacus Excellentiae located to the northeast of crater Schickard.
® Note the crater Clausius on the floor of Lacus Excellentiae.
® Near crater Schickard, observe the craters Drebbel, Lehmann, and Inghirami located farther to the west. (You may need to wait for the terminator.)
© To the northeast of Lacus Excellentiae, note the eroded crater Lee and the complex crater Vitello.

128 – Vieta & Fourier – 29.2 S 56.3 W	Check □

Origin: Impact **Size:** 87 km, 52 km **Rukl:** 51, 61 **Type:** CC

Notable craters near Mare Humorum, with four and two craters, respectively, on their floors.

® Identify the craters Vieta and Fourier located to the southwest of the prominent crater Mersenius.
© To the north, look for the crater Cavendish and the secondary craters Cavendish E, F, and A. To the northwest look for the craters named Henry and Henry Freres.

129 – Phocylides & Wargentin – 52.9 S 57.3 W **Check □**

Origin: Impact / Volcanic **Size:** 114 km, 84 km **Rukl:** 70 **Type:** CS/CC

Phocylides is a prominent crater, and crater Wargentin is a very interesting, unique flooded structure that is filled to its brim with lava.

® Look for two distinctly different craters near each other. Note the unique features of Wargentin.
® Observe the craters Nasmyth and Phocylides C that together make this a four-crater group.
© Farther east, look for the crater Noggerath surrounded by several secondary craters.

130 – Mons Rümker – 41.0 N 58.0 W **Check □**

Origin: Volcanic **Size:** 70 km, **Rukl:** 8 **Type:** Dome

Multiple volcanic domes. These require a favourable nearby placement of the terminator to obtain a good view.

® Observe Mons Rümker, a low-lying, unique mountain massif in Oceanus Procellarum.
© In central Mons Rümker, note the diamond-shaped depression that may be a collapsed volcanic caldera.

131 – Reiner Gamma & Galilaei – 8.0 N 59.0 W **Check □**

Origin: Unknown **Size:** N/A **Rukl:** 28 **Type:** Albedo and Crater

Unique and currently uncharacterized local "swirl" of lighter material on the floor of Oceanus Procellarum and an area with a stronger than usual magnetic field. The crater, named for the famous astronomer Galileo Galilei, is located to the southwest of Reiner Gamma.

® Observe Reiner Gamma, the site of a very strong localized magnetic field. This may be an area where the lunar surface is protected from cosmic ray bombardment (retaining a lighter colour).
® Observe the crater Galilaei (also spelled Galilei), named in honour of Galileo, who was the first person to use a telescope to look at the Moon and other celestial objects.
® Observe nearby Planitia Descensus, the Plain of Descent. This area was named in recognition of the first soft landing of a spacecraft (Luna 9) on the Moon.
® Farther north, identify the area of the landing site of Luna 8 and, to the west, the craters Cavalerius and Hevelius.
© Sketch Reiner Gamma, using the blank lunar drawing template provided on p. 49.

132 – Sirsalis & Rimae Sirsalis – 12.5 S 60.4 W **Check □**

Origin: Impact and Tectonic **Size:** 42 km **Rukl:** 39, 50 **Type:** Crater and Rill

Crater and system of rilles, the largest of which is clearly visible through a small telescope.

® Observe the duo of craters, Sirsalis and Sirsalis A, located in the southwestern highlands.
® Observe Rima Sirsalis and trace as much of it as possible.
© Note the secondary craters Sirsalis J, F, G, and H, and the lava-filled, dark crater Crüger (Rukl 50) which is a marker pointing the direction toward Mare Orientale, which is Libration Challenge Object # L10
© Observe Rimae Darwin at 20.0 S, 67.0 W (Rukl 50)

133 – Pythagoras, Harpalus, & Bouguer – 63.5 N 62.8 W **Check □**

Origin: Impact **Size:** 130 km, 39 km, 23 km **Rukl:** 2 **Type:** Craters

Prominent craters near the northwestern limb of the Moon.

® Note the effects of foreshortening near the lunar limb.
® Observe crater Harpalus, located in Mare Frigoris, and note Bouguer and Foucault, two nearby craters that form a triangle with crater Harpalus.
® For crater Bouguer note the classic example of an intermediate-sized crater, and compare it with the nearby small craters Bouguer A & B to the east.
® Observe the large, prominent crater Pythagoras near the edge of the Moon, and note its double central peaks. This area is easier to observe during favourable libration.
© Note the nearby craters J. Herschel and Babbage.
© In crater Pythagoras, try to resolve the dual nature of its central peak.

134 – Grimaldi – 5.2 S 68.6 W **Check □**

Origin: Impact and Volcanic **Size:** 222 km, **Rukl:** 39 **Type:** Basin

Large basin with flooded, dark floor that can be seen using binoculars whenever this area is in sunlight.

® Note this basin which forms the nose of the "rabbit jumping over the Moon" an interesting "image" that covers a wide expanse of the dark maria areas at, or near, the time of full Moon.
© Observe Rimae Grimaldi, a system of rilles 230 km in length, located in the highlands to the southeast of Grimaldi.

135 – Lacroix & Southwestern Limb Region – 33.2 S 72.0 W **Check □**

Origin: Impact **Size:** 38 km, **Rukl:** 61 **Type:** CS

Centred on crater Lacroix, this area is heavily modified by the Mare Orientale impact.

® Identify crater Lacroix, and look for the overlapping crater Lacroix J on its southwestern wall. In addition, note other unnamed secondary craters nearby.
® Note the degraded and in-filled nature of craters in this region.
© Identify Vallis Inghirami and Vallis Baade.

Part Three

Libration Challenge Features (Optional)

The following Libration Challenge Features are interesting objects to seek during favourable librations. Many of these features are visible only occasionally and for a relatively short period of time. The right combination of a strong libration or nodding of the Moon and favourable Sun angle is needed to view these features. Check the RASC's *Observer's Handbook* for times when libration is favourable in both longitude and latitude, during each lunation, along the lunar limb. The information can be found in the "Sky Month by Month" section under the title Moon on the left-hand pages. In addition, on the right-hand pages, the current libration is given for every second day of each month. The position and the size of each small dot, located near the diagram of each lunar phase, indicates the location and the amount of libration for that day. Reasonable interpolation can enable the observer to estimate libration for the intervening dates.

L1 – Mare Australe – The "Southern Sea" – 46.0 S 91.0 E	**Check □**
Origin: Impact and Volcanic **Size:** 900 km **Rukl:** 76, 69 **Type:** Basin - Mare	
An ancient impact basin badly degraded by cratering. © Observe this mare during favourable libration of the southeastern quadrant. Look for the dark-floored crater Oken near Mare Australe.	

L2 – Mare Marginis – The "Border Sea" – 12.0 N 88.0 E	**Check □**
Origin: Impact and Volcanic **Size:** 360 km **Rukl:** 38, 27 **Type:** Basin - Mare	
Interesting mare areas that lie on the eastern limb. © Note these mare areas and deformations of the lunar limb caused by their depressions.	

L3 – Mare Smythii – "Smyth's Sea" – 2.0 S 87.0 E	**Check □**
Origin: Impact and Volcanic **Size:** 360 km **Rukl:** 38, 49 **Type:** Basin - Mare	
Circular mare on the eastern limb, located south of Mare Marginis. © Note mare areas and topographic features of lunar limb; they are characterized by depressions.	

L4 – Hubble – 22.1 N 86.9 E	**Check □**
Origin: Impact **Size:** 81 km **Rukl:** 27 **Type:** Crater	
Lava-filled crater, located on the east-northeastern limb. © Observe this flooded crater, named after the noted American astronomer, Edwin Hubble.	

L5 – Gartner & Democritus – 59.1 N 34.6 E	**Check □**
Origin: Impact **Size:** 39 km, 102 km **Rukl:** 6, 5 **Type:** CC	
Remnants of two once-prominent craters. This area of the Moon is an interesting challenge to navigate. © Observe these two somewhat remote craters and the more challenging ones to the north – craters Cusanus, Arnold, and Petermann.	

L6 – Markov – 53.4 N 62.7 W	**Check □**
Origin: Impact **Size:** 40 km **Rukl:** 1 **Type:** CS	
A sharply-defined crater, located in a remote area of the Moon. © Identify crater Markov during favourable libration in the northwestern quadrant of the lunar disk. Also, observe the nearby crater Oenopides, and the more challenging remote craters Xenophanes and Volta.	

L7 – Seleucus – 21.0 N 66.6 W	**Check □**
Origin: Impact **Size:** 43 km **Rukl:** 17 **Type:** CC	
A lava-filled crater, located near the edge of Oceanus Procellarum. © Identify crater Seleucus and the nearby craters Briggs and Krafft. Identify the Luna 13 landing site and the craters Eddington, Struve, and Russell.	

L8 – Bailly – 66.8 S 69.4 W	**Check □**
Origin: Impact **Size:** 303 km **Rukl:** 71 **Type:** CC	
This is the largest crater visible on the near side of the Moon, and with some libration, its entire surface can be seen. © Observe crater Bailly, a spectacular, enormous crater that dwarfs all others on the near side of the Moon. © Identify as many secondary craters as you can on the floor of crater Bailly.	

L9 – Ulugh Beigh & Aston – 32.7 N 81.9 W	**Check □**
Origin: Impact **Size:** 54 km, 43 km **Rukl:** 8 **Type:** Craters	
Craters near the western edge of the Moon, just beyond the edge of Oceanus Procellarum. © Note the dark-floored crater Ulugh Beigh. © Note Aston, a small crater in the background of Ulugh Beigh.	

L10 – Mare Orientale – The "Eastern Sea" – 20.0 S 95.0 W	**Check □**
Origin: Impact and Volcanic **Size:** 640 km **Rukl:** 50, 39 **Type:** Basin - Mare	
Mare Orientale is the one of the youngest major impact basins on the Moon, and the visible effects of that gigantic impact are widespread on the extreme western areas of the Moon. See also Rűkl VII. © Note Montes Cordillera, which is the outermost ring of the multi-ring basin structure.	

Isabel Williamson Lunar Observing Certificate

Part Four

Observable Craters with Canadian Connections (Optional)

The following seven objects represent an entirely optional observing project, ranging from easy to near impossible. Their relation to existing objectives is indicated by [objective number]. In addition to these, there are four unobservable *far side* craters: Chant, Foster, McKeller, Petrie. The crater CAN7 Plaskett has a foot in both camps.

CAN1 – Avery – 1.4 S 81.4 E **Check □**

Size: 9 km **Rukl:** 49 & IV

Named for Oswald Avery (1877–1955), born in Halifax, NS. US physician and DNA researcher.

A bowl-shaped impact crater on the edge of Mare Smythii [L3], W of Haldane. Former name Gilbert U. Libration object

CAN2 – Banting – 26.6 N 16.4 E **Check □**

Size: 5 km **Rukl:** 23

Named for Sir Frederick Banting (1891–1941), born in Alliston, Ont. Doctor and Nobel laureate for co-discovery of insulin.

Isolated bowl-shaped impact crater in Mare Serenitatis [41] SE of Linné [57]. Former name Linné E.

CAN3 – Beals – 37.3 N 86.5 E **Check □**

Size: 48 km **Rukl:** 16 & III

Named for Carlyle Beals (1899–1979), born in Canso, NS. Former Dominion Astronomer, former President of the RASC (1951–52), and Officer of the Order of Canada. Namesake asteroid Beals 3314.

Impact crater E of Gauss and Geminus [8]. Former name Riemann A. Libration object.

CAN4 – Cook – 17.5 S 48.9 E **Check □**

Size: 47 km **Rukl:** 59

Named for British naval captain and explorer James Cook (1728–1779) who spent four winters (1758–1762) in Halifax, NS, preparing charts and sailing directions for eastern Canadian seaways, five years (1763–1767) carrying out the first accurate coastal survey of Newfoundland, and he established the location of the coast of British Columbia (in 1778).

Flooded crater in western Mare Fecunditatis [13] near Colombo.

CAN5 Daly – 5.7 N 59.6 E **Check □**

Size: 17 km **Rukl:** 38

Named for Reginald Daly (1871–1957), born in Napanee, Ont. Highly honoured Harvard professor of geology.

Impact crater NW of Apollonius. Former name Apollonius P.

CAN6 Newcomb – 29.9 N 43.8 E	Check □
Size: 39 km **Rukl:** 25	
Named for Simon Newcomb (1835–1909), born in Wallace, NS. Professor of Mathematics at US Naval Observatory and internationally renowned astronomer of his time. Namesake asteroid Newcombia 855. His popular astronomy writing inspired the RASC Simon Newcomb Award. Fresh impact crater already included as objective [19], between Cleomedes and Posidonius, NW of Mare Crisium.	

CAN7 Plaskett – 82.3 N 176.2 W	Check □
Size: 110 km **Rukl:** II	
Named for John Plaskett (1865–1941), born in Hickson, Ont. Former Director of the Dominion Astrophysical Observatory in Victoria, BC, and former President of the RASC (1914–15). Namesake asteroid Plaskett 2905. The RASC and the Canadian Astronomical Society jointly award the Plaskett Medal every two years to the best doctoral thesis in astronomy or astrophysics. Large, fresh impact crater technically on the far side of the Moon, beyond Goldschmidt [76]. Extremely difficult if not impossible to view: both maximum libration of the north limb combined with favourable illumination would be required. Suggested as location for a lunar base.	

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Part Five

Lunar 1000 Challenge (Optional)

For observers who have completed the Isabel Williamson Lunar Observing List, we suggest the following interesting project: to determine the number of **named** features on the Moon you can identify. A total of 1000 is achievable, and in the process, a thorough knowledge of the lunar surface would be attained. One such list is available online at

www.rasc.ca/sites/default/files/Lunar1000Challenge.pdf

The RASC Observing Committee will recognize those who have identified and recorded 1000 or more named (not lettered) features on the Moon by issuing an official letter of recognition.

Clear Skies,

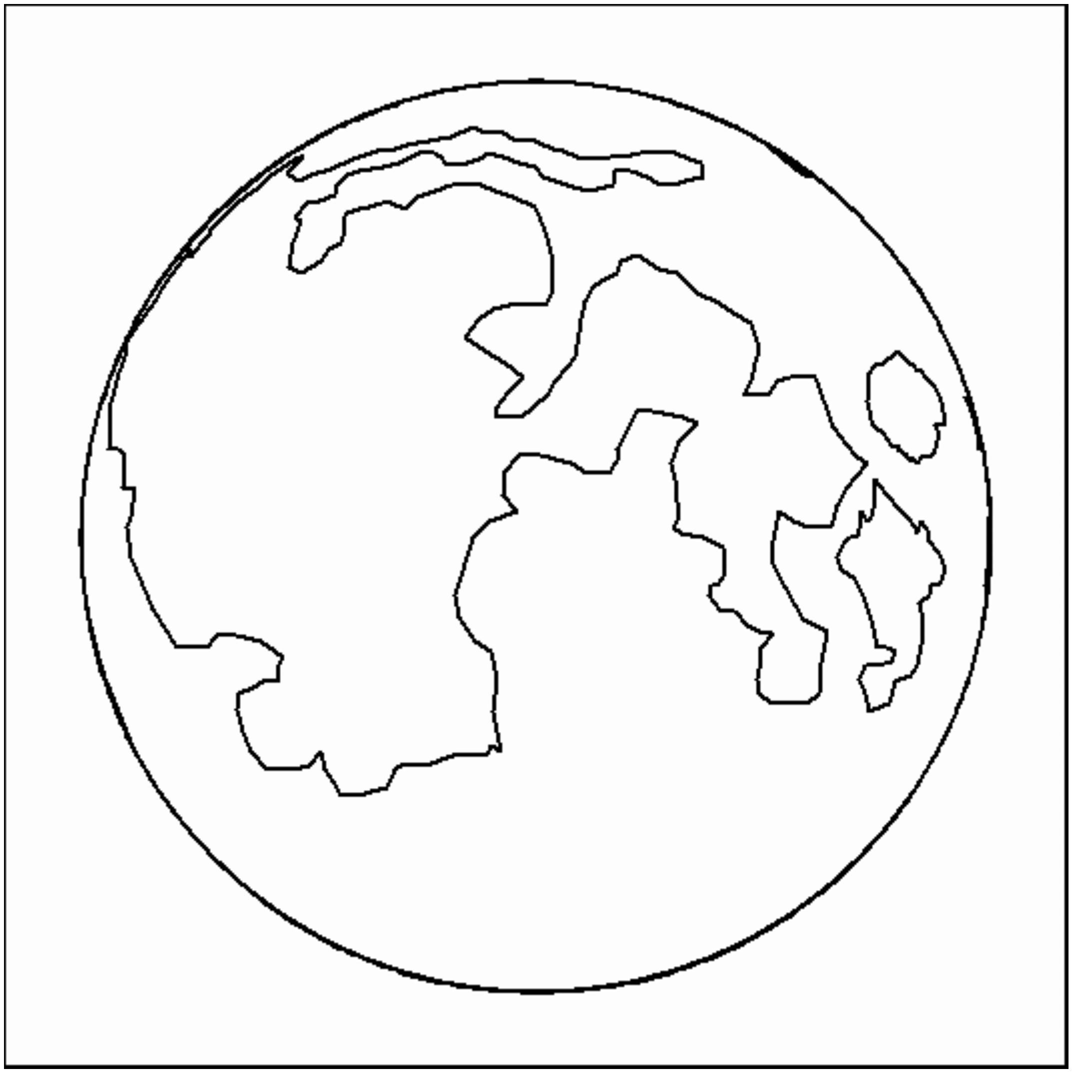
RASC Observing Committee

W.H. Pickering Unaided Eye Scale

This challenge activity will test the sharpness of your vision and help you gain a better understanding of pre-telescopic observations of the Moon. The following list, originally proposed by W.H. Pickering, presents, in order of probable difficulty, twelve lunar features you may be able to observe **without** any optical aid.

1. Bright surroundings of crater Copernicus
2. Mare Nectaris
3. Mare Humorum
4. Bright surroundings of crater Kepler
5. Region of crater Gassendi
6. Region of crater Plinius
7. Mare Vaporum
8. Crater Lubiniezky Region
9. Sinus Medii
10. Faint shading near crater Sacrobosco
11. Dark spot at foot of the Montes Apennines
12. Montes Riphaeus

Ray System Extent



Instructions for this optional challenge activity:

Using a pencil, and using this line drawing as a base map, shade in your observations of the major ray systems on the Moon. Observe within a day or two of full Moon using tripod-mounted binoculars, or a telescope at low power,

Unaided Eye Libration Challenge

Date: ________________

Time: ________________

Notes: ________________

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Date: ________________

Time: ________________

Notes: ________________

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Date: ________________

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Date: ________________

Time: ________________

Notes: ________________

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Lunar Drawing Template

Feature: ______________________________

Instrument: ___________________

Magnification: _________________

Date: __________________

Time: __________________

Notes: ____

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Observation Recording Form

Feature / Objective	Date	Time

Objective Index for Isabel Williamson Lunar Observing Program

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