

FOREWORD

The work before you is an important contribution to Islam's body of knowledge. It attempts to answer, quite exhaustively I might add, some of the main arguments against the Fiqh Council of North America's decision to determine holy days through computation rather than naked-eye sighting. This is a particularly onerous task, not simply because it breaks with scholarly tradition, but because tradition, being remarkably familiar with both computation's method and logic, was able to vigorously argue against it centuries ago. In those arguments, an example of which appears in the fatawa of Ibn Taymiyyah, scholars go only so far as to admit that lunar phases can indeed be computed accurately. They all hasten to add, however, that the same is not true of predicting physical sightings, which for them was the only criterion for establishing Islamic dates. As will be shown in the chapters ahead, some very notable scholars, among them Ibn Qutaybah, Ibn Surayj, and Taj al-Din al-Subki, were advocates of computation in one form or another. But for them calculations were no more than a corroboration of a naked-eye sighting, and not an independent alternative to it. The arguments that follow therefore differ in that they are meant to show the juridical validity of the computational method as well as the practical and social benefits it offers.

This brings me to computation's other benefit, that of reducing the uncertainties of religious life in the West, particularly with regard to the holy days. For Muslims in the past as well as for the large majority today that still lives as a majority, waiting for news of the moon is part of the festivities of these holy days, and not seeing it means no more than the first fast being delayed one day. But this is not problematic because it affects the nation as a whole. The social disruptions that occur as a result affect everyone equally, in the work force, at school, and on travel. The same is not true of Muslims who live in the West. In addition to all of the foregoing inconveniences they shoulder waiting for "news of the moon," there is also the added embarrassment of explaining to friends and colleagues one additional oddity of their faith. This shift to computation as the method of determining the holy days of Islam will definitely be welcomed by such people.

Two further contributions are more academic than social and apply, as such, to enhancing the overall literacy of Muslims today. The first of these is in its comprehensive citation of the classical sources; the second is in its accurate and pithy analysis of the major scholarly arguments vis-à-vis computation. The author has done readers a great service by digging deep into the Qur'an as well as the prophetic traditions to quote verbatim the relevant evidence and to then translate such evidence into English. This is a tedious task but one that is quite necessary, I might add, if only because it helps reassure the reader that no shred of relevant textual evidence has been overlooked. Any scholar or lay person wanting to know what the Qur'an and the Traditions say on moon-sighting will find easy access to both the Arabic texts as well as their translations.

As for the arguments of Muslim scholarship, these give readers unfamiliar with Muslim scholarship a meaningful glimpse into the method and rationale of the traditional scholar. It introduces them to the building blocks of Islamic law, to juridical consensus (ijma'), for instance, its multiple iterations within scholarly circles, and its various usages in this and other discussions in the past. It includes discussions on the etymological and syntactical aspects of language, the use of words in their literal and allegorical senses, and the differences between exclamatory and declarative statements. Such discussions serve not only to educate Muslims as to the complexities of the interpretative process, but also to caution them against hastily drawing legal conclusions without the requisite training and skill.

This current discussion on computation, which touches almost all Muslims to some degree, has succeeded in sucking in opinions even from those who are otherwise disinclined to speak their minds. This is particularly true in the West, where Muslims are generally more independently minded and better educated but lacking in political authority. Those who do weigh in go all the way – from theologians perturbed by this latest sacrifice of tradition at the altar of modernity to lay Muslims who would much rather abandon that tradition than spend another sleepless night awaiting lunar confirmation.

On the other hand, for those in Karachi, Istanbul, and Damascus who live their religious lives as a majority, them such discussions are either academic and arcane, or superfluous and inconsequential to their daily grinds. In such countries it is the state, with or without the concurrence of the scholars, that determines the beginning and the end of Ramadan. Even in case where scholarship enjoys limited autonomy, or where multiple legal opinions on moon sighting are tolerated, official government announce-

ments that endorse one opinion over all others helps remove the cloud of uncertainty found in the West.

Scholars worry however, that this effort toward greater unity through computation is, if anything, making that effort itself all the more elusive. Abandoning tradition in determining the beginning and end of Ramadan, they argue, means breaking with the juridical consensus of posterity and with the sacred teachings of the Prophet. But such breaks are far from unique, I would argue; if anything, they occurred so frequently in the past that they became a defining feature of our juridical legacy. In early times, for instance, scholars differed in their interpretation and application of the *ṣūmū* (fast sighting the moon) hadith. One group, following a rule that came to be known as *ikhtilāf al-maṭāli'* (diversity of the horizons) restricted sightings to people of that specific vicinity, while another extended any single sighting to parts of the world. Today that same regional difference has undergone a further adjustment in accordance with the political changes Muslim countries have undergone since colonialism. Sightings today follow fault lines that are almost exclusively political; as such it does not matter that parts of Saudi Arabia and Yemen share the same longitudinal space and ought to be treated, scientifically speaking, as a single geographical unit. But political borders established during colonial times by the British, for example, the French, or the Dutch are what act as *de jure* cut off points beyond which sightings will not apply. There is no scriptural evidence to support such rulings, and yet even the most conservative scholars seems to find nothing untoward about this interpretation of the *sumu* hadith!

And it does not end there: rulings on moon sighting today are as unprecedented and innovative as the times in which we live. Take the 'Id after hajj ruling, for instance: never in the history of Islamic law has any scholar even remotely suggested that 'Id al-Adha' be performed on the day after 'Arafah in Arabia. And yet a sizeable group of prominent scholars is doing just that by advocating that Muslims celebrate it in accordance with the hajj ceremonies in Makkah. The ruling itself, in my opinion, is a step in the right direction – not because it tracks perfectly with some moment in our early history, but because it more adequately addresses the challenges we as a community now face in this global village. It helps unite Muslims around their high holy days at a time when the community is more diverse and widely distributed than ever.

This attempt at unity, most scholars would agree, is as much a religious responsibility as is the fulfillment of the ritual obligations themselves. All

the core rituals of Islam, in fact, serve as much as symbols of each person's quest for proximity to his or her fellow human being than they do as symbols of each person's quest for proximity to God. This is why the daily prayer is almost always more meritorious when performed in congregation, why Friday congregational prayers cannot but be performed in congregation, why such prayers must be performed facing Makkah, and why they must conform (more or less) to the same physical movements.

With all of this emphasis on the symbolic value of unity, one finds inexplicable the tendency in scholarly circles to reduce unity to no more than a supererogatory ideal to be pursued only if particular rules and regulations remain inviolate. This, then, is the challenge legal scholarship faces: how best to interpret the law's secondary elements such that they do not hamper the pursuit of Islam's greater objectives?

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PREFACE

THE REGULARITY AND PERMISSIBILITY OF USING THE CALCULATION METHOD IN DETERMINING THE CRESCENT IN ACCORDANCE WITH THE HIGHER OBJECTIVES OF THE SHARI'AH

(هُوَ الَّذِي جَعَلَ الشَّمْسُ ضِيَاءً وَالْقَمَرَ نُورًا وَقَدَرَهُ مَنَازِلَ لِتَعْلَمُوا عَدَدَ السِّنِّينَ وَالْحِسَابَ مَا خَلَقَ اللَّهُ ذَلِكَ إِلَّا بِالْحَقِّ يُفَصِّلُ الْآيَاتِ لِقَوْمٍ يَعْلَمُونَ.) (يونس: 5)

It is He who made the sun a shining radiance and the moon a light and measured out phases for it so that you might know the number of years and calculate time. Allah did not create all this without a true purpose. He explains His signs for those who understand. (10:5)

(الشَّمْسُ وَالْقَمَرُ بِحُسْبَانٍ.) (الرحمن: 5)

The sun and the moon follow courses (exactly) computed. (55:5)

Allah created the sun and moon, both of which move according to precise and predefined patterns. Knowledge of these patterns help people calculate time, days, and years. This pattern is not only for Ramadan, but also for all time periods throughout the year. Allah tells us that we should pray our daily salah and begin and end our fasts based on the sun's movement.

(أَقِمِ الصَّلَاةَ لِذُلُوكِ الشَّمْسِ إِلَى غَسَقِ اللَّيْلِ وَقُرْآنَ الْفَجْرِ إِنَّ قُرْآنَ الْفَجْرِ كَانَ مَشْهُودًا.) (الإسراء: 78)

Perform regular prayers in the period from the time the sun is past its zenith till the darkness of the night, and recite (the Qur'an) at dawn – dawn recitation is always witnessed. (17:78)

(...وَكُلُوا وَاشْرَبُوا حَتَّى يَتَبَيَّنَ لَكُمُ الْخَيْطُ الْأَبْيَضُ مِنَ الْخَيْطِ الْأَسْوَدِ مِنَ الْفَجْرِ ثُمَّ أَتُمُوا الصِّيَامَ إِلَى اللَّيْلِ....) (البقرة: 187)

...and eat and drink, until the white thread of dawn appear to you distinct from its black thread; then complete your fast till the night appears.... (2:187)

Allah also told us that the crescent moons (of various months) are for people to observe time, especially the time of hajj:

(يَسْأَلُونَكَ عَنِ الْأَهْلِ قُلْ هِيَ مَوَاقِيتُ لِلنَّاسِ وَالْحَجِّ.) (البقرة: 189)

They ask thee concerning the new moons. Say: They are but signs to mark fixed periods of time in (the affairs of) men, and for Pilgrimage. (2:189)

The Prophet (ṢAAS)* explained how to observe the sun's movement to establish the times of the salah and the beginning and end of the daily fasts and of Ramadan. For centuries, Muslims observed the sun's movement with their naked eyes every day for their five daily prayers. When clocks were invented, they started to calculate its movement. They established the timings of the salah and developed perpetual salah timetables for the whole year. Now, instead of physically watching its movement, Muslims follow a timetable based on its calculated movements.

Timetables sometimes differ on the basis of the fiqh of prayer times. Some Muslims have determined that *ḥajr* should start when the sun is 18° below the horizon; others have determined that it should start when the sun is 15° below the horizon. Some calculate *maghrib* as beginning when the sun sets on the horizon; others calculate it as beginning when the red twilight disappears. There are similar differences with regard to the beginning and end of periods of fasting. However, Muslims have accepted the calculation of salah times and the preparation of salah timetables for the convenience of people.

Similar to this is using the crescent moon for determining the Islamic dates. The Prophet told us that we should see the crescent to begin and end the month of Ramadan:

سَمِعْتُ أَبَا هُرَيْرَةَ رَضِيَ اللَّهُ عَنْهُ يَقُولُ قَالَ النَّبِيُّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ أَوْ قَالَ قَالَ أَبُو الْقَاسِمِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ صُومُوا لِلرُّؤْيِيِّ وَأَفْطِرُوا لِلرُّؤْيِيِّ فَإِنْ غُبِّي عَلَيْكُمْ فَأَكْمِلُوا عِدَّةَ شَعْبَانَ ثَلَاثِينَ.¹

Fast with sighting it [moon] and break the fast with sighting it. Complete thirty days of Shaḥban if it is cloudy.

He also said:

عَنْ نَافِعٍ عَنِ عَبْدِ اللَّهِ بْنِ عُمَرَ رَضِيَ اللَّهُ عَنْهُمَا أَنَّ رَسُولَ اللَّهِ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ ذَكَرَ رَمَضَانَ فَقَالَ لَا تَصُومُوا حَتَّى تَرَوْا الْهَيْلَالَ وَلَا تُفْطِرُوا حَتَّى تَرَوْهُ فَإِنْ غُمَّ عَلَيْكُمْ فَأَقْمِرُوا لَهُ.²

* ṢAAS: Many Muslims say *ṣallā Allāh ‘alayhi wa sallam* (may the peace and blessings of Allah be upon him) after mentioning the Prophet.

Do not fast until you see the crescent and do not break the fast until you see it. Estimate about it in case it is cloudy.

The goal was that everyone should begin and end Ramadan with full confidence that the month has begun and that Muslims should be united in observing their fasts and celebrating their ‘Id. Why did the Prophet emphasize the observance of the *hilāl*? He answered that in another authentic hadith:

حَدَّثَنَا سَعِيدُ بْنُ عَمْرٍو أَنَّهُ سَمِعَ ابْنَ عُمَرَ رَضِيَ اللَّهُ عَنْهُمَا عَنِ النَّبِيِّ صَلَّى اللَّهُ عَلَيْهِ وَسَلَّمَ أَنَّهُ قَالَ
إِنَّا أُمَّةٌ أُمِّيَّةٌ لَا نَكْتُبُ وَلَا نَحْسِبُ الشَّهْرَ هَكَذَا وَهَكَذَا يَعْنِي مَرَّةً تِسْعَةً وَعِشْرِينَ وَمَرَّةً ثَلَاثِينَ.³

We are an unlettered people; we do not know how to write and how to calculate. The month is thus and thus, meaning either twenty-nine days or thirty days.

The Prophet was fully aware of his people’s condition when he gave them these instructions. He did not impose a burden upon them beyond their capacity, because he wanted them to begin and end their fast and enjoy their ‘Id with ease and convenience.

In general, Muslims continued to sight the crescent to determine the month of Ramadan and celebrate their ‘Ids. We also have on record the statements of some early scholars and jurists who, after learning the science of astronomy, indicated that calculating the crescent can be used for Ramadan. Imam Taqi al-Din al-Subki, a great Shafi‘i jurist, even said that calculations were more reliable than naked-eye sighting.

After Muslims acquired a more advanced knowledge of the astronomical sciences, more voices were raised to rely on calculating the crescent instead of physical sighting. Most jurists did not accept calculations due to their uncertainty of whether they were correct or could be trusted. With the further development of the astronomical sciences in the last one hundred years, more and more voices are being raised by jurists in support of calculations. The famous *muḥaddith* Shaykh Ahmad Muhammad Shakir wrote a long article emphasizing that calculation is both permissible and is the most appropriate method of determining the lunar months.

The objective of the Shari‘ah is that Muslims begin and end the month of Ramadan with assurance and be united in their observance of these blessed times. The objective does not seem to engage Muslims in moon sightings or to remain uncertain about the times of *‘ibādah* until the last minute. The astronomical sciences are highly advanced today, and more reliable methods are available to determine the beginning of the lunar

months. On the basis of the principles of the Shari‘ah, just as timetables for salah and *ṣiyām* are prepared, it is possible to prepare calendars for the lunar months and the beginning and end of Ramadan. This knowledge is now easily available and can be used.

It is ironic that instead of taking advantage of this knowledge and making things easy, the *hilāl* issue has become a very controversial and divisive matter. In Muslim countries, official bodies make the decision. Some people differ, but they have no choice except to follow the official decision. In countries where Muslim minorities live, there is more division. In Western Europe and North America, moon sighting has become far more divisive.

We thank Dr. Zulfiqar Ali Shah, the Executive Director of the Fiqh Council of North America, who has collected the basic evidence from the Qur’an and the Sunnah, as well as the linguistic usages and juristic discussions on this subject. He has given us the arguments of both sides: those who emphasize physical sighting and those who allow calculation. It is clear that our Shari‘ah is flexible in this matter, and we are allowed to adopt a method that meets the rules’ objectives and makes things easy for Muslims.

عن أبي هريرة عن النبي صلى الله عليه وسلم قال: إن الدين يسر ولن يشاد الدين أحد إلا غلبه فسددوا وقاربوا وأبشروا واستعينوا بالغدوة والروحة وشيء من الدلجة.⁴

The Prophet said: “Religion is easy and whoever overburdens himself in his religion will not be able to continue in that way. So you should be straight, facilitate understanding and receive the good tidings that you will be rewarded; and gain strength by worshipping in the mornings, the evening and part of the night.”

We pray to Allah to keep us on the right path and help us to keep our minds open for ideas that are consistent with new knowledge without contradicting the basic principles of our *dīn*.

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INTRODUCTION

The debate about naked-eye moonsighting versus calculation goes back to the first century of the Islamic era. In fact, this debate had taken multiple twists and turns among Jewish scholars centuries before its systematic deliberation by Muslim scholars. Given its long history, many of the arguments on both sides have almost become standardized. The nature of this debate and scholarly reasoning among Muslims are a little different from that of the Jews, for the former have two divinely inspired sources of law that are historically authenticated. The Islamic discourse has predominantly revolved around various Qur'anic verses and the Sunnah. As classical Islamic jurisprudential discourse is heavily dependent upon these two sources, most of the traditional arguments reoccur in the books of *tafsīr*, hadiths, fiqh, and fatwas.

The main arguments against using calculations in determining the beginning or end of Ramadan can be summarized as follows¹:

- 1: The Qur'an requires naked-eye sighting of the moon to confirm the beginning and end of Ramadan, Dhu al-Hijjah, and other devotional months. The act of "witnessing the month of Ramadan" stated in the Qur'an means actually sighting the new moon of Ramadan with one's eyes. The Qur'anic term for the crescent moon is *al-hilāl*, which, they argue, literally means "the sighted moon."
- 2: The prophetic traditions, which reach to the level of infallibility, also require naked-eye sighting in these cases. The prophetic injunctions approve only two definitive methods: naked-eye sighting and completing thirty days.
- 3: Over the centuries, Islamic scholarship has accepted these two methods as the norm, and thus jurists have rejected all efforts to use mathematically computed astronomical calculations* and opposed those who did so, either in part or in total. Some of these scholars, among them Ibn al-Shikhir, Ibn Surayj, and al-Subki, were otherwise highly

* Throughout this book, I use "calculations" with the understanding that they are "mathematically computed astronomical calculations."

respected and appreciated for their knowledge and piety. Rejecting calculations has been an established norm in all Sunni and Shi'i jurisprudential schools of thought.

- 4: The majority of jurists has not advocated for accepting the use of calculations. But a small minority has, based upon some misguided or weak interpretations. Even this minority opinion, however, does not permit bypassing naked-eye sighting altogether, for calculations can be used if the moon is obscured by clouds.
- 5: Naked-eye sighting has been the universal prophetic practice. The Jews were required to follow this method in determining their lunar months, and history has shown that they adhered to it. Over time, however, they changed this practice in an effort to synchronize their religious festivals and schedules with the solar civil calendars of the secular authorities (e.g., emperors). Devising a calculated calendar for Islamic months, therefore, would be nothing short of following the Jews into misguidance and error.
- 6: Some contemporary scholars contend that the pre-Islamic Arabs as well as first-generation Muslims were quite capable of employing calculations to determine the lunar months. But the Muslims rejected this method because the Sunnah prohibited it. Astronomy only reached its climax among Muslim scholars, owing to their special interest in monitoring the movements of the sun, moon, planets, and other celestial bodies. Some jurists, among them Shihab al-Din al-Qarrafi and Ibn al-ʿArabi, were also qualified astronomers who could establish precise calendars for lunation, recognize conjunctions, and predict the possible appearance of the new moon. In spite of that, however, they did not use calculations to determine the beginning and end of Ramadan and other Islamic months. As observational astronomy has not developed much over the past centuries, the Fiqh Council's current dependence upon scientifically proven calculations to fix an Islamic calendar is not progress, but sheer backwardness.²

I would like to state from the outset that all of these arguments do not stand up to a detailed analysis. The Qur'an never required naked-eye sighting of the moon, but asked Muslims to "witness the month." Scholars agree that the Qur'anic phrase "whoever witnessed the month" means whoever is present in his/her place of residence and comes to learn of

Ramadan's arrival in any way, including (but not confined to) sighting. In reality, the prophetic reports require "certainty" vis-à-vis Ramadan's arrival and end. Physical sighting of the new moon was prescribed as a *means of achieving* that certainty, not the *objective* of fasting. The Qur'anic word *al-ahillah* is the plural of *al-hilāl*, which denotes "the beginning part of something like rain, an announcement, a cry of joy, calling out in a loud voice." *Al-hilāl* has been used both culturally and metaphorically to symbolize the new moon of the first two to seven nights and then the last two nights of the month.

In addition, there are conflicting reports about the Prophet's actual response upon looking at the new moon for the first time. One hadith states that he used to turn his face away from it and seek Allah's protection from its evils. The other popular report indicates that he would recite specific supplications upon sighting it. Al-Bukhari, Muslim, and other hadith authorities never reported any of these supplications; Ibn Dawud stated that both the above-mentioned purported prophetic reports were untrustworthy. The assertion that completing thirty days in the case of obscurities (*ikmāl*) is the only permitted alternative (second to actual sighting) is also debatable.

There is no *ijma'* (scholarly consensus) that using calculations to determine Ramadan is prohibited (*ḥarām*), especially if there are obscurities. Jurisprudential literature contains several assertions of such an *ijma'*; however, no such thing exists in reality. This debate has been going on since the time of the Successors. The majority of classical jurists opposed the use of calculations for several reasons. There is a long list of possibly valid reasons as to why the classical juristic discourse has been so strongly opposed to this method, especially in matters of faith (*imān*) and worship (*'ibādah*). In the past, scholars like Mutarrif ibn 'Abd Allah ibn al-Shikhīr, Ibn Surayj, Ibn Qutaybah, Taqī al-Dīn al-Subkī, and others actually deployed calculations to confirm or negate Ramadan if there were atmospheric obscurities. Many of their colleagues and later classical jurists rebuked them for doing so, as will be discussed later in this book.

The use of such calculations in religious matters has been dubbed a Jewish innovation, for the fixed Jewish calendar is an intercalated calendar. The rabbis did their best to synchronize their lunar calendar with the solar calendar in order to celebrate religious festivals during specific seasons and to harmonize their holidays with the civil holidays. The pre-Qur'anic Arabs also used to add extra days and an extra thirteenth month in their lunar cal-

endar almost every three years so that hajj would fall during those seasons that were good for travel and business. Thus the sacred period was compromised and hajj was performed at the wrong time. The Prophet insisted upon restoring the calendar and stipulated that each of the new months would start only after the actual sighting of the crescent moon.

Ismail K. Poonawala, author of “Ramadan” in Encarta, explains

In the pre-Islamic Arabic calendar, the month of Ramadan fell during the heat of summer. The word Ramadan means “scorcher” in Arabic. The early Arabic calendar, like the current Islamic calendar, was lunar. Because a lunar month has only 29 or 30 days, a year of 12 lunar months falls short of the 365 days in a solar calendar. In the pre-Islamic calendar, the lunar months kept their place in the seasons by the insertion of an extra month every two or three years. The Islamic calendar abolished this practice and fixed the Islamic year at 12 months totaling 354 days. As a result Ramadan occurs about 11 days earlier each year, and it rotates through the seasons in a cycle totaling about 33 years.³

Therefore, developing and then using precise calculations to determine the new moon’s appearance, as well as to confirm or negate the actual new moon of the Islamic lunar months, would not subject the Muslims to imitating the Jews in religious matters. This does not change the sacred period of the established lunar months, but rather helps us determine them with precision and certainty.

Finally, astronomy has made great advances over the centuries. Ancient Babylonian and Greek astronomical practices were based upon an incorrect understanding of the solar system, and Ptolemaic astronomical principles, which had predominated since the second century AC, were also flawed:

The Ptolemaic theory held that Earth is stationary and at the center of the universe; closest to Earth is the moon, and beyond it, extending outward, are Mercury, Venus, and the sun in a straight line, followed successively by Mars, Jupiter, Saturn, and the so-called fixed stars.⁴

The Muslims were keen observers; a few of them were even proficient astronomers. While they tried to fix many faulty aspects of Ptolemaic astronomy, they did not fully succeed because the Ptolemaic geocentric theory of the universe was based upon an error. According to Fred L. Whipple and Vera C. Rubin:

After the decline of classical Greek culture Arabian astronomers attempted to perfect the system by adding new epicycles to explain unpredicted variations in the motions and positions of the planets. These efforts failed, however, to resolve the many inconsistencies in the Ptolemaic system, which was finally superseded in the 16th century by the Copernican system.⁵

The systematic explanation that the universe is solocentric, as opposed to geocentric, is credited to Nicolaus Copernicus, who, in 1543, explained the movement of the planets around the sun:

The Copernican system advanced the theories that the earth and the planets are all revolving in orbits around the sun, and that the earth is spinning on its north–south axis from west to east at the rate of one rotation per day. These two hypotheses superseded the Ptolemaic system, which had been the basis of astronomical theory until that time. Publication of the Copernican system stimulated the study of astronomy and mathematics and laid the basis for the discoveries of the German astronomer Johannes Kepler and the British astronomer Sir Isaac Newton.⁶

Medieval Islamic civilization witnessed a flourishing of scientific development and progress in many fields, including astronomy. But the Muslims' astronomical discoveries were hampered by several innate mistakes in the foundational principles of Ptolemaic theory. Medieval scientists also lacked most of our modern instruments (e.g., high-level telescopes), well-equipped laboratories, NASA's expeditions to the moon, and many other discoveries that have helped astronomy branch out into gamma-ray astronomy (e.g., X-ray, ultraviolet, infrared, radio, and radar astronomy). Countless projects have focused entirely upon the earth–moon relationship and the moon's movement in its orbit around the earth. For instance, since 1957 the IGY (International Geophysical Year) project has used powerful Markowitz cameras, located at over twenty observatories worldwide, to study and then calculate the moon's movements and positions.⁷