The Historical and Cosmographical Context of *Hayʾat al-arḍ* with a Focus on Quṭb al-Dīn Shīrāzī's *Nihāyat al-Idrāk*

by

Fateme Savadi

Institute of Islamic Studies

McGill University, Montreal

December 2018

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctoral of Philosophy

To my parents

عجب علمیست علم هیئت عشق

که چرخ هشتمش هفتم زمین است

What a knowledge is the ***hay*ʾ*a*** of love!
For which the eighth orb is like the seventh earth.

Ḥāfiẓ

CONTENTS

ABSTRACT

Works belonging to a specific astronomical genre of the pre-modern Islamic world called *hayʾa* often include a section called *hayʾat al-arḍ*. This section discusses the physical and geographical characteristics of the Earth as a physical, spherical body located at the center of the world in a stationary state, along with a discussion of the astronomical phenomena associated with this body. Even though it originally emerged and evolved within the context of the *hayʾa* tradition of theoretical astronomy, *hayʾat al-arḍ* sections contain various physical and geographical discussions. This thesis is aimed at defining *hayʾat al-arḍ* as a distinct genre of scientific geography and at showing how the development of this genre is central to any study of the evolution of not only the *hayʾa* tradition, but also the geographical and cosmographical traditions of the pre-modern Islamic world. Part I of the thesis contains four introductory chapters discussing different aspects of the *hayʾat al-arḍ* genre. Chapter 1 presents a review of the current literature and state of research. Chapter 2 provides a brief history of the formative period of the *hayʿa* and geography traditions in the 2nd–4th/7th–10th centuries in order to shed light on exchanges between these traditions. As a concrete case study, the *hayʾat al-arḍ* section of Quṭb al-Dīn Shīrāzī's (d. 1311) *Nihāyat al-idrāk fī dirāyat al-aflāk* has been edited and translated into English. Hence, chapter 3 presents a study of Shīrāzī's life and his *hayʾa* works. Finally, in chapter 4, the contents of *hayʾat al-arḍ* are discussed and analyzed with a focus on the *Nihāya*, the evolution of *hayʾat al-arḍ*, its sources, and its influence on similar Latin traditions and genres. The critical edition of the *hayʾat al-arḍ* section, that is, Book III of the *Nihāya*, constitutes Part II of the thesis, after an introduction describing the manuscripts and editorial procedures. Part III of the thesis presents an English translation of Book III of the *Nihāya*.

RÉSUMÉ

Les œuvres appartenant à un genre astronomique spécifique du monde islamique prémoderne appelé comprennent souvent une section appelée *hayʾat al-arḍ*. Cette section traite des caractéristiques physiques et géographiques de la Terre en tant que corps physique sphérique situé au centre du monde à l'état stationnaire, ainsi que des phénomènes astronomiques associés à ce corps. Bien qu'elle ait émergé et évolué à l'origine dans le contexte de la tradition *hayʾa* de l'astronomie théorique, les sections *hayʾat al-arḍ* contiennent diverses discussions physiques et géographiques. Cette thèse vise à définir le genre de l'*hayʾat al-arḍ* comme genre distinct de la géographie scientifique et à montrer comment le développement de ce genre est au cœur de toute étude de l'évolution de la tradition, non seulement, de la tradition de l'*hayʾa*, mais aussi des traditions géographiques et cosmographiques du monde islamique prémoderne. La partie I de la thèse contient quatre chapitres d'introduction traitant de différents aspects du genre de l'*hayʾat al-arḍ*. Le chapitre 1 présente une revue de la littérature actuelle et de l'état de la recherche. Le chapitre 2 présente un bref historique de la période de formation des traditions du *hayʿa* et de la géographie aux II^{e}–IV^{e}/VII^{e}–X^{e} siècles afin de mettre en lumière les échanges entre ces traditions. Comme étude de cas concret, la section *hayʾat al-arḍ* de Quṭb al-Dīn Shīrāzī (mort en 1311), *Nihāyat al-idrāk fī dirāyat al-aflak*, a été éditée et traduite en anglais. Ainsi, le chapitre 3 présente une étude de la vie de Shīrāzī et de ses œuvres de *hayʾa*. Enfin, au chapitre 4, le contenu de l'*hayʾat al-arḍ* est discuté en mettant l'accent sur le *Nihāya*, et l'évolution de l'*hayʾat al-arḍ*, ses sources et son influence sur des genres latins similaires sont analysés. L'édition critique de la section *hayʾat al-arḍ*, c'est-à-dire le livre III du *Nihāya*, constitue la partie II de la thèse, après une introduction décrivant les manuscrits et la procédure éditoriale. La partie III de la thèse présente une traduction anglaise du livre III du *Nihāya*.

ACKNOWLEDGMENTS

My first debt of gratitude is to my advisor, Professor F. Jamil Ragep, whose insight, direction, and rigor shaped every aspect of my dissertation and each step of my degree. I am also grateful to Professors Robert Wisnovsky and Rula Jurdi Abisaab for their guidance and for all that I learned from them. I am indebted to Professors Martin Grant, France Bouthillier, and Khaled Medani who graciously maneuvered the administrative process to help me bring this dissertation to fruition.

A word of sincere thanks is owed to Anne Farray, Adina Sigartau, and Zeitun Manjothi of the Institute of Islamic Studies at McGill University for all their support and kindness.

Professors Hadi Alemzadeh, Hossein Masoumi Hamedani, and Mohammad Bagheri, served as my mentors and encouraged me to continue my studies in the history of science, for which I am forever grateful. To Dr. Sally Ragep, thank you for your affection, warmth, and wisdom; to Hasan Umut and Mahmoud Shahidy, thank you for your support and collegiality.

I am grateful beyond words to Osama Eshera who has always been ready to help me with the editorial work.

My love and appreciation to Sajjad Nikfahm-Khubravan, my husband, friend and companion in life, whose brilliance shines through in all of my work; and to Saba Nikfahm-Khubravan, my seven-year old artist, whose loving handicrafts instantly extinguished the difficulties of this journey.

This dissertation is dedicated to my parents, Mohammad-Ali Savadi and the late Nasrin Sanaʾi, in whose unmitigated love and wholehearted support I have been always enfolded. Words cannot convey my indebtedness to them.

Part I

Hayʾat al-arḍ: a Distinct Genre

1.1 Introduction

Various traditions of theorizing about the shape of the Earth and its relation to the cosmos can be traced from classical Greek to the medieval Islamic era in different disciplines such as physics, astronomy, cartography, and meteorology. Generally speaking, ancient and medieval geographical traditions cover a number of fields that can be classified along two major lines: scientific and descriptive. *Hayʾat al-arḍ* (configuration of the Earth) emerged and evolved as a scientific geographical genre within a specific tradition of theoretical astronomy of the pre-modern Islamic world, called *hayʾa*. *Hayʾa* works aimed at presenting the main results of Ptolemy's *Almagest*, without the proofs and within a cosmographical framework, and reconciling them with Aristotelian physics in keeping with Ptolemy's *Planetary Hypothesis* wherein he treats orbs as *physical* bodies, not merely circles. *Hayʾa* works often included a major section called *hayʾat al-arḍ* that provided a general description of the spherical surface of the Earth, the placement of land and water on the Earth, the characteristics of different localities, and geodesy. Such works also included discussions of astronomical phenomena, methods, and data that vary with the change of localities and horizons due to the sphericity of the surface of the Earth. To be more specific, *hayʾat al-arḍ* treats those astronomical discussions that operate within the horizontal coordinate system, that is, the altitude-azimuth or declination-ascension coordinates, as opposed to planetary theories that operate within the zodiacal coordinate system and were dealt with in another main section on the configuration of the heavens (*hayʾat al-samāʾ*). In sum, the *hayʾat al-arḍ* sections within *hayʾa* works share specific geographical, geodesic and astronomical contents, the specific composition and arrangement of which may vary from one work to another. Despite the differences exhibited by different *hayʾat al-arḍ* sections of *hayʾa* works, they can still be considered a coherent genre. The objective of this study is to define *hayʾat al-arḍ* as a distinct genre of scientific geography and to show how it was formed and evolved within the related astronomical and geographical traditions of the pre-modern Islamic world.

The first and most important step toward studying *hayʾat al-arḍ* as a genre is to make its exemplars readily accessible to researchers. As such, we chose *Nihāyat al-idrāk fī dirāyat al-aflāk* (the utmost attainment in comprehending the orbs) of Quṭb al-Dīn Shīrāzī (d. 710/1311) as a concrete case study. The *Nihāya*, initially written in 680/1281 and revised several times until 684/1285, is the first and most voluminous among Shīrāzī's four major *hayʾa* works, in which he drew extensively on his predecessors. A critical edition and English translation of Book III of the *Nihāya*, being one of the most comprehensive and longest textual exemplars of the *hayʾat al-arḍ* genre, are presented in Parts II and III of this thesis and represent a contribution to studies on astronomical and geographical traditions of the pre-modern Islamic world. Extensive codicological and paleographical analysis of some of the oldest manuscripts of the *Nihāya* revealed that it existed in multiple versions. Through a scrupulous study of its early manuscript witnesses and by identifying the original composition and the revisions of the *Nihāya* in conjunction with Shīrāzī's other *hayʾa* works, the different versions of the *Nihāya* were identified and established in the introduction of Part II. Shīrāzī wrote and revised the *Nihāya* and two of his other *hayʾa* works during his residence in Anatolia. Even though Shīrāzī has attracted quite a bit of attention from modern historians, the Anatolian episode of his life has not been examined in recent scholarship. Thus, in chapter 2 of Part I, using some important but neglected sources, such as autobiographical material in Shīrāzī's own works, Persian chronicles, regional histories and manuscript witnesses, this thesis sheds light on this aspect of Shīrāzī's life and his intellectual activities in Anatolia. In addition, I provide there a general description of the *Nihāya*.

In the opening chapter of Book III of the *Nihāya*, in the course of the description of the inhabited part of the land and important bodies of water, Shīrāzī mentioned more than 200 geographical names, which is without precedent in previous *hayʾa* works. This fact, together with Shīrāzī's precise revisions of the parts containing these names, indicate that he had access to geographical sources as well. There are many different genres of geography in the pre-modern Islamic world, but Shīrāzī and his Islamic predecessors only refer to one specific genre called *al-masālik wa-al-mamālik* (routes and kingdoms). Interestingly, the formation of this genre occurred around the same time as the formation of *hayʾa* as a genre. Thus, chapter 3 of Part I presents a careful examination of the formation and a brief history of these two genres.

The contents of Book III of the *Nihāya* in particular, and generally those of the *hayʾat al-arḍ* section of similar *hayʾa* works, cover a wide range of material from the fields of geography, astronomy and geodesy. What unites all these topics under the heading of *hayʾat al-arḍ* is that they all relate to the sphericity of the surface of the Earth and the natural, astronomical and practical consequences accruing to this sphericity. The wide range of these topics, however, makes the study of all of them impossible in one single research project. Given that the astronomical and geodesic contents of *hayʾat al-arḍ* have been more discussed in the secondary literature, this project focuses on the geographical content of *hayʾat al-arḍ* and highlights parts dealing with some of the most important and sometimes controversial issues of scientific geography.

Thus, using a historical and textual approach, in chapter 4 of Part I of this thesis, we drew parallels and contrasts between the specific contents of Book III of the *Nihāya* and those of some of its predecessors. This required researching material related to these contents from a variety of geographical, scientific and philosophical primary sources, a particularly consuming task given the scarcity of secondary literature on the subject. In the following section, I survey the most important secondary literature under four main themes, namely *ʿilm al-hayʾa* and the *hayʾa* tradition; Shīrāzī's life and works; geography in pre-modern Islamic world; and cross cultural influences and transmissions.

1.1.1 *ʿIlm al-hayʾa* and the *hayʾa* tradition

Cosmography in the sense of a general physical-mathematical description of the universe, encompassing both the study of the heavens and of the Earth, was called *ʿilm al-hayʾa* in the pre-modern Islamic world. The Egyptian encyclopedist Ibn al-Akfānī (d. 749/1348) defines *ʿilm al-hayʾa* as "the science from which one learns the situations of the lower and upper simple bodies, their forms, their positions, their magnitudes, the distances between them, the motions of the orbs and the planets and their amounts. Its subject is the aforementioned bodies from the point of view of their quantities, positions, and inherent motions."[1] That being so, we find most *hayʾa* works containing two main parts, one dealing with the configuration of the heavens (*hayʾat al-samāʾ*) and the other with the configuration of the Earth (*hayʾat al-arḍ*). These works were mainly based on a theoretical and philosophical foundation derived principally from Aristotle's (384–322 BC) cosmology and physics and from Ptolemy's (ca. 90–168 CE) astronomy.[2]

The subject matter of Aristotelian physics, namely terrestrial and celestial bodies undergoing change and/or motion, makes it distinct from mathematics, whose subject matter is entities that do not undergo change.[3] Celestial bodies were studied by the natural philosopher as well as by the mathematician—the astronomer, to be more specific—but while the former studied their shapes and motions with regard to their substance, the latter considered mostly their motion and applied his mathematical knowledge to it, regardless of their substance.[4] However, despite the distinction frequently drawn between 'mathematics' (*al-taʿālīm*) and 'natural philosophy' (*al-ṭabīʿiyyāt*) in the pre-modern Islamic world, it is known that they often

[1] F.J. Ragep, "Astronomy," in *Encyclopaedia of Islam, THREE*, ed. Gudrun Krämer et al. (Brill, 2013), Consulted online on 22 October 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_22652>. Ibn al-Akfānī's definition is most probably taken from Naṣīr al-Dīn Ṭūsī's (d. 672/1274) *al-Tadhkira fī ʿilm al-hayʾa* (see F.J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's Memoir on Astronomy (al-Tadhkira fī ʿilm al-hayʾa)* (New York: Springer-Verlag, 1993), 1:90–91). Here we do not deal with different definitions of *ʿilm al-hayʾa* and its relation with other branches of astronomical knowledge. This was discussed in the works of medieval bibliographers, encyclopedists as well as by scholars who discussed the classification of the sciences. These writers provide somewhat different ways of understanding the different branches of astronomical knowledge. Nevertheless, *ʿilm al-hayʾa* was a recognized genre of cosmographical writing, based on certain common characteristics that are discussed by F.J. Ragep under the entry "Astronomy" in the third edition of *Encyclopaedia of Islam*, and the introduction to his edition of Naṣīr al-Dīn Ṭūsī's *al-Tadhkira fī ʿilm al-hayʾa*. See: F.J. Ragep, *al-Tadhkira*, 1:29–36.

[2] F.J. Ragep, "Astronomy."

[3] Edward Grant, *A History of Natural Philosophy: From the Ancient World to the Nineteenth Century* (Cambridge; New York: Cambridge University Press, 2007), 41–42.

[4] Paul Lettinck, *Aristotle's "Physics" and Its Reception in the Arabic World: With an Edition of the Unpublished Parts of Ibn Bājja's Commentary on the Physics* (Leiden; New York; Köln: E. J. Brill, 1994), 123.

overlapped significantly[5]—a fact that can be seen if we consider the *hayʾa* tradition to be a critical synthesis of Aristotelian physics and Ptolemaic mathematical astronomy. In other words, the fact that *hayʾa* scholars applied mathematical principles to natural bodies makes *ʿilm al-hayʾa* an intermediary discipline between mathematics and physics. *Hayʾa* scholars admit the physicality of natural bodies, celestial or terrestrial, take motion into account, and consider planes, lines, and points as limits of physical bodies, as opposed to pure mathematical entities. Ibn Sīnā (d. 428/1037) in the *Ṭabīʿiyyāt* section of the *Shifāʾ* explicitly says that "it is as if this *ʿilm* [*al-hayʾa*] is a combination of physics (*ṭabīʿī*) and mathematics (*taʿlīmī*)."[6] This approach is apparent in Ibn al-Haytham's (d. c. 431/1040) *al-Maqāla fī hayʾat al-ʿālam* (treatise on the configuration of the world) and also in his *al-Shukūk ʿalá Baṭlamiyūs* (doubts on Ptolemy), which contains his criticisms of Ptolemy's *Almagest, Planetary Hypotheses*, and *Optics*.[7]

In his *Muntahá al-idrāk fī taqāsīm al-aflāk* (the utmost attainment on the structure of the orbs), Bahāʾ al-Dīn al-Kharaqī (d. 553/1158), who was familiar with the works of Ibn Sīnā and Ibn al-Haytham, followed the same reconciling approach. The *Muntahá* has been edited and commented upon by Hanif Ghalandari in his 2012 PhD dissertation.[8] Ghalandari in the introduction to his edition provides us with a discussion of various classifications and definitions of astronomical knowledge extracted from the works of different scholars of the pre-modern Islamic world, with a focus on the difference between *ʿilm al-nujūm* and *ʿilm al-hayʾa*, arguing that the former is more general than the latter. Ghalandari believes that most *hayʾa* authors after Kharaqī relied heavily on him in writing their *hayʾat al-arḍ* sections.[9] Ghalandari then summarizes the content of the chapters of this section of the *Muntahá* that deal with a

---

[5] A. I. Sabra, "Science and Philosophy in Medieval Islamic Theology: The Evidence of the Fourteenth Century," *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* (1994): 4.

[6] Ibn Sīnā, *al-Shifāʾ, Ṭabīʿiyyāt, al-Samāʾ al-ṭabīʿī*, ed. Saʿīd Zāyid (Cairo: 1983), 42:

«فهذا العلم كأنه ممتزج من طبيعي ومن تعليمي.»

[7] See Y. Tzvi Langermann, *Ibn Al-Haytham's on the Configuration of the World* (London: Routledge, 2017); Y. Tzvi Langermann, "Arabic Cosmology," *Early Science and Medicine* 2 (1997): 185–213; F.J. Ragep, "Astronomy."

[8] Hanif Ghalandari, "A survey of the works of "*hayʾa*" in the Islamic period with a critical edition, translation and commentary of the treatise *Muntahá al-idrāk fī taqāsīm al-aflāk*, written by Bahāʾ al-Dīn al-Kharaqī (d. 553AH/1158AD)," PhD dissertation (Tehran: Institute for humanities and cultural studies, 2012).

[9] Ghalandari, "*Muntahá*," 1: 94.

general description of the land on the surface of the Earth and the characteristics of the equator and oblique horizons.[10] In this study, I have used Ghalandari's work and especially his critical edition of the *Muntahá* to discuss the form and contents of *hayʾat al-arḍ* as a genre.

A very important work influenced by Kharaqī's *Muntahá* is *al-Tadhkira fī ʿilm al-hayʾa* (written in 659/1261; revised in 672/1274) by Naṣīr al-Dīn Ṭūsī (d. 672/1274). Relying on his mastery of Avicennan philosophy and his grasp of the mathematical sciences, Ṭūsī shows a remarkable effort toward the reconciliation of Aristotelian physics and Ptolemaic astronomy in the *Tadhkira*. A precise edition and English translation of the *Tadhkira* was published by F.J. Ragep in 1993. Given that Shīrāzī's *Nihāya* can be regarded as part of the commentary tradition of the *Tadhkira*, Ragep's work plays a central role in this research. The structure of Book III of the *Nihāya* is very similar to that of the *Tadhkira*. Furthermore, most of the text of Book III of the *Tadhkira* has been incorporated by Shīrāzī into Book III of the *Nihāya*. Thus, Ragep's edition and translation of the *Tadhkira* was constantly in use throughout different stages of this study. In the introduction to his edition, Ragep presents an extensive discussion of *hayʾa* as a distinct genre of astronomy in the pre-modern Islamic world. The second volume of Ragep's work, which contains a modern commentary on the *Tadhkira*, is more focused on planetary models in general. Moreover, Ragep's commentary on Book III, dealing with *hayʾat al-arḍ*, covers mostly the astronomical content of this book. Still, this part of Ragep's commentary can be considered as the earliest and most fundamental secondary literature on *hayʾat al-arḍ*.

Ṭūsī has another *hayʾa* work, entitled *al-Rīsāla al-muʿīniyya*, which pre-dates the *Tadhkira*. Ṭūsī wrote the *Muʿīniyya* in Persian in 632/1235 and, after nearly 10 years, wrote a supplement to the *Muʿīniyya* in 643/1245. Ṭūsī later revised both the *Muʿīniyya* and its supplement and, as part of this revision, removed the dedication and references to his former Ismāʿīlī patron from these works. The *Muʿīniyya* has a complex textual history that makes producing a critical edition rather challenging. Hassan Amini, as part of his master's thesis in 2008, prepared a reasonably good edition of the *Muʿīniyya* based on four manuscripts. Amini and F.J. Ragep are currently working on a more precise critical edition based on all witnesses

[10] Ghalandari, "*Muntahá*," 1: 94–100.

representing different versions of the *Muʿīniyya*. For the purpose of this research on the *hayʾat al-arḍ*, we have used Amini's thesis.[11]

In the *Nihāya*, Shīrāzī continued Ṭūsī's reconciliation project. Besides proposing innovative solutions to different problems of planetary models in Book II of the *Nihāya*, Shīrāzī also tried to enrich his Book III on *hayʾat al-arḍ*. Toward this latter purpose, Shīrāzī used both the *Muʿīniyya* and the *Tadhkira* along with some other *hayʾa* works, which he considered to be reliable. Fortunately, one of these works, Jaghmīnī's *al-Mulakhkhaṣ fī al-hayʾa al-basīṭa* (written in 602–603/1205–1206), which Shīrāzī took to be authoritative, has been edited and translated into English. The *Mulakhkhaṣ*, according to its editor Sally P. Ragep, "was an extremely popular astronomical text-book that played a critical role in the teaching, dissemination, and institutional instruction of Islamic theoretical astronomy."[12] Jaghmīnī's "straightforward basic definitions" must have been appealing to Shīrāzī, who quoted some of them verbatim in the *Nihāya* III.3. Shīrāzī also in some of the chapters of Book III of the *Nihāya*, such as chapter 9 on dawn and dusk and chapter 12 on shadows, has quoted extensively from Muʾayyid al-Dīn al-ʿUrḍī's (d. 664/1266) *Kitāb al-hayʾa*. This important work has been edited and published by George Saliba.[13]

Another contribution to the field of *hayʾa* is Ahmad S. Dallal's critical edition, English translation and technical commentary of an astronomical text by Ṣadr al-Sharīʿa al-Thānī (d. 747/1347), a scholar who worked and taught in the city of Bukhara. This text, entitled *Kitāb taʿdīl hayʾat al-aflāk* (the adjustment of the configuration of the celestial spheres), is the third section of a three-part encyclopedic survey on logic, theology, and astronomy entitled *Taʿdīl al-ʿulūm* (the adjustment of the sciences). According to Dallal, the work is extant "in the traditional form of a commentary, where the author gives his own text and the comments on the

---

[11] Hassan Amini, "*al-Risāla al-Muʿīniyya* of Khwādja Naṣīr al-Dīn al-Ṭūsī: A Critical Edition and Study," Master's thesis (Institute for the History of Sciences, University of Tehran: 2008).

[12] Sally P. Ragep, *Jaghmīnī's Mulakhkhaṣ: An Islamic Introduction to Ptolemaic Astronomy*, (Switzerland: Springer, 2016), 1.

[13] George Saliba, *The Astronomical Work of Muʾayyad al-Dīn al-ʿUrḍī, A Thirteenth Century Reform of Ptolemaic Astronomy: Kitāb al-hayʾah*, (Beirut: Markaz Dirāsāt al-Waḥda al-ʿArabiyya, 1990).

same."[14] Dallal, however, has only edited the original text without Ṣadr's commentary. In the astronomical part that belongs to the *hayʾa* genre, Ṣadr extensively refers to Ṭūsī's *Tadhkira* and Shīrāzī's third *hayʾa* work, *al-Tuḥfa al-shāhiyya* (written in 684/1285).

1.1.2. Shīrāzī and the *Nihāya*

The *Nihāya* and parts of its text and contents have been the subjects of several studies. Eilhard Wiedemann has discussed passages of the *Nihāya* in several of his works.[15] E.S. Kennedy has studied Shīrāzī's Moon and Mercury models in the *Nihāya* and his other *hayʾa* work, *al-Tuḥfat al-shāhiyya*.[16] The introduction and conclusion of the *Nihāya* was published by F.J. Ragep in 2013.[17] In the same year, Amir Mohammad Gamini and Hossein Masoumi Hamedani discussed Shīrāzī's account of the Ptolemaic equant point and published the relevant text from the *Nihāya*.[18] In a more recent article, Gamini has discussed some of Shīrāzī's planetary models in his different works including the *Nihāya*.[19]

Shīrāzī himself, moreover, is quite famous in modern scholarship. Kaveh Niazi in his book, entitled *Quṭb al-Dīn Shīrāzī and the Configuration of the Heavens*, and in his article,

---

[14] Aḥmad S. Dallal, *An Islamic Response to Greek Astronomy: Kitāb taʿdīl hayʾat al-aflāk of Ṣadr al-Sharīʿa*, (Leiden: Brill, 1995), 3.

[15] See for example E. Wiedemann, "Zu den optischen Kenntnissen von Ḳuṭb al-Dîn al-Schîrâzî," *Archiv für die Geschichte der Naturwissenschaften und der Technik*, iii (1912), 187–193; and E. Wiedemann, "Über die Gestalt, Lage und Bewegung der Erde, sowie philosophisch-astronomische Betrachtungen von Ḳuṭb al-Dîn al-Schîrâzî," *Archiv für die Geschichte der Naturwissenschaften und der Technik*, iii (1912), 395–422.

[16] E.S. Kennedy, "Late Medieval Planetary Theory," *Isis* 57, no. 3 (1966): 365–378. http://www.jstor.org.proxy3.library.mcgill.ca/stable/228366.

[17] F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*: Introduction and Conclusion," *Tārīkh-e Elm* 11 (2013): 52.

[18] Amir Mohammad Gamini, and Hossein Masoumi Hamedani, "al-Shīrāzī and the Empirical Origin of Ptolemy's Equant in His Model of the Superior Planets," *Arabic Sciences and Philosophy* 23, no. 1 (2013): 47–67. doi:10.1017/S0957423912000070.

[19] Amir Mohammad Gamini, "Quṭb al-Dīn al-Shīrāzī and the Development of Non-Ptolemaic Planetary Modeling in the 13th Century," *Arabic Sciences and Philosophy* 27, no 2 (2017), 165–203. doi:10.1017/S0957423917000017.

"Quṭb al-Dīn Shīrāzī as Depicted in Early Historical Sources,"[20] has critically analyzed modern and pre-modern biographies of Shīrāzī, noting discrepancies and contradictory information from different narratives based mostly on Shīrāzī's own autobiographical material. With regard to modern sources, Niazi completely neglected Reza Pourjavady and Sabine Schmidtke's series of studies on Shīrāzī, which contains illuminating information about Shīrāzī's life.[21] In his book, Niazi has compared Shīrāzī's discussions of some problems relating to certain planetary models in the *Nihāya* to his Persian *hayʾa* work, *Ikhtiyārāt-i muẓaffarī*, and provided an English translation of relevant fragments from both works.

In the present research, access to the aforementioned latest secondary studies on the life of Shīrāzī facilitated our job to some extent and helped guide us in choosing the primary sources. It should be noted that modern scholarship does not have much to offer with regard to Shīrāzī's life in Anatolia; thus, in this project, we had to rely mostly on primary sources in order to shed some light on this episode of his life during which the *Nihāya* was written.

1.1.3. *Al-Masālik wa-al-mamālik* and the geographical tradition

The story of geography in the pre-modern Muslim world is rather complex, as ancient influences are not confined to Greeks sources. Persian and Roman influences, in particular, are traceable in the descriptive geographical tradition and cartography, respectively. However, the geographical tradition of the pre-modern Islamic world is distinguished from its predecessors by a certain set of attitudes, methods, techniques and questions. This geographical tradition should be seen in the context of related scientific traditions, especially astronomy, with improvements in observation methods and instruments and in mathematical techniques that made possible conceptual developments in the configuration of the surface of the Earth. The

---

[20] Kaveh Niazi, *Quṭb al-Dīn Shīrāzī and the Configuration of the Heavens: A Comparison of Texts and Models* (Dordrecht: Springer, 2013); "Quṭb al-Dīn Shīrāzī as Depicted in Early Historical Sources," *Tārīkh-e Elm* 11 (2013) 23–39.

[21] Reza Pourjavady, and Sabine Schmidtke, "Quṭb al-Dīn al-Shīrāzī (d. 710/1311) as a Teacher: an Analysis of His Ijāzāt (Studies on Quṭb al-Dīn al-Shīrāzī III)," *Journal Asiatique* 297.1 (2009): 15–55; "The Quṭb al-Dīn al-Shīrāzī (d. 710/1311) Codex (MS Marʿashī 12868) [Studies on Quṭb al-Dīn al-Shīrāzī, II]," *Studia Iranica* 36 (2007): 279–301; "Quṭb al-Dīn al-Shīrāzī's (634/1236–710/1311) *Durrat al-tāj* and its sources (Studies on Quṭb al-Dīn al-Shīrāzī, I)," *Journal Asiatique* 292.1–2 (2004): 311–330.

vast territory of Islamic lands and remote voyages of travelers enriched and pushed the boundaries of the geographical tradition of the pre-modern Islamic world.

The geographical tradition of the pre-modern Islamic world includes many genres and forms. To mention a few genres, one can refer to travelogues,[22] books on wonders,[23] geographical encyclopedias and dictionaries,[24] and *al-masālik wa-al-mamālik*. Significant geographical data and information can be found in astronomical works, chronicles and literary works too. The entry on "Dj̲ug̲h̲rāfiyā" in the *Encyclopaedia of Islam Second Edition* covers all different areas of geography in the pre-modern Islamic world. According to this entry, Kharaqī's *Muntahá al-idrāk* belongs to a "tradition of describing the world as a whole as practised by the geographers of the classical period," however "[t]he pattern of description and arrangement was also different from the earlier works" and "[t]here was a tendency towards rapprochement between astronomical and descriptive geography in these works, and Greek influence was still prominent in some works."[25] Nevertheless, the authors do not offer further detail that would have helped us with recognizing any specific genre within this tradition.

Barthold's introduction to Minorsky's edition of *Ḥudūd al-ʿālam*,[26] the oldest Persian descriptive geographical work whose author is unknown, contains valuable information about different types of geographical knowledge. This introduction is an essential read for any researcher in the field of history of geography in the pre-modern Islamic world, especially due to Barthold's good grasp of geographical and historical literature of this period that enabled him to put forth a comparative discussion of selected material from the most important geographical works.

---

[22] As an example, see Ibn Baṭūṭa, *Kitāb riḥlat Ibn Baṭūṭa: al-musammā Tuḥfat al-nuẓẓār fī gharāʾib al-amṣār wa-ʿajāʾib al-asfār* (Cairo: Maṭbaʿa Wādī al-Nīl, 1287/1867).

[23] See for example Ferdinand Wüstenfeld, *Zakarija Ben Muhammed Ben Mahmud El-Cazwini's Kosmographie* (Göttingen: Verlag Der Dieterichschen Buchhandlung, 1848).

[24] Geographical dictionaries include Yāqūt al-Ḥamawī, *Muʿjam al-buldān* (Beirut: Dār Ṣādir, 1995).

[25] S. Maqbul Ahmad, "Dj̲ug̲h̲rāfiyā," *Encyclopaedia of Islam, Second Edition*, vol. 2, edited by B. Lewis et al. (Leiden: Brill, 1965), 584.

[26] Vladimir Minorsky, *Ḥudūd al-ʿālam: 'the Regions of the World,' a Persian Geography, 372 A.H.–982 A.D*, preface by V.V. Barthold, ed. Clifford Edmund Bosworth (London: Luzac, 1970).

Recent scholarship has also offered various analytic models for identifying and classifying different geographical works, such as the conceptualization of ʿIrāqī vs. Balkhī Schools or scientific vs. descriptive approaches. Although these models were quite useful as simple classification tools at the time of their formulation by modern scholars, they failed to provide epistemological frameworks for distinguishing genres. To clarify this further, let us have a look at the ʿIrāqī/Balkhī model, which is related to the formative period studied in the present thesis.

Proponents of the ʿIrāqī vs. Balkhī dichotomy assume that the ʿIrāqī School represents the formative stage of geographical knowledge in the pre-modern Islamic world under the apparent influence of the works made available during the translation movement. The Balkhī School, on the other hand, represents an appropriation stage in which the geographical tradition of the pre-modern Islamic world attained an intellectual maturity. The most manifest problem of this model is the obfuscation of different geographical genres by classifying them in the same category.[27] This model also presents discrepancies regarding the chronological order of the early works, due to the lack of biographical information about the authors. This issue is evident in the very name of this model: the Balkhī School was named after the well-known scholar Abū Zayd Aḥmad b. Sahl al-Balkhī (d. 322/934) whose fame as a geographer depends exclusively on a sole work, the authorship of which was already disputed half a century after his own death. The first mention of such a work by Balkhī appears in the *Aḥsan al-taqāsīm fī maʿrifat al-aqālīm* of al-Muqaddasī (or al-Maqdisī, d. after 381/991), the famous geographer of the second half of the 4th/10th century. Muqaddasī tells us that he saw three different copies of the same work: one attributed to Balkhī, one without an authorial attribution—although the author was believed to be Ibn al-Marzbān al-Karkhī—and one with the author's name given as Ibrāhīm b. Muḥammad al-Fārisī,[28] known as al-Iṣṭakhrī (d. ca. 350/961–962) in the modern literature.

---

[27] An example of this problem is the classification of the works of Ibn Khurdā<u>dh</u>bih, the author of the earliest extant *masālik* work, and Abū al-Ḥasan ʿAlī b. al-Ḥusayn al-Masʿūdī (d. 345/956), the celebrated historian who "regarded geography as a part of history," as representatives of the same (*i.e.*, ʿIrāqī) school (see Ahmad, "<u>Dj</u>u<u>gh</u>rāfiyā," 579, 581). This is misleading since Ibn Khurdā<u>dh</u>bih's work is a proper geographical text whereas Masʿūdī, as a historian, incorporates geographical information to supplement his historical work.

[28] See Muḥammad b. Aḥmad al-Muqaddasī, *Kitāb Aḥsan al-taqāsīm fī maʿrifat al-aqālīm*, ed. M. J. de Goeje (1906; repr. Beirut: Dār Ṣādir, n.d.), 5:

Muqaddasī then adds that the last identification is the soundest, because he had met a group of people who witnessed Iṣṭakhrī's composition of the work, of whom he specifically mentions two names.[29]

These are some of the issues raised by the frameworks offered by 19th- and 20th-century scholarship in this field. Examining all of these frameworks and analyzing their advantages and disadvantages would constitute a research project in its own right. However, one can claim that an issue common to all of them is that they are built upon a blurry vision of the formative period.

In the field of scientific geography, the available secondary literature is more rigorous. Abū al-Rayḥān al-Bīrūnī (d. after 440/1048) is probably one of the few scholars who composed monographs in the field of mathematical geography. His monograph is entitled *Taḥdīd nihāyāt al-amākin li-taṣḥīḥ masāfāt al-masākin* (the determination of the coordinates of the localities for the correction of the distances of the regions); according to its modern commentator, E.S. Kennedy, it "is a self-contained treatise on medieval geodesy with numerous items of interest to historians of astronomy, mathematics and technology."[30]

«رأيت كتاباً بخزانة الصاحب ينسب إلى أبي زيد البلخي... ورأيته بعينه بنيسابور... غير مترجم زعموا أنّه من تصنيف ابن المرزبان الكرخي، ورأيته ببخارا مترجماً لإبراهيم بن محمد الفارسي.»

[29] See Muqaddasī, *Aḥsan al-taqāsīm*, 5:

«وهذا أصحّ لأنّي لقيت جماعتاً ممّن لقيه وشاهده يصنّفه منهم الحاكم أبو حامد الهمداني، والحاكم أبو نصر الحرير (الحربي).»

For French translation, see: Muḥammad b. Aḥmad al-Muqaddasī, *Aḥsan al-taqāsīm fī maʿrifat al-aqālīm (La Meilleure Répartition Pour La Connaissance Des Provinces)*, trans. André Miquel (Damas: Institut Français De Damas, 1963), 14–15.

For modern discussions of the Balkhī-Iṣṭakhrī authorship dispute/confusion, see Barthold's preface to the *Ḥudūd al-ʿālam* in: Minorsky, *Ḥudūd*, 19; Gerald R. Tibbetts, "The Balkhī School of Geographers," in: *The History of Cartography, Volume 2, Book 1: Cartography in the Traditional Islamic and South Asian Societies*, eds. J. B. Harley and David Woodward, 109–110 (Chicago: University of Chicago Press, 1992); and for arguments against Balkhī's authorship, see Ibrāhīm b. Muḥammad al-Iṣṭakhrī, *al-Masālik wa-al-mamālik*, ed. Muḥammad Jābir ʿAbd al-ʿĀl al-Ḥīnī (Cairo: The United Arab Republic, Ministry of Culture and National Guidance, General Culture Administration, 1961), 8–9.

[30] E.S. Kennedy, *A Commentary upon Bīrūnī's Kitāb taḥdīd al-amākin: an 11th Century Treatise on Mathematical Geography* (Beirut: American University of Beirut, 1973) xv; see also David King, "A world-map in the tradition of al-Bīrūnī (ca. 1040) and al-Khāzinī (ca. 1120) Presented by Sirāj al-Dīn al-Sajāwandī (1210)," in:

Raymond Mercier, in his contribution to *The History of Cartography* vol. 2, book 1, examines in detail Bīrūnī's determination of the longitude of Ghazna (modern Ghazni, Afghanistan).[31] In this chapter, Mercier also tries to reappraise the Sinjār geodetic expedition for the measurement of the length of a degree during the Maʾmūn caliphate but Mercier's use of the primary sources in this case is problematic.[32] Mercier finally concludes that the result of this measurement "is an accurate result, indeed probably too accurate to have been determined by the methods claimed" by Ibn Yūnus and others.[33] This conclusion seems hasty, especially when one notes that according to Mercier himself "[w]e have no information about the methods used to fix the latitude, and no details about the instruments or the observations."[34]

Ahmad Dallal's "al-Bīrūnī on Climates" presents an English translation and commentary of a chapter in Bīrūnī's *al-Qānūn al-Masʿūdī*. This chapter is a brief description of the inhabited world, followed by tables of the seven climes' dimensions.[35] In "A world-map in the tradition of Bīrūnī (ca. 1040) and al-Khāzinī (ca. 1120)," David King analyzes different aspects of a map from a work on folk astronomy that was prepared using either Bīrūnī's lost world map or its values for coordinates of localities preserved by Khāzinī in his *al-Zīj al-Sanjarī*.

Because of Bīrūnī's geographical achievements, it is important to trace his influence upon the mathematical geography literature of pre-modern Islamic world, especially in *hayʾa* works. As for whether his achievements were influential or not, we should be wary of drawing hasty conclusions, as King unfortunately did in this article, saying "[t]he ultimate demise of Islamic science is well reflected in the fact that the highly sophisticated geographical achievements of Bīrūnī bore virtually no fruit until they were rediscovered and published by orientalists in the

---

Mélanges offerts à Hossam Elkhadem par ses amis et ses élèves, edited by F. Daelemans et al. (Brussels: Archives et bibliothèques de Belgique, 2007) 131–160. Reprinted in: David King, *Islamic astronomy and geography* (Burlington: Ashgate, 2012) 134: "*Taḥdīd*…is the most important single work on the subject from the entire Middle Ages."

[31] Raymond P. Mercier, "Geodesy," in: *The History of Cartography, Volume 2, Book 1: Cartography in the Traditional Islamic and South Asian Societies*, eds. J.B. Harley and David Woodward (Chicago: University of Chicago Press, 1992), 175–188.

[32] Mercier, "Geodesy," 178–181.

[33] Mercier, "Geodesy," 181.

[34] Mercier, "Geodesy," 181.

[35] Ahmad Dallal, "al-Biruni on Climates," *Archives Internationales d'histoire des Sciences* 34 (1984).

20th century."[36] In another article titled "Mathematical Geography in 15th-Century Egypt: An Episode in the Decline of Islamic Science," King tries to show how "uncritical handling of a superfluity of uncontrolled data" (*i.e.*, geographical coordinates) by two leading Egyptian scholars can be regarded as their contribution "to the decline of Islamic science," without providing convincing evidence.[37]

The History of Cartography, vol. 2, book 1, contains some interesting chapters discussing mostly cartographic aspects of geography in the pre-modern Islamic world. The three chapters by Gerald R. Tibbets, Chapter 3 on The Beginnings of a Cartographic Tradition,[38] Chapter 5 on The Balkhī School of Geographers[39] and Chapter 6 on Later Cartographic Developments,[40] are worthy of mention. Tibbetts concludes his three chapters by explicitly saying that there is no reflection of the medieval Muslim geographers' cartographic and geodetic achievements in the surviving maps from the medieval Islamic period. Although Tibbetts' research is solid and he is probably right about specific maps found in later *al-masālik* works,[41] his generalizations are suspect. For example, he states that "[t]he tables of Ptolemy and their Arabic adaptations were never really applied overall to Islamic maps, except perhaps in the large sectional maps of al-Idrīsī, which themselves never became the common property of the whole Islamic world,"[42] and "[t]he ultimate outcome of all these tables of longitude and latitude was virtually nothing cartographic"[43]; but as with King's generalizations, Tibbetts does not adduce any strong evidence.

---

[36] King, "World-map," 156.

[37] David King, "Mathematical Geography in 15th-Century Egypt: An Episode In The Decline Of Islamic Science," in David King, *Islamic astronomy and geography*, XII: 20

[38] Harley and Woodward, *Cartography*, vol. 2, book 1, 90–107.

[39] Harley and Woodward, *Cartography*, vol. 2, book 1, 108–136.

[40] Harley and Woodward, *Cartography*, vol. 2, book 1, 137–155.

[41] See Tibbetts, "The Balkhī School," 128.

[42] Gerald R. Tibbetts, "Later Cartographic Developments," in: *The History of Cartography, Volume 2, Book 1: Cartography in the Traditional Islamic and South Asian Societies*, eds. J. B. Harley and David Woodward (Chicago: University of Chicago Press, 1992), 154.

[43] Gerald R. Tibbetts, "The Beginnings of a Cartographic Tradition," in: *The History of Cartography, Volume 2, Book 1: Cartography in the Traditional Islamic and South Asian Societies*, eds. J. B. Harley and David Woodward (Chicago: University of Chicago Press, 1992), 106.

Evidence and arguments against such approaches can be found in the works of the late Fuat Sezgin, especially in his invaluable book *The Contribution of the Arabic-Islamic Geographers to the Formation of the World Map*.[44] Sezgin, made especially notable contributions to the history of geography and cartography in the pre-modern Islamic world. In volumes 10–12 of his *Geschichte des Arabischen Schrifttums*,[45] Sezgin attempted to re-examine the history of mathematical geography and cartography. In these volumes, Sezgin presents a considerable amount of data that had been neglected by historians of geography and cartography.

1.1.4 Cross cultural influences and transmissions

Although a significant amount of research has been done on the different genres of geographical knowledge in the pre-modern Islamic world, little attention has been paid to comparative studies that are critical for tracing the transmissions and exchanges of geographical ideas and practices between different cultures. Fortunately, there are a few scholarly works on cross cultural transmissions of geographical knowledge that are worth mentioning here.

Chapters 15 to 17 of book 1, vol. 2 of *The History of Cartography* on South Asian cartography and cosmography by Joseph E. Schwartzberg provide us with material about the Indo-Islamic exchange of geographical knowledge. On Sino-Islamic geographical exchanges, *Mapping the Chinese and Islamic Worlds, Cross-Cultural Exchange in Pre-modern Asia* by

---

[44] Fuat Sezgin, *The contribution of the Arabic-Islamic Geographers to the Formation of the World Map* (Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 1987).

[45] Fuat Sezgin, *Geschichte des Arabischen Schrifttums, Band X–XI, Mathematische Geographie und Kartographie im Islam und Ihr Fortleben im Abendland—Historische Darstellung, Teil 1–2* (Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 2000); *Geschichte des Arabischen Schrifttums, Band XII, Mathematische Geographie und Kartographie im Islam und ihr Fortleben im Abendland—Kartenband* (Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 2000). See also Fuat Sezgin, *Mathematical Geography and Cartography in Islam and their Continuation in the Occident, Volume I Historical Presentation Part I being an English Version of volume X of Geschichte des Arabischen Schrifttums*, translated from the German by Guy Moore and Geoff Sammon (Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 2005).

Hyunhee Park is probably the only work of its kind that fully and equally deals with both sides of the exchange. It would have been fitting, if she knew Persian, for her to consult Persian primary sources directly.

There is more technical scholarship from proceedings of conferences on the same topic, such as *The Journey of Maps and Images on the Silk Road*, by Philippe Forêt and Andreas Kaplony. This important collection brings together a number of studies of exchange of iconic and geographical ideas under the theme of the Silk Road. The third part of this collection starts with Kaplony's comparison of "al-Kāshgharī's map to his text" and deals with "the transmission of Arabic-Islamic maps".[46] Following this, in "*The Book of Curiosities*: a medieval Islamic view of the East," Yossef Rapoport addresses the image of the East in the *Book of Curiosities*, a treatise[47] acquired by the Bodleian Library in 2002.[48] In the fourth section of the book, Paul Kunitzsch deals with the "Celestial maps and illustrations in Arabic-Islamic astronomy".[49] Finally, in an interesting contribution entitled "Revisiting Catalan Portolan Charts: do they contain elements of Asian provenance?" Sonja Brentjes shows shared visual forms between Arabic, Byzantine, and Catalan maps which "points to a shared ancestry."[50] She writes that "it is nevertheless almost impossible to pinpoint this ancestry with certainty due to the present lack of relevant sources."[51]

Brentjes' contribution is especially important because modern scholarship on the history of European geography tends to totally ignore any exchange between the pre-modern Islamic

[46] Andreas Kaplony, "Comparing al-Kāshgharī's Map to His Text: on the Visual Language, Purpose, and Transmission of Arabic-Islamic Maps," in *The Journey of Maps and Images on the Silk Road*, edited by Philippe Forêt, and Andreas Kaplony (Brill, 2008), 137.

[47] Published as a facsimile along with the edited text and English translation in 2013: Y. Rapoport and E. Savage-Smith, *An Eleventh-Century Egyptian Guide to the Universe: The Book of Curiosities, Edited with an Annotated Translation* (Leiden: Brill, 2013).

[48] Yossef Rapoport, "*The Book of Curiosities*: A Medieval Islamic View of the East," in Forêt and Kaplony, *Journey of Maps*, 155–171.

[49] Paul Kunitzsch, "Celestial Maps and Illustrations in Arabic-Islamic Astronomy," in Forêt and Kaplony, *Journey of Maps*, 175–180.

[50] Sonja Brentjes, "Revisiting Catalan Portolan Charts: Do They Contain Elements of Asian Provenance," in Forêt and Kaplony, *Journey of Maps*, 188.

[51] Brentjes, "Revisiting," 188–189

world and Europe. One of the examples of this Eurocentric attitude among modern historians of European geography is Randles' article "Classical Models of World Geography and Their Transformation Following the Discovery of America."[52] Randles' main argument in this article is the importance of Ptolemy's *Geography* on the subject of geography in the Renaissance. His statement that "Ptolemy's principal contribution was to mathematicize the subject, something which the Middle Ages had been unable to do," is enough to show his ignorance of the history of science.[53] According to F.J. Ragep, the fact that Ptolemy's "proofs of the basic cosmological features (the sphericity of the Earth and universe, the Earth's centrality, and so forth) generally rel[ied] upon mathematics and observations"[54], was acknowledged by medieval Muslim astronomers.

Sidestepping the whole tradition of Ptolemaic astronomy and geography in the pre-modern Islamic world, Randles writes that "a pale reflection of the definition [of the relation between the earth and the seas] given in Ptolemy's *Geography* was transmitted to the Middle Ages by the Arabic astronomer Alfraganus (al-Farghani)."[55] However, it seems that Randles is aware of a 'missing link' between Greek antiquity and Medieval European scholars when he says "[t]he sources of Grosseteste's idea that 'the water withdraw into the cavities of the earth' can be traced to … John Philoponus and Olympiodorus, but one cannot conclude that he had read them himself directly."[56]

Shalev sounds completely right when he challenges the revolutionary effect of the rediscovery of Ptolemy's *Geography* on European geography and cartography at the beginning of the fifteenth century. He believes that "[t]his traditional, oft repeated account, while

---

[52] William Graham Lister Randles, "Classical Models of World Geography and Their Transformation Following the Discovery of America," in *The Classical Tradition and the Americas, Vol. I: European Images of the Americas and the Classical Tradition*, ed. W. Haase, and M. Reinhold (Berlin; New York: Walter De Gruyter, 1994), 9.

[53] Randles, "Classical Models," 35.

[54] F.J. Ragep, *al-Tadhkira*, 40.

[55] Randles "Classical Models," 18.

[56] Randles "Classical Models," 26.

providing a basic narrative outline, suffers from too narrow a focus on geography and cartography as isolated and autonomous disciplines."[57]

So, as is clear, the Islamic-European episode of geographical exchange is mostly unexplored. One of these grounds on which one can build the foundations for the study of this exchange is the direct or indirect influence or transmission of *hayʾat al-arḍ* in different Latin cosmographical traditions. This may be especially fruitful given that in 17th-century Europe, authors of a specific genre called "Theories of the Earth" initiated a tradition of the study and visual representation of the Earth as a whole. Kerry Magruder's article entitled "Global Visions and the Establishment of Theories of the Earth" discusses "how the emergence of visual representations contributed to the establishment of a new print tradition of multicontextual discourse and critical debate."[58] According to Magruder, "Kepler's theorizing about the Earth was oriented in the context of astro-meteorology, a science of sublunar nature at the intersection between mathematical cosmology and the Earth, consistent with a Neoplatonic natural philosophy. His incidental use of global depictions reflected his strong preference for mathematical diagrams and his distrust of other kinds of images."[59] On the other hand, in *Principles of Philosophy*, Descartes "raised the stature of theorizing about the Earth to a position of prominence in natural philosophy,"[60] to the extent that "[a]fter setting out to explain all of cosmology in Part 3, Descartes significantly concluded the work by giving the Earth its own separate section (the longest of the work) in Part 4, entitled simply 'De Terrâ' or 'on the Earth'," in which "Descartes bestowed a high status upon Theories of the Earth by claiming that a natural philosophy fails if it can explain the cosmos, but not the Earth which is more accessible to us."[61]

---

[57] Zur Shalev, "Main Themes in the Study of Ptolemy's *Geography* in the Renaissance," in Shalev and Burnett, *Ptolemy*, 1.

[58] Kerry V. Magruder, "Global Visions and the Establishment of Theories of the Earth," *Centaurus* 48, no. 4 (2006): 234.

[59] Magruder, "Global Visions," 252

[60] Magruder, "Global Visions," 243–244

[61] Magruder, "Global Visions," 244

The *Nihāya*, due to its being "a kind of historical summing up of the *hayʾa* (theoretical astronomy) literature up to Shīrāzī's time"[62] seems to be an excellent choice for looking for possible intercultural exchanges.

[62] F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*," 42.

1.2 Quṭb al-Dīn al-Shīrāzī and the *Nihāya*

Quṭb al-Dīn al-Shīrāzī, the great polymath of the 7–8th/13–14th centuries has attracted quite a bit of attention from both pre-modern and modern biographers, bio-bibliographers, historians and other scholars. He was a prolific author and his works cover a wide range of topics from Arabic grammar to astronomy, medicine and philosophy to Qurʾān and *ḥadīth* studies. However, many of his works are commentaries or translations of other scholars' works, whence comes his title *al-shāriḥ* (the commentator). Shīrāzī was also a prolific copyist, as evident in the significant number of his authenticated autograph anthologies that are extant in many manuscript collections around the world.

In this introduction, I will try to go beyond the common narrative of Quṭb al-Dīn al-Shīrāzī's biography to uncover another perspective on his life and works, with a focus on the trajectory of his travels, through the use of some important but neglected sources, such as autobiographical material that can be found in his own works, Persian chronicles, regional histories and manuscript witnesses. Arabic sources in general, and Mamluk ones in particular, have been exhausted by historians. On the other hand, Ilkhanid sources and chronicles from Seljuq Anatolia have often been neglected, even though they include brief but valuable contemporaneous material that can provide important information from a different perspective. The following narrative will be more focused on the episodes of his life related to his astronomical career and the composition of his first astronomical work, namely *Nihāyat al-idrāk fī dirāyat al-aflāk*. Thus, this should not be considered a full account of his biography; nevertheless, I hope it will be of use for anyone with a general interest in the life of Shīrāzī.

1.2.1 Shīrāzī's biography revisited

In his extant autographs, Shīrāzī usually introduces himself as "the neediest of God's creation, Maḥmūd b. Masʿūd b. al-Muṣliḥ al-Shīrāzī, may God make his end be good."[63] His *kunya* has been mentioned in the biographical sources as Abū al-Thanāʾ.[64] Later Mamluk sources mention his *Shāfiʿī* affiliation and give him honorary titles such as the philosopher (*al-faylasūf*), theologian (*al-mutakallim*), guide (*al-imām*), commentator (*al-shāriḥ*), polymath (*al-ʿallāma*), and experienced in many fields (*dhū al-funūn*).[65] However, contemporaneous historians, such as Ibn al-Fuwaṭī (d. 723/1323) or Khʷāja Rashīd al-Dīn Faḍl Allāh Hamadānī[66] (d. 718/ 1318), sufficed to call him "our master (*mawlānā*), Quṭb al-Dīn [al-]Shīrāzī" with titles such as philosopher (*al-ḥakīm*), geometer (*al-muhandis*) and scholar (*dānishmand*).[67]

The introduction to Shīrāzī's commentary on Ibn Sīnā's *Canon of Medicine*, entitled *al-Tuḥfa al-saʿdiyya*, contains important autobiographical information, wherein we learn that he was born to a well-known family of physicians originally form Kazerun (Kāzirūn, a city near Shiraz). Shīrāzī's father, the "high-minded *imām*," Ḍiyāʾ al-Dīn Masʿūd b. Muṣliḥ Kāzirūnī (d. 651/1254), was acknowledged unanimously by his colleagues as the Hippocrates and Galen of

---

[63] The original Arabic reads as:

«أحوج خَلق الله إليه محمود بن مسعود بن المصلح الشيرازي ختم الله له بالحُسنى»

[64] ʿAbd al-Razzāq b. Aḥmad Ibn al-Fuwaṭī, *Majmaʿ al-ādāb fī muʿjam al-alqāb*, ed. Muḥammad al-Kāẓim, 6 vols. (Tehran: Vizārat-i Farhang va Irshād-i Islāmī, 1995), 3:440; Shams al-Dīn Dhahabī, *Dhayl Tārīkh al-Islām*, ed. Māzin b. Sālim Bā Wazīr (Riyadh: Dār al-Mughnī li-al-Nashr wa-al-Tawzīʿ, 1998), 112, 115; Muḥammad b. Rāfiʿ Sallāmī, *Tārīkh ʿulamāʾ Baghdād al-musammá Muntakhab al-mukhtār*, ed. ʿAbbās ʿAzzāwī (Beirut: Dār al-ʿArabiyya li-al-Mawsūʿāt, 2000), 176; Khalīl b. Aybak al-Ṣafadī, *Aʿyān al-ʿaṣr wa-aʿwān al-naṣr*, facs. ed. Fuat Sezgin and Māzin ʿAmāwī, 3 vols. (Frankfurt: Institut für Geschichte der Arabisch-Islamischen Wissenschaften, 1990), 3:268; Khalīl b. Aybak al-Ṣafadī, *Kitāb al-wāfī bi-al-wafayāt*, ed. Aḥmad Arnāʾūṭ and Turkī Muṣṭafá, 29 vols. (Beirut: Dār Iḥyāʾ al-Turāth al-ʿArabī, 2000), 25:201.

[65] Ṣafadī, *Aʿyān*, 3:268; Ṣafadī, *al-Wāfī*, 25:201; Aḥmad b. ʿAlī Ibn Ḥajar al-ʿAsqalānī, *al-Durar al-kāmina fī aʿyān al-miʾa al-thāmina*, ed. Muḥammad Sayyid Jād al-Ḥaqq, 5vols. (Cairo: Dār al-Kutub al-Ḥadītha, 1966), 5:108; Jalāl al-Dīn Suyūṭī, *Bughyat al-wuʿāt fī ṭabaqāt al-lughawiyyīn wa-ʾl-nuḥāt*, ed. Muḥammad Abū al-Faḍl Ibrāhīm, 2 vols. (Cairo: Maṭbaʿat ʿĪsá al-Bābī al-Ḥalabī, 1964), 2:282.

[66] A well-known statesman and the greatest historian of the Ilkhanid period.

[67] Ibn al-Fuwaṭī, *Majmaʿ*, 3: 440; Rashīd al-Dīn Faḍl Allāh Hamadānī, *Jāmiʿ al-tavārīkh*, ed. Bahman Karīmī, 2 vols. (Tehran: Shirkat-i Nisbī-yi Ḥāj Muḥammad Ḥusayn Iqbāl va Shurakā, 1959), 2:788, 822.

his time[68] and was also an ascetic and *ṣūfī*. Ḍiyāʾ al-Dīn traveled extensively and was a companion of Fakhr al-Dīn al-Rāzī (d. 606/1210). After abandoning Rāzī's company, Ḍiyāʾ al-Dīn joined Najm al-Dīn Kubrá (d. 610 or 618/1213–14 or 1221–22), the founder of the *Kubrawiyya* order. He was then invested, by Najm al-Dīn, with the *ṣūfī* habit (*khirqa*) and studied with him.[69] Ḍiyāʾ al-Dīn returned to Shiraz where he resided for the rest of his life.[70] His return to Shiraz must have been before 630/1232–33, since we know he started his career as physician and professor of medicine in the Muẓaffarī hospital in Shiraz around 630.[71] In his *Kashf al-asrār al-īmāniyya wa-hatk al-asrār al-ḥuṭāmiyya*, Ḍiyāʾ al-Dīn raised objections against Shaykh Shihāb al-Dīn Suhrawardī's (d. 632/1234)[72] positions in *Rashf al-naṣāʾiḥ al-īmāniyya fī kashf al-faḍāʾiḥ al-yūnāniyya*.[73] Ḍiyāʾ al-Dīn passed away in Dhū al-Ḥijja 651/1254 in Shiraz and was buried in his own *zāwiya* (*ṣūfī* corner) when Quṭb al-Dīn was 14 years old.[74] This means Quṭb al-Dīn was born in Shiraz in 637/1239–40.[75]

---

[68] Quṭb al-Dīn Shīrāzī, *al-Tuḥfa al-saʿdiyya*, MS Ayasofya 3649, f. 3a.

[69] We do not know much about Ḍiyāʾ al-Dīn's other teachers or his study of other subjects; however, there is evidence that Ḍiyāʾ al-Dīn studied *hayʾa* with Jaghmīnī; see S. Ragep, *Jaghmīnī*, 19, fn. 75.

[70] ʿĪsá b. Junayd Shīrāzī, *Hazār mazār* (Shiraz: Kitābfurūshī-yi Aḥmadī, 1941), 41.

[71] Ḥasan b. Ḥasan Fasāʾī, *Fārs-nāma-yi Nāṣirī*, (Tehran: Intishārāt-i Kitābkhāna-yi Nisāʾī, 1312–1314/1894–1896), 250.

[72] Shaykh Shihāb al-Dīn Abū Ḥafṣ ʿUmar Suhrawardī (d. 632/1234) was a Persian Sufi and nephew of Abū al-Najīb Suhrawardī (d. 563/1168), who was the spiritual ancestor of the *Suhrawardiyya* order. Shihāb al-Dīn Suhrawardī is the author of the *ʿAwārif al-maʿārif*, a well-known work in *Taṣawwuf*.

[73] Junayd b. Maḥmūd Shīrāzī, *Shadd al-izār fī ḥaṭṭ al-awzār ʿan zawwār al-mazār*, ed. Muḥammad Qazvīnī and 'Abbās Iqbāl (Tehran: Navīd, 1987), 60–70; Junayd Shīrāzī, *Hazār mazār*, 41.

[74] Junayd Shīrāzī, *Hazār mazār*, 41–42; Fasāʾī, *Fārs-nāma*, 250. The date Dhū al-Ḥijja 651/1254 is clearly mentioned in *Hazār mazār* by ʿĪsá b. Junayd Shīrāzī, which is a Persian translation and revision of his father's Arabic work, *Shadd al-izār*. In the printed edition of *Shadd al-izār*, the death date of Quṭb al-Dīn's father is "*Dhī al-Ḥijja ḥijja* [*sic*. probably *sana*] *khams wa-khamsīn wa-sittamiʾa*" (Junayd Shīrāzī, *Shadd al-izār*, 70), *i.e.*, 655 H. This date does not accord with other dated events of Shīrāzī's life at all and would make Shīrāzī much younger than his depiction in pre-modern biographical dictionaries would suggest. Since this edition of *Shadd al-izār* is a very scholarly one, there is little chance of this being a typographical error. I consulted a manuscript witness of *Shadd al-izār* (MS 17618 National Library and Archives of I.R. of Iran, f. 17b) and found the date there as "*Dhī al-Ḥijja sana 655*." In another printed edition of *Hazār mazār* by Nūrānī Viṣāl, which, by the editor's own admission, is based on a very erroneous manuscript, the date has been mentioned as "*māh-i Dhī al-Ḥijja dar sāl-i shishṣad va*

Quṭb al-Dīn began his study of medicine with his father from a very young age and quickly learned by heart all the well-known epitomes dealing with medicine. He also learned common remedies and how to perform manual operations, specifically the "operation for cataracts" (*qadḥ*, couching of cataracts) in which, according to Shīrāzī himself, his "family was the most well-versed."[76] After his father's death, Quṭb al-Dīn was appointed as a physician and

---

panjāh va panjum az hijrat [*i.e.*, 655 AH]" (see ʿĪsá b. Junayd Shīrāzī, *Tadhkira-yi hazār mazār, tarjima-yi Shadd al-izār (mazārāt-i Shīrāz)*, ed. Nūrānī Viṣāl (Shiraz: Intishārāt-i Kitābkhāna-yi Aḥmadī, 1985), 111). Thereafter, I checked a random manuscript witness of *Hazār mazār* (MS 2437 National Library and Archives of I.R. of Iran, f. 50a) and found the date to be the same as the one in the older edition I use, namely "*māh-i Dhī al-Ḥijja dar sāl-i shishṣad va panjāh va yikum az hijrat* [*i.e.*, 651 AH]. There is an implication in Fasāʾī's entry about Shīrāzī's father in *Fārs-nāmay-i Nāṣirī*, 250, that can further confirm our date. He says:

«مسیح ثانی مستخرج قانون معانی امام همام ضیاءالدین مسعود طبیب بن مصلح کازرونی والد ماجد استاد الکل فی الکل مولانا قطب الدین محمود علّامهٔ شیرازی، و از بزرگان علماء و حکماء کازرونست سلطان الحکما و مقتدای فضلا کمال الدین ابوالخیر طبیب کازرونی برادر ضیاء الدین مسعود. **در حدود سال ششصد و سی و ششصد و پنجاه در بیمارستان مظفری شیراز هر یک بعد از دیگری** مشغول تدریس علم و طب و معالجه مرضی بودند.»

"The Second Christ, the excavator of the Canon of the concepts, the high-minded Imām, Ḍiyāʾ al-Dīn Masʿūd, the physician, son of Muṣliḥ Kāzirūnī, [is] the celebrated father of the master of everything, our lord, Quṭb al-Dīn Maḥmūd, the polymath from Shiraz. King of the sages and leader of the learned people, Kamāl al-Dīn Abū al-Khayr, the physician from Kāzirūn, brother of Ḍiyāʾ al-Dīn Masʿūd, is also one of the greatest scholars and sages of Kāzirūn. They were teaching science and medicine and treating patients in the Muẓaffarī hospital of Shiraz, **one after the other** in about 630/1232–1233 and 650/1252–1253."

The last sentence, and the phrase "one after the other" in particular, implies that Shīrāzī's uncle, Kamāl al-Dīn, taught medicine in the Muẓaffarī hospital and worked there right after Shīrāzī's father in about 650/1252–1253 when he was no longer alive.

[75] Our earliest biographers give different birth dates: Ibn al-Fuwaṭī mentions 630/1232–1233, Dhahabī 634/1236 and Sallāmī Ṣafar 634/1236 (Ibn al-Fuwaṭī, *Majmaʿ*, 3: 441; Dhahabī, *Dhayl*, 112; Sallāmī, *Muntakhab*, 182). Other sources all repeated 634/1236, apparently after Dhahabī or Sallāmī. Since 634 in Arabic is written أربع وثلثين وستمائة and 637 سبع وثلثين وستمائة, there is a possibility that a very early orthographic confusion might have happened due to graphic similarities of أربع and سبع in *taʿlīq* script. As we will see below, the year 637/1239 fits better in the chronology of Shīrāzī's life. *Muntakhab al-Mukhtār* by Ibn Rāfiʿ Sallāmī (d. 774/1372) contains the longest, yet least authentic biography of Quṭb al-Dīn Shīrāzī. To the best of my knowledge, it is the only biographical source in which the month of Shīrāzī's birth date is mentioned. It is also the only source that contains superficial anecdotes about the rivalry and hostility between Shīrāzī and Rashīd al-Dīn Faḍl Allāh Hamadānī (ca. 645–718/ca. 1247–1318), the famous statesman and historian of the Ilkhanid period.

[76] Shīrāzī, *al-Tuḥfa al-saʿdiyya*, f. 3a; Fasāʾī, *Fārs-nāma*, 140.

ophthalmologist at the Muẓaffarī Hospital. At this time, Quṭb al-Dīn's uncle Kamāl al-Dīn Abū al-Khayr b. Muṣliḥ Kāzirūnī (d. 659/1260–1261),[77] also a physician and *ṣufī*, assumed his brother's teaching position there.[78] Quṭb al-Dīn continued his medical studies with Sharaf al-Dīn Zakī Būshkānī (d. 677/1278–1279),[79] Shams al-Dīn Muḥammad Kīshī (d. 694/1294–1295),[80] and his uncle, Kamāl al-Dīn, all of whom were expert teachers of Ibn Sīnā's *Canon of Medicine*.[81]

After 10 years at the Muẓaffarī Hospital, in 661/1262–1263 Shīrāzī abandoned his job and traveled to Khurasan to find a master in medicine.[82] He ended up in Juwayn where he met

---

[77] Aḥmad b. Abī al-Khayr Zarkūb, *Shīrāz-nāma*, ed. Muḥammad Javād Jiddī and Iḥsānullāh Shukrullāhī, (Tehran: Muʾassasa-yi Taʾlīf, Tarjima va Nashr-i Āthār-i Hunarī-yi "Matn," 2011), 247.

[78] Fasāʾī, *Fārs-nāma*, 250.

[79] Junayd Shīrāzī, *Hazār mazār*, 13; Zarkūb Shīrāzī, *Shīrāz-nāma*, 242.

[80] Mudarrisī, *Sarguzasht*, 198-199.

[81] Shīrāzī, *al-Tuḥfa al-Saʿdiyya*, f. 3a–b

[82] Shīrāzī, *al-Tuḥfa al-Saʿdiyya*, f. 2b. Shīrāzī here gives the chronological order of his travels, after he explains that in order to learn more about medicine and the *Canon* of Ibn Sīnā, one cannot rely only on studying its commentaries, but must also practice with skilled physicians:

«...لا يكفي في معرفة هذا الكتاب الاحاطة بالقواعد الحكمية بل يجب أن يكون الشخص، مع ذلك طبيب النفس، ذا دُربة وممارسة بقانون العلاج في تعديل المزاج ثمّ سافرت إلى بلاد خراسان **ومنها** إلى عراق العجم **ثمّ** إلى عراق العرب بغداد ونواحيه **ومنه** إلى بلاد الروم»

"For learning this book, understanding of theoretical principles is not enough, and one, though himself a physician, should become skilled and experienced in methods of medical treatment and temperamental balance. Then, I traveled to Khurāsān, **and from there** to ʿIrāq al-ʿajam [Persia], **then** to ʿIrāq al-ʿArab [Iraq], *Baghdād* and its neighborhoods, **and from there** to bilād al-Rūm [Anatolia]."

Before mentioning his travels, Shīrāzī refers to his seeking assistance from Naṣīr al-Dīn Ṭūsī regarding his issues with Ibn Sīnā's *Canon of Medicine*. In modern literature, this reference has been taken as an implication of Shīrāzī's travel to Maragha in 658/1260 prior to his aforementioned series of travels. But this seems problematic for several reasons: 1) Shīrāzī is clear about the order of his travels; 2) being in Maragha in 658/1260 does not conform either with the death date of Shīrāzī's father nor with Shīrāzī's autobiographical details about his age at that time, which lead us to assume that 661/1263 is the earliest possible date for his departure from Shiraz; 3) this being so, there is no evidence of Ṭūsī's presence at Maragha in 661/1263. We know Ṭūsī was in Maragha between 657/1257 and 659/1261, but, apparently, he traveled to Khurasan to seek financial resources for the observatory that was being built in Maragha. Based on these reasons, Shīrāzī's seeking assistance from Ṭūsī could have been either direct or indirect. Since Shīrāzī refers to his seeking assistance as part of the description of his self-study of the commentaries of the *Canon*, he might be referring to the self-study of a work by Ṭūsī on the *Canon*, or more

Najm al-Dīn ʿAlī Dabīrān al-Kātibī (d. 675/1277) and stayed for two years to study philosophy and *kalām* with him. Shīrāzī became Kātibī's *muʿīd* in his lectures in a *madrasa* in Juwayn founded by Shams al-Dīn Juwaynī (executed in 4 Shaʿbān 683/17–18 Oct. 1284), who was *Ṣāḥib-i Dīvān* (approximately equivalent to a finance minister) to the Ilkhanid rulers Hülegü (r. 654–663/1256–1265), Abaqa (r. 663–681/1265–1282), and Aḥmad Tegüder (r. 681–683/1282–1284). Juwaynī was also a close friend of Ṭūsī and the future patron of Shīrāzī.[83] From a very important manuscript offered at Christie's auction in London on 26 April 2018[84] containing a copy of the *Tadhkira* followed by a copy of Ṭūsī's certificate for Shīrāzī, we learn that Shīrāzī studied the *Tadhkira* with Ṭūsī in 661/1263. Since we have assumed that in 661/1263 Shīrāzī left Shiraz for Khurasan, we can claim that Shīrāzī's first encounter with Ṭūsī was in Khurasan in the same year. He must have resided in Khurasan for two years because, in a conversation

---

probably a correspondence with him in this regard, especially since Shīrāzī says: "He [*i.e.*, Ṭūsī] resolved some of the obscurities:"

«**توجّهتُ** تلقاء مدينة العلم وشطر كعبة الحكمة وهي حضرة العلية البهية القدسية والسُدّة السنية الزكيّة الفيلسوفية الأستاذية النصيرية قدس الله نفسه وروّح رمسه **فانحلّ بعض المنغلق** وبقي البعض إذا لا يكفي في معرفة هذا الكتاب...[الخ]»

According to Lane *Lexicon*, *tawajjaha* has a connotation of indirect encounter with someone or something:

5. تَوَجَّهَ He tended, repaired, or betook himself, to, or towards, him, or it, **either in a direct course, or indirectly.**

Apparently, Ṭūsī wrote a super-commentary (*taʿlīqa*) on Ibn Sīnā's *Canon* and a treatise containing his response to Quṭb al-Dīn Shīrāzī's question, along with several treatises in response to Kātibī's objections to the *Canon* (see Mudarrisī, *Sarguzasht*, 144–145).

This is our preferred hypothesis as it conforms better to other data we have about Shīrāzī. The other hypothesis, favored by most modern and medieval scholars, is that Shīrāzī is here simply referring to a trip to Maragha, which was then followed by his other travels.

[83] Muḥaqqiq, "Quṭb," 172; Mudarris Raḍavī, *Aḥvāl va āthār*, 137-38. See also Anonymous, "Ṣudūr," 5:

«وقال الاربلى: وأخبرني الشيخ ضياء الدين الطوسي قال: اجتمعت بقطب الدين الشيرازي بقزوين وهو يقرأ الفقه على الشيخ علاء الدين الطاووسي صاحب التعليقة قال فسألته عن بعض أحواله فحكي لي اشتغاله بالطب وأنّه ترك معالجة الناس وخرج من شيراز وقصد بلاد خراسان وانه توفر مدة سنين على تحصيل علم المعقولات من علم الكلام قال وقال لي ما وجدت نفسي في عمري متوفراً على طلب العلم لم اشتعل بسوى (كذا) **هاتين السنتين هما كانتا خير تحصيل حصلت فيهما من العلوم النظرية ما أحياني** لكني غير عالم بالفقه فقصدت الشيخ علاء الدين الطاووسي لاقرأ عليه الفقه فقرأت عليه الحاوي الصغير وكتاب الوجيز.»

[84] This MS contains several works of Ṭūsī and his recensions of *mutawassiṭāt* ('middle works,' which were required to be studied between Euclid's *Elements* and Ptolemy's *Almagest*). Fortunately, a microfilm of this manuscript is extant in the Central Library of the University of Tehran (microfilm no. 2885). The entire codex seems to be copied from Shīrāzī's autograph copy.

with the *Shāfiʿī faqīh* Ḍiyāʾ al-Dīn al-Ṭūsī (d. 706/1306)[85] in Qazvin, Shīrāzī refers to his two-year study of rational sciences in Khurasan and described them as his best years of studying during which he attained "what gave him a new life."[86] Shīrāzī's expression is especially important if we see it in the context of the history of Shiraz. The Salghurid ruler of Shiraz during Quṭb al-Dīn's time there, Atābak Muẓaffar al-Dīn Qutlugh Khān Abū Bakr b. Saʿd (r. 623–659/1226–1261), the founder of the Muẓaffarī Hospital, was such a zealot that no one dared to study logic and philosophy during his era.[87] According to Vaṣṣāf al-Ḥaḍara, a contemporaneous chronicler from Shiraz, "he believed in ascetics and *ṣūfī*s but was scared of the sagacious people, so he harassed a group of them who were teaching philosophy and expelled them from Shiraz."[88]

In Qazvin, which seems to have been his next destination after Khurasan, Shīrāzī felt the need to study jurisprudence, so he started studying with Shaykh ʿAlāʾ al-Dīn Ṭāwūsī.[89] Shīrāzī might have traveled to Maragha from Qazvin in 663/1264[90] since, from the colophons of a very

---

[85] Ibn Qāḍī Shuhbah, Abū Bakr b. Aḥmad, *Ṭabaqāt al-fuqahāʾ al-Shāfiʿiyya*, ed. al-Ḥāfiẓ ʿAbd al-ʿAlīm Khān, 2 vols. (Beirut: Dār al-Nashr, 1987), 1:113.

[86] Anonymous, "Ṣudūr," 5. See fn. 83 above.

[87] ʿAbd al-Muḥammad Āyatī, *Taḥrīr-i Tārīkh-i Vaṣṣāf*, (Tehran: Bunyād-i Farhang-i Īrān, 1967), 91.

[88] Āyatī, *Taḥrīr*, 93. Modern biographers, probably due to Sallāmī's problematic account (*Muntakhab*, 178), considered this Khurasan trip chronologically after Shīrāzī's Maragha era and confused it with Shīrāzī's second Khurasan trip from Maragha during which he accompanied Ṭūsī (see Mudarris Raḍavī, *Aḥvāl va āthār*, 138).

[89] Dhahabī, *Dhayl*, 113; Anonymous, "Ṣudūr," 5.

[90] Cf. Ibn al-Fuwaṭī, *Majmaʿ*, 3:440 where he says Shīrāzī came to Maragha to the presence of our master Naṣīr al-Dīn in 658/1260 (قدم مراغة إلى حضرة مولانا وسيدنا نصير الدين سنة ثمان وخمسين وستمائة). This date contradicts our first-hand information about Shīrāzī's life from his autobiographical account and from local sources. Furthermore, we cannot prioritize Ibn al-Fuwaṭī's report only on the ground the he was a contemporary. It is true that Ibn al-Fuwaṭī was the Maragha observatory librarian and that he wrote his biographical encyclopedia, *Majmaʿ al-ādāb*, based on his own observations (for his life and scholarly activity, see Ryo Mizukami, "Nigāhī bi zindagī va faʿʿāliyat-hāyi ʿilmī-yi Ibn-i Fuwaṭī," *Āyina-yi Pajūhish* 157 (April–May 2016): 20–43). However, Ibn al-Fuwaṭī's biography of Shīrāzī has the implication that he did not witness Shīrāzī's arrival in Maragha himself. This can be supported by the following facts: 1) Even though Ibn al-Fuwaṭī was present at Maragha from 657/1259 when Ṭūsī was preparing the foundation of the observatory, he might have started his work as the librarian of the observatory sometime around 662/1263–1264, after which he was travelling back and forth between Maragha and Tabriz (see Mizukami, "Ibn-i Fuwaṭī," table in 21–22, 24); 2) In *Majmaʿ al-ādāb*, Ibn al-Fuwaṭī uses the phrase "came to us in Marāgha" (قدم علينا

important autograph codex, MS Ahmet III 3455,[91] we know he was copying different works of Naṣīr al-Dīn Ṭūsī and other scholars on various topics, including astronomy, between 663/1264 and 664/1266 in Maragha. So, it is clear that he continued studying astronomy in Maragha with Ṭūsī and probably others. We are not sure if Shīrāzī had the chance to study with Muʾayyid al-Dīn al-ʿUrḍī who died in Maragha in 664/1266, almost a year after Shīrāzī's arrival. However, Shīrāzī's astronomical works show that he was certainly familiar with the work of ʿUrḍī.

In 665/1267 Ṭūsī travelled to Khurasan with an entourage of his pupils, including Shīrāzī.[92] From the colophon of Shīrāzī's autograph copy of Ṭūsī's *Zubdat al-hayʾa* in MS Ahmet III 3455, we learn that Ṭūsī wrote the *Zubda* during this trip while visiting the Khudāyshāh tomb[93] in Jazīn, Southern Khurasan.[94] It is apparently at the end of this almost

---

مراغة) in the biographies of the individuals whose arrival at Maragha he has witnessed himself (see for example Ibn al-Fuwaṭī, *Majmaʿ*, 2:459, 542; 3:78, 402, 533; 4:32, 65, 97, 100, 118, 259; 5:108, 248, 258, 367, 552, 563, and many other places), which he does not use for Shīrāzī; 3) Ibn al-Fuwaṭī also gives erroneous information about Shīrāzī's most known astronomical work *i.e.*, *Nihāyat al-idrāk* (Ibn al-Fuwaṭī, *Majmaʿ*, 4:564).

So, it is very reasonable to assume that because Ibn al-Fuwaṭī had, since he started his job as the librarian of the observatory, always seen Shīrāzī accompanying Ṭūsī, it occurred to him that Shīrāzī came to Maragha in 658/1260. However, later during Shīrāzī's residence in Tabriz (689–710/1290–1311), Ibn al-Fuwaṭī, who attended scholarly assemblies in Shīrāzī's *zāwiya* in Charandāb (see for example, Ibn al-Fuwaṭī, *Majmaʿ*, 3: 470; 4:138-139, 499), got to know Shīrāzī to the extent that he began his biography with the statement: "If I want to start describing his manners I would need a volume for just this; he possesses prophetic virtue, divine knowledge, noble soul, magnanimity, and generosity."

[91] Topkapı Sarayı (Istanbul, Turkey). My colleague, Sajjad Nikfahm-Khubravan, and I are preparing a technical description of this codex.

[92] Mudarrisī, *Sarguzasht*, 84, 91; Mudarris Raḍavī, *Aḥvāl va āthār*, 138; Jorati, *Science and Society*, 194; see also Ibn al-Fuwaṭī, *Majmaʿ*, 4:96–97, no. 3425 for a mention of Ṭūsī's Khurasan trip in 666/1268, and 4:259, no. 3802 that shows he was back in Maragha by 668/1270.

[93] It is a tomb in the village of Jazīn, near the historical city Tūn (modern Ferdows) in Southern Khurasan Iran.

[94] MS Ahmet III 3455, f. 68b:

«تمّ الكتاب قبيل الصبح في العشر الأخير من ربيع الآخر سنة ست وستين وستمائة بمقام خدايشاه جزين وكتبه أحوج خلق الله إليه محمود بن مسعود بن المصلح المتطبب الشيرازى أصلح الله أعماله من نسخة مكتوبة من أصل المصنف دام ظلّه مقابلة به ايضاً»

"This book has been completed shortly before the morning in the last tenth of the Rabīʿ al-Ākhir of the year 666 in Khudāyshāh of Jazīn. The neediest servant of God, Maḥmūd b. Masʿūd b. al-Muṣliḥ, the physician, al-two-year trip that the 30-year-old Shīrāzī had been invested with the "habit of aspiration" (*khirqat al-irāda*) by Muḥyī al-Dīn Aḥmad b. ʿAlī b. Abī al-Maʿālī al-Jājarmī of the *Kubrawiyya* order.[95]

From the introduction to *al-Tuḥfat al-saʿdiyya*, we know that Shīrāzī at some point left ʿIrāq al-ʿajam (Persia) for ʿIrāq al-ʿArab (Iraq), visited Baghdad and its neighboring regions, and from there traveled to bilād al-Rūm (Anatolia). Shīrāzī must have parted with Ṭūsī before the latter's final revisions of the *Tadhkira* in 672/1273 in Baghdad because, in his super-commentary on the *Tadhkira*, Shīrāzī refers to revisions in the *Tadhkira* made by Ṭūsī after Shīrāzī had left his company.[96]

Shīrāzī apparently arrived in Konya, Anatolia in his early thirties, according to Rūmī's (d. 5 Jumādá al-Thānī 672/ 17–18 December 1273) hagiographer, Shams al-Dīn Aflākī (d. 761/1360) who relates an account of Shīrāzī's discipleship to Rūmī on the authority of Shīrāzī himself in his *Manāqib al-ʿārifīn*.[97] Konya at the time was a great learning center with scholars and *ṣūfī* figures like Ṣadr al-Dīn Qūnawī (d. 16 Muḥarram 673/22–23 July 1274) and Rūmī who attracted hundreds of students there. We know that Qūnawī's *Jāmiʿ al-aḥādīth* lectures were very famous and even high-ranked officials of the Seljuq state of Anatolia like Muʿīn al-Dīn Parvāna (executed in 1 Rabīʿ al-awwal 676/2–3 August 1277) had attended them.[98] An

---

Shīrāzī—may God amend his deeds—has copied it from a manuscript written from and also collated with the original [manuscript] of the author, whose patronage may continue."

[95] Pourjavady and Schmidtke, "Ijāzāt," 30–31, 45

[96] See Shīrāzī, *Faʿalta fa-lā talum*, f. 27a; F.J. Ragep, *al-Tadhkira*, 1:72–73, 78. The version of the *Tadhkira* upon which Shīrāzī has based his longest *hayʾa* work, entitled *Nihāyat al-idrāk fī dirāyat al-aflāk*, does not contain Ṭūsī's latest revisions.

[97] Shams al-Dīn Aḥmad Aflākī, *Manāqib al-ʿārifīn*, ed. Tahsin Yazıcı, 2 vols. (Ankara: Türk Tarih Kurumu Basımevi, 1959), 1:423:

«الحکایة: همچنان راویانِ حکایت و حاویانِ حکمت از خدمتِ ملك المدرسین، سلطان القضاة، مولانا قطب الدینِ شیرازی رحمةُ اللهِ عَلَیْهِ چنان روایت کردند که روزی در مجمعِ فضلای تبریز حکایت کرد که در اوانِ شرح[کذا] الشبابي چون بقونیه رسیذم و...»

According to Lane *Lexicon*, شرخ means "the beginning, commencement, or first period or state of a thing, or an affair, and also of youth"; and شباب and شبیبة [and شبابیة] means "the age before الکهولة or the state between thirty and forty."

[98] Aflākī, *Manāqib*, 1:165.

autograph note by Shīrāzī on the title page of a manuscript of the second volume of Ibn Athīr's *Kitāb jāmiʿ al-uṣūl fī aḥādīth al-rasūl*[99] indicates he had been reading the entire book to Ṣadr al-Dīn Qūnawī in the latter's house in Konya in 673/1274, which Qūnawī acknowledged orally.[100] Shīrāzī could only manage to finish the correction of this copy of Ibn Athīr's *Jāmiʿ al-uṣūl* five years later in 678/1279, due to the difficult circumstances following the death of Qūnawī in 673/1274.[101]

Shīrāzī entered Anatolia at a very turbulent time. The rulers of Anatolia, which was under the Mongol Protectorate at the time, were originally subordinate lines of the Seljuq family who managed to maintain themselves in Anatolia after the overthrow of the Great Seljuq Empire. However, at this time Seljuq sultans were only puppet rulers since all the power within the Seljuq state was held by a semi-independent ruling class whose members were directly appointed by the Mongols. This ruling class took shape within the Seljuq state after the Köse Dagh battle in 641/1243, which opened up Anatolia to the Mongols. Among this ruling class, Muʿīn al-Dīn Sulaymān Parvāna (personal assistant of the sultan), who was directly appointed by the Mongols, eventually became the *de facto* ruler of the Seljuq state in Anatolia and began "to resent increasing Mongol encroachment on Sal<u>dj</u>ūḳ territory and the Mongols' systematic exploitation of its economic resources," to the extent that in 672/1273–1274 he requested the removal of the Ilkhan Abaqa's brother and representative of the time in Anatolia, Ajāy.[102]

---

[99] MS no. 300 Feyzullah, Millet Library, Istanbul, Turkey.

[100] Hellmut Ritter, "Autographs in Turkish Libraries," *Oriens* 6, no. 1 (1953): 84, plate XIII. Given that Qūnawī passed away at the beginning of 673/1274 (see below), this implies that Qūnawī probably acknowledged Shīrāzī's *qirāʾa* of *Jāmiʿ al-uṣūl* to him while the former was housebound due to the shock of Rūmī's death. According to Āqsarāyī (d. between 723/1323 and 733/1333), a contemporary chronicler of Anatolia, after Rūmī's death in 672/1273 [5 Jumādá al-Thānī 672/ 17–18 December 1273], Qūnawī performed his funeral prayer, fell sick immediately after and had to be carried back to his *zāwiya*. Eight months later [16 Muḥarram 673/22–23 July 1274] he too passed away (see Maḥmūd b. Muḥammad Āqsarāyī, *Musāmarat al-akhbār wa musāyarat al-akhyār*, ed. Osman Turan (Ankara: Türk Tarih Kurumu Basımevi, 1944), 119.

[101] Ritter, plate XIII.

[102] Carole Hillenbrand, "Muʿīn al-Dīn Sulaymān Parwāna," in: *Encyclopaedia of Islam, Second Edition*, ed. P. Bearman et. al. Consulted online on 28 November 2017 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_5442> First published online: 2012.

This year, 672/1273–1274, is a critical year in the history of Seljuq Anatolia. From the beginning of this year, "tremendous afflictions occurred to the grandees of religion and the masters of truth and faith, who were all companions and friends of Parvāna, and they passed away one after another such that when the calamity of the Shām (Syria, in Persian it also means night) attack happened [see below], nothing was left from their clear morning," according to Āqsarāyī (d. between 723/1323 and 733/1333), a contemporary chronicler of Anatolia.[103] Under the section on the "death of grandees" in 672/1273–1274, Āqsarāyī continues with the stories of the death of Rūmī, Ṣadr al-Dīn Qūnawī and Naṣīr al-Dīn Ṭūsī. According to Āqsarāyī, this year was also disastrous with respect to the death of judges in Anatolia. He mentions particularly Sirāj al-Dīn ʿUrmawī, judge of Konya, and ʿIzz al-Dīn ʿUrmawī, judge of Sivas, among those who passed away in 672/1273–1274. It is probably due to the vacuum created as a result of the demise of the Shaykh al-Islam Qūnawī and several judges that Parvāna appointed Shīrāzī as the judge of Malatya and Sivas.[104] It might have been at this time that Shīrāzī took up residence in Sivas.

In 674/1276, certain Anatolian *amīrs*, along with Parvāna's son, went to Syria and provoked the Mamluk sultan to invade Anatolia and rid it of the Mongol yoke. In 675/1277, Baybars (r. 658-675/1260–1277) invaded Anatolia and defeated the Mongol army at Albistān (10 Dhū al-Qaʿda 675/16–17 April 1277).[105] After the battle, the Mamluk sultan entered Kayseri and summoned the Parvāna who had retreated to his stronghold at Tokat. Parvāna refused to consent to his request. After a week or so, Baybars withdrew to Syria. In Ṣafar 676/July 1277 Ilkhan Abaqa departed Tabriz for Anatolia and visited the battlefield at Albistān. He then burst into anger, punished Anatolian nobles, and ordered the sack of several cities, including Sivas where Shīrāzī lived. Shams al-Dīn Juwaynī intervened and when half of Sivas was being sacked, Juwaynī told Abaqa that "a just king never punishes the masses for the

---

[103] Āqsarāyī, *Musāmara*, 119:

«و از ابتدای سنه اثنین و سبعین و ستمائة اول حوادث اجل روی بدان بزرگان دین و ارباب صدق و یقین آورد و چون جمله جلیس و انیس پروانه بودند پیش از واقعهٔ او جمله یکان یکان درگذشتند چنان‌که چون نازلهٔ خروج لشگر شام شد از صبح صفای ایشان اثری نمانده بود.»

[104] Dhahabī, *Dhayl*, 114.

[105] Rashīd al-Dīn, *Jāmiʿ al-tavārīkh*, 2:768.

nobles' offense." Abaqa accepted Juwaynī's intercession. He left Anatolia for Alataq[106] after destroying Parvāna's strongholds in Tokat and in 676/1277 put a Mongol prince in charge of protecting Anatolian territory with a large army. After Abaqa's return, Parvāna, who was under suspicion of having been in league with the Mamluks and clearly very frightened, surrendered himself in Alataq. He was finally convicted of collusion with the Mamluks and executed in 1 Rabīʿ al-Awwal 676/2–3 August 1277. The demise of the Parvāna marked the end of semi-independent Seljuq rule in Anatolia and brought it under the direct rule of the Ilkhans. In 17 Rabīʿ al-Thānī of the same year/18–19 September 1277, Shams al-Dīn Juwaynī went to Anatolia to reconstruct the sacked cities and establish an Ilkhanid tax system.[107]

Shīrāzī refers to this stormy period in the introduction of his first astronomical work, namely *Nihāyat al-idrāk fī dirāyat al-aflāk*, the first version of which was completed in mid-Shaʿbān 680/late November 1281 in Sivas. He describes this time as "an extended period, during which the pain of hardship had injured [my] soul and the difficult circumstances of distress had afflicted it, there being no pathway from the blessing of security to my heart nor a leader or guide taking me to that [security], I sought help once again by contacting his honor…"[108] By "his honor," he means that of Shams al-Dīn Juwaynī who was his patron at the time. Regarding the "security" he sought, Shīrāzī was most likely referring to protection from the aftermath of the tumultuous events leading to the execution of his patron Muʿīn al-Dīn Parvāna.

Shortly after preparing the first draft of the *Nihāya*, Shīrāzī started revising it. Meanwhile, he also finished another astronomical work entitled the *Ikhtiyārāt-i muẓaffarī* (Muẓaffarī

---

[106] Alātāq, Ālāṭāgh (آلاطاغ) or Alātāgh, written in Modern Turkish as Aladağ, is a Turkish place name that means "variegated mountain." Here, it refers to the Ilkhans' summer camp in the north of Lake Van, probably at the foothills of Tendürek Dağı (Mount Tendürek) in Modern Turkey.

[107] Rashīd al-Dīn, *Jāmiʿ al-tavārīkh*, 2:768–769. There is an inscription in the Çifte Minareli madrasa in Sivas saying that it was built/restored in 670/1270–1271 by the order of "*al-Ṣāḥib al-aʿẓam malik mulūk al-wuzarāʾ fī al-ʿālam **Shams** al-dunyā wa-**al-Dīn** Muḥammad b. Muḥammad b. Muḥammad **Ṣāḥib al-Dīwān***" (see, Etienne Combe, Jean Sauvaget, and Gaston Wiet, *Répertoire chronologique d'épigraphie Arabe*, vol. 12 (Le Caire: L'Institut Français d'archéologie orientale, 1943), 163). This can be taken as an indication of Shams al-Dīn Juwaynī's intellectual and fiscal interest in Anatolia, in general, and Sivas, in particular.

[108] Ragep, "Shīrāzī's *Nihāyat*," 53.

selections) in Persian on 9 Dhū al-Ḥijja 680/22–23 March 1282 in Sivas, almost three months after the appearance of the first version of the *Nihāya*.[109] However, we know that he continued revising the *Nihāya* after the completion of the *Ikhtiyārāt* since the latter was referred to in the revisions of the *Nihāya*. He dedicated the *Ikhtiyārāt* to Muẓaffar al-Dīn Yavlak Arslan (r. 1280–1292), the local ruler of a small emirate in Kastamonu.

On 20 Dhū al-Ḥijja 680/1–2 April 1282, Ilkhan Abaqa died and on 26 Muḥarram 681/6–7 May 1282, Aḥmad Tegüder was selected as the next Ilkhan. Aḥmad Tegüder launched a series of political measures right after his ascension to the throne in 13 Rabīʿ al-Awwal 681/21–22 June 1282. The most important of these was his decision to make peace with the Mamluk sultan, Sayf al-Dīn Qalāwūn (r. 1279–1290), and he subsequently sent a diplomatic mission to him.[110] Shams al-Dīn Juwaynī suggested that Shīrāzī be the main envoy for this mission. Shīrāzī was probably called to Alataq in Rabīʿ al-Thānī 681/July 1282[111] and might have arrived there by the beginning of Jumādá al-Ūlá/August of the same year. He left Alataq on 19 Jumādá al-Ūlá 681/25–26 August 1282 for Egypt with Atābak Bahāʾ al-Dīn.[112] They were decreed to deliver a letter to the Mamluk sultan, Sayf-al-Dīn Qalāwūn (r. 1279–1290), signed by the Ilkhan in mid Jumādá al-Ūlá 681/late August 1282 in Alataq,[113] containing the news of his conversion to Islam. In the letter, Shīrāzī was referred to as "the most-learned judge (*aqḍá*

[109] Niazi, "Quṭb al-Dīn," 33, fn. 1; 34.

[110] Shīrāzī, *al-Tuḥfa al-Saʿdiyya*, f. 4b; Muḥyī al-Dīn Ibn ʿAbd al-Ẓāhir, *Tashrīf al-ayyām wa-ʾl-ʿuṣūr fī sīrat al-Malik al-Manṣūr*, ed. Murād Kāmil and Muḥammad ʿAlī Najjār, 2 vols. (Cairo: al-Jumhūriyya al-ʿArabiyya al-Muttaḥida, Wizārat al-Thaqāfa wa-al-Irshād al-Qawmī, al-Idāra al-ʿĀmma li-al-Thaqāfa, 1961) 1:5; Āqsarāyī, *Musāmara*, 136; Rashīd al-Dīn, *Jāmiʿ al-tavārīkh*, 2:788; Āyatī, *Taḥrīr*, 70.

[111] From Rashīd al-Dīn, *Jāmiʿ al-tavārīkh*, 2:788, we know that Aḥmad Tegüder dispatched an army to Anatolia in 4 Rabīʿ al-Thānī 681/12–13 July 1282 to safeguard its territory, especially from sporadic Mamluk encroachments. Shīrāzī might have received the royal decree for his nomination as Aḥmad Tegüder's envoy to Malik Manṣūr Qalāwūn from the officials of this army.

[112] Rashīd al-Dīn, *Jāmiʿ al-tavārīkh*, 2:788. See Āqsarāyī, *Musāmara*, 136, who mentions Bahāʾ al-Dīn Rūdkurdī. This person is very likely the Bahāʾ al-Dīn Verkurdī mentioned in: Anonymous, *Tārīkh-i Āl-i Saljūq dar Ānāṭūlī*, ed. Nādira Jalālī (Tehran: Daftar-i Nashr-i Mīrāth-i Maktūb, Āyina-yi Mīrāth, 1999), 109–110.

[113] Ibn ʿAbd al-Ẓāhir, *Tashrīf*, 10. Cf. Āyatī, *Taḥrīr*, 70, who has the signature date as the end of Jumādá al-Ūlá, which cannot be true because according to the contemporary chronicler, Rashīd al-Dīn (*Jāmiʿ al-tavārīkh*, 2:788), Shīrāzī left Alataq on 19 Jumādá al-Ūlá 681/25–26 August 1282.

al-quḍāt)"[114] and one of the authorities (*min thiqāt*) of the Ilkhanid state. He had probably returned to Anatolia from this mission by the beginning of 682/April 1283.[115]

In the period between 682/1283 and 689/1290, Shīrāzī very likely stayed in Anatolia, mostly Sivas, and was occupied with writing different works. In 682/1283 Shīrāzī started the composition of his commentary on Ibn Sīnā's *Canon of Medicine*,[116] the main sources needed for which were acquired during his mission to Egypt.[117] He finished the first part in 694/1294–1295 in Tabriz and dedicated it to Ṣāḥib-i Dīvān of the time, Saʿd al-Dīn Sāvajī (d. 10 Shawwāl 711/19–20 February 1312).

In 4 Shaʿbān 683/17–18 October 1284 Shīrāzī's major patron *Ṣāḥib-i Dīvān* Shams al-Dīn Juwaynī was killed, after the murder of Aḥmad Tegüder by his brother and the next Ilkhan, Arghūn (r. 683–690/1284–1291).

In Jumādá al-Ūlá 684/July–August 1285 in Sivas, Shīrāzī finished his third astronomical work *al-Tuḥfa al-shāhiyya* (the imperial gift) in Arabic and dedicated it to the Seljuq official Amīr Shāh b. Tāj al-Dīn Muʿtazz b. Ṭāhir, whose appointment as "lieutenant of the sultan" (*nāʾib al-salṭana*) was confirmed by the Ilkhanid state in the same year.[118] Along with Amīr Shāh, Fakhr al-Dīn Qazvīnī was confirmed as the vizier of the Anatolian province. Unlike Amīr Shāh, who was very popular, Fakhr al-Dīn was regarded by his people as "a greedy tax-

---

[114] According to Dihkhudā, *aqḍá al-quḍāt* was considered a high position among the judges but not as high as "the chief judge (*qāḍī al-quḍāt*);" see ʿAlī-Akbar Dihkhudā, *Lughat-nāma*, under the entry *aqḍá al-quḍāt*.

[115] According to Ibn ʿAbd al-Ẓāhir (*Tashrīf,* 6), on their way to Egypt, the delegates arrived in Aleppo on 21 Jumādá al-Thānī 681/26–27 September 1282. They then went to Damascus and from there to Egypt. After accomplishing their mission, on their way back to Alataq, they arrived in Aleppo on 6 Shawwāl 681/7–8 January 1283 (Ibn ʿAbd al-Ẓāhir, *Tashrīf,* 16). Within one month, they might have arrived in Alataq with Malik Manṣūr's reply to the Ilkhanid ruler Aḥmad Tegüder.

[116] Shīrāzī, *al-Tuḥfa al-saʿdiyya*, f. 4b

[117] Shīrāzī, *al-Tuḥfa al-saʿdiyya*, f. 4a

[118] Āqsarāyī, *Musāmara*, 148. See also Gary Leiser, "al-Aqsarāyī, Karīm al-Dīn," in *Encyclopaedia of Islam, THREE,* edited by: Kate Fleet, Gudrun Krämer, Denis Matringe, John Nawas, Everett Rowson (Consulted online on 05 November 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_26349>). According to Leiser, Mujīr al-Dīn Amīr Shāh was appointed by Abaqa to administer the finances, including the *iqṭāʿ*s, of the Ilkhanid treasury and had been appointed as *nāʾib al-salṭana* by the Seljuq sultan Masʿūd II (r. 682–696/1283–1296).

collector."[119] They did not get along well, so Anatolia was divided between them in 688/1289 and Amīr Shāh controlled the Western part of the territory, namely Dānishmandiyya province, the area from Sivas and Tokat to Kastamonu and along the Sinop and Samsun coastlines.[120] This was the case until the vizierate of Saʿd al-Dawla Yahūdī (executed in 3 Rabīʿ al-Awwal 690/6–7 March 1291) in 690/1291. Saʿd al-Dawla appointed a new vizier and lieutenant for Anatolia, and summoned Amīr Shāh and Qazvīnī to Alataq the same year. They were humiliated by new Ilkhanid officials and sent to Alataq under arrest along with their entourage. According to Āqsarāyī, who had been at Amīr Shāh's service since his appointment as the *nāʾib al-salṭana* and was thus directly involved in this event, they finally arrived in Alataq in the spring of 690/1291, sometime between Jumādá al-Ūlá and Thānī/May and June.[121] Although Āqsarāyī never mentions any names of those who accompanied Amīr Shāh, and considers it enough to say: "his entourage including the ruler and the subject, and master and servant,"[122]

---

[119] Apparently, the office of the lieutenancy was below the vizierate in the administrative ranking of the Seljuqs of Anatolia, as Āqsarāyī (*Musāmara*, 149) says:

«اگر چه صاحب قزوینی چون صفر میان تهی که بر رقم تقدم نماید باسم وزارت بر امارت مجیرالدین امیرشاه تقدم می‌نمود، اما به نسبت امارت و نیابت اصلی، حل و عقد کلی و جزوی در تحت امر و نهی مجیرالدین امیرشاه بود و چون خلق رغبت کلی به واسطهٔ حسن و خلق به درگاه او می‌نمودند، نسبت قزوینی با شکوه جاه او از ثری تا به ثریا و از ارض تا سما تفاوت داشت.»

"Even though Ṣāḥib Qazvīnī by his vizierate title had priority over Mujīr al-Dīn Amīr Shāh's lieutenancy, but like a hollow zero that is prior to a digit, with regard to the real commandership and lieutenancy, Mujīr al-Dīn Amīr Shāh possessed the power over all affairs, and since people were generally inclined to his highness, the glory of his dignity compared to Qazvīnī's was a horse of a another color."

[120] Āqsarāyī, *Musāmara*, 153.

[121] Āqsarāyī, *Musāmara*, 161 (for the full story, see 156–167).

[122] Āqsarāyī, *Musāmara*, 160, 162, 198. He does not even clearly say that he himself was among them, although it is certain from pages 162–163 where he says "to sum up, Mujīr al-Dīn, together with his entourage including the ruler and the subject, and master and servant, **we** [all] **hold out** [against this ordeal] like a strand of hair [coming out of the] dough."

[فی الجمله مجیرالدین نائب و اتباع او از صدمت آن ورطه از حاکم و محکوم و خادم و مخدوم چون موی از خمیر **بیرون آمدیم**.]

For another witness of Āqsarāyī being among the entourage in this ordeal, see Āqsarāyī, *Musāmara*, 198:

«مؤلف گوید: فضل نامتناهی الهی مدد کرد که بمشاورت رای و استخارت آرای ثاقب مجیرالدین امیرشاه از تقاعد او تباعد نمود **و ما جمله اصحاب** از دایرهٔ تخلف او بتکلیف **بیرون آمدیم** و از معرض آن سیلاب بلیت **احتراز نمودیم**... [الخ]»

See also Leiser, "al-Aqsarāyī, Karīm al-Dīn."

Rashīd al-Dīn’s account of the events around the same time implies Shīrāzī was among them. We will mention here Rashīd al-Dīn’s account of Shīrāzī’s intercession for Amīr Shāh since it offers an important depiction of Shīrāzī’s position in the Ilkhanid state:

> “… The royal army/Urdū tended toward Alataq and arrived there on 13 Shaʿbān 689[/22–23 August 1290], and from there toward Van. Then the Sulṭān [Arghūn] returned, and in that residence [*i.e.*, Alataq] *Mawlānā* Quṭb al-Dīn was received by the sultan and presented a map of the Mediterranean Sea with its gulfs and coastline, which includes many of the Western and Northern provinces. The king extremely enjoyed his conversation with him, since he was describing the provinces of Anatolia. Meanwhile ʿAmmūriyya,[123] which is in Anatolia, caught the king’s eye [who was looking at the map] and he ordered Quṭb al-Dīn to talk about it. He gave a very nice speech comprising the praise of the King and the description of ʿAmmūriyya, which was desirable to the king who was about to leave for hunting. The king told *Mawlānā* ‘let us have a conversation when I am back, since you speak so nicely.’ He ordered Saʿd al-Dawla to call the three of them, namely Amīr Shāh, Fakhr al-Dīn Mustawfī and the son of Ḥājī Laylī, as they were caught and brought from Anatolia. *Mawlānā* Quṭb al-Dīn blamed Saʿd al-Dawla for [arresting] Amīr Shāh, and Saʿd al-Dawla ran after the king and saved him [*i.e.*, Amīr Shāh].”[124]

Amīr Shāh survived this ordeal and held the position of lieutenancy until his death in 7 Rajab 701/9–10 March 1302, while the other two were killed.

---

[123] Ancient Amorium; its ruins are located under and around the modern village of Hisarköy, Turkey.

[124] Rashīd al-Dīn, *Jāmiʿ al-tavārīkh*, 2:822–823:

«... رایات همایون متوجه به ییلاق الاتاق شدند و در سیزدهم [شعبان ۶۸۹] آن‌جا رسیدند و از آن‌جا به راه وان، و سلطان مراجعت فرمود و در آن منزل [الاتاق] مولانا قطب الدین شیرازی به بندگی رسید و صورت دریای مغرب و خلیج‌ها و سواحل آن که مشتمل است بر بسیاری ولایات غربی و شمالی، به محل عرض رسانید و پادشاه را محاورهٔ او به غایت خوش آمد، چه شرح ولایات روم می‌داد و در اثنای آن، نظر پادشاه بر عموریه افتاد که روم اندرونست و به بیان او مولانا را اشارت فرمود. او فصلی به غایت پاکیزه مشتمل بر دعا و ثنای پادشاه و شرح آن حال ادا کرد و او را عظیم موافق افتاد و به عزیمت شکار برمی‌نشست، مولانا را گفت چون بازگردم بیا تا سخن گوییم که به غایت خوش می‌گویی و به سعدالدوله اشارت کرد که بگو تا هر سه را بخوانند ـــ یعنی امیرشاه و فخرالدین مستوفی و پسر حاجی لیلی ـــ چه هر سه از روم گرفته آورده بودند. و مولانا قطب الدین به جهت امیرشاه با سعدالدوله معاتبت کرد. او بر عقب پادشاه دوانید و او را خلاص داد.»

Apparently Shīrāzī never returned to Anatolia and spent the rest of his life in Tabriz where he taught and wrote several other important works. Among them we will only mention his last astronomical work, namely *Faʿalta fa-lā talum* (*lit.* "you've done it so don't blame [me]," completed sometime after 700/1300 in Tabriz), a super-commentary on Ṭūsī's *Tadhkira* and in fact a harshly worded attack on the commentator of the *Tadhkira* who, according to Shīrāzī, plagiarized his *Tuḥfa*.

Shīrāzī's life in Tabriz, compared to Anatolia, was rather peaceful and stable. Most of this last episode of his life passed under the Ilkhanate of Ghāzān (r. 694–713/1295–1304) who, following many of the Ilkhanid military elite, converted to Islam and attempted to establish his rule largely on religious grounds and independent from the Great Qāʾān in China. Under Ghāzān and his influential vizier, Khʷāja Rashīd al-Dīn Faḍl Allāh Hamadānī, [125] Tabriz experienced a secure and prosperous era. Shīrāzī apparently spent most of his time as a great prestigious scholar, teaching and writing. His *zāwiya* in Charandāb was a center for scholarly gatherings. His most known students in Tabriz were Niẓām al-Dīn al-Nīsābūrī (d. 1329–1330) and Kamāl al-Dīn al-Fārisī (d. 1319).

Shīrāzī died on 16 Ramaḍān 710/7–8 February 1311 in Tabriz and was buried in Charandāb.

1.2.2 The *Nihāya*

The *Nihāyat al-idrāk fī dirāyat al-aflāk* (the utmost attainment in comprehending the orbs) is Shīrāzī's first and most voluminous work on *hayʾa*. This work is apparently Shīrāzī's first major scholarly product after the stormy years of 672–676/1273–1277, when he finally found the opportunity to get back to *hayʾa* which was, according to him, "the most noble of the sciences," and compose a treatise on *hayʾa* for himself and for his colleagues, a task which he had resolved to do probably since his time with Ṭūsī.[126]

[125] During Ghāzān's reign in 697/1298, Rashīd al-Dīn was appointed associate vizier to Saʿd al-Dīn Sāwajī.

[126] F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*," 52.

The style and process of composition of the *Nihāya* is interesting. Shīrāzī informs us in the introduction that he decided on its composition style based on two requests by his close friend:[127]

1) to give brief references to the observations and the quality of the derivation of motions and other things from them, as needed; and
2) to follow the wording of the *Tadhkira* and to incorporate it in the course of the exposition, if it is clear, and expound upon it, if it is obscure.[128]

Attempting to fulfill these two requests, Shīrāzī began the composition of the *Nihāya* from the text of his master's *Tadhkira*, "nothing before which has surpassed it and nothing after which has overtaken it."[129] Shīrāzī also probably made use of his notes from the time he had studied the *Tadhkira* with Ṭūsī. It is for this reason that we find him incorporating the original text of the *Tadhkira* in the style of a mixed commentary (*sharḥ mazjī*), in which the main text and the commentary are at times mixed in such a way that the main text is not discernable from the commentary at first glance, especially since Shīrāzī did not highlight Ṭūsī's text using another color, as he did in his self-declared mixed commentary of Ibn Sīnā's *Canon of Medicine*, or with overlining, or using some other scribal technique. In fact, based on the textual analysis and word count of Book III of the *Nihāya* and of the *Tadhkira*, we know that the first version of Book III of the *Nihāya* contains almost 75% of Book III of the *Tadhkira*, but this text transmitted from the *Tadhkira* accounts for only 18% of the entirety of Book III of the *Nihāya*. This means that the remaining 82% of the material is either from Shīrāzī himself or from his other sources. Shīrāzī refers to his other *hayʾa* sources in the introduction and in the final passage of the *Nihāya*; these sources include Ṭūsī's other *hayʾa* works, that is: *al-Risāla al-muʿīniyya* (written in 632/1235) and *Zubdat al-hayʾa* (written in 666/1268); Jaghmīnī's *al-Mulakhkhaṣ fī al-hayʾa al-basīṭa*; Kharaqī's *Muntahá al-idrāk, Tabṣira fī al-hayʾa,* and *ʿUmda-yi khʷārazmshāhī*; Jūzjānī's *Tarkīb al-aflāk*; a certain *Ghāyat al-afkār*, which is probably Athīr al-Dīn Abharī's *Ghāyat al-idrāk fī dirāyat al-aflāk*; and *al-Lubāb* and *al-Muḥaṣṣal,* which we

[127] Shīrāzī introduces him as "the dear brother, the most excellent of the age and unique of the time, Ashraf al-Dīn, noblest of peers, Muḥammad ibn ʿUmar al-Badakhshānī;" see F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*," 49, 54.

[128] F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*," 52.

[129] F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*," 52.

could not identify so far. According to Shīrāzī, these works, together with the *Tadhkira*, are the reliable compositions in the field of *hayʾa* (*al-kutub al-muʿtabara al-muṣannafa fī hādha al-bāb*).[130]

In Book III of the *Nihāya*, Shīrāzī cites the following Greek works, or their recensions, directly or indirectly: Aristotle's *Meteorologica*; Ptolemy's *Almagest* (*al-Majisṭī*) and *Geographia* (*Jughrāfiyā*); Theodosius' *On Habitations* (*al-Masākin*); and Menelaus' *Sphaerica* (*Kuriyyāt/al-Ashkāl al-kuriyya*)

In this book, Shīrāzī also cites Imām Shāfiʿī, Abū Ḥanīfa, Sharaf al-Dīn Masʿūdī (the author of *Jahān-i dānish* on *hayʾa* in Persian), Bīrūnī (probably from *al-Tafhīm*), Jayhānī and other *masālik* writers very likely through Kharaqī, Kūshyār, Khayyām (*Zīj*), Ibn Sīnā (from the *Canon of Medicine* and the *Shifāʾ*) and Fakhr al-Dīn al-Rāzī (very likely from *Sharḥ mushkilāt*

---

[130] In the explicit, Shīrāzī says: "One may know this by examining the authentic books composed in this discipline, some of **which have been referred to in the introduction of the book** such as: ***al-Risāla al-mughniyya***, ***al-Zubda***, ***al-Lubāb***, ***Ghāyat al-afkār***, ***al-ʿUmda li-ūli al-albāb***; and such as ***al-Mulakhkhaṣ***, ***Tarkīb al-aflāk***, ***al-Tadhkira***, ***al-Muḥaṣṣal***, ***Muntahá al-idrāk***, and ***al-Tabṣira***."

«... وإنّما يُعرَف ذلك من تصفّح الكتب المعتبرة المصنّفة في هذا الباب المومئ إلى بعضها في خطبة الكتاب كـ**الرسالة المغينية** و**الزبدة** و**اللباب** و**غاية الأفكار** و**العمدة لأولى الألباب** وكـ**الملخّص** و**تركيب الأفلاك** و**التذكرة** و**المحصّل** و**منتهى الإدراك** و**التبصرة**...»

In the introduction, Shīrāzī mentions the titles of his major *hayʾa* sources in a nice word play as the characteristics of the *Nihāya*:

"I resolved at one time to compose for myself and for all colleagues a treatise in *ʿilm al-hayʾa*… a treatise **independent** of others, comprising **the essence** of the detailed publications and **the gist** of the written compilations dealing with **the arrangement of the orbs** and containing **an epitome** of what has been reached, and **the outcome** that has been attained by **the utmost discernment** so that it would be **enlightening** for the beginner and a **memento** for the consummate; indeed, **a support** for the most discerning, and **a final destination** for those with cognition."

« فإنّي قد كنت برهة من الزمان عازماً على أن أحرّر لنفسي ولسائر الإخوان في علم الهيئة... رسالة **مغنية** عن غيرها مشتملة على **زبدة** المبسوطات المؤلّفة و**لباب** المجموعات المصنّفة في **تركيب الأفلاك** ومحتوية على **ملخّص** ما وصل إليه و**محصّل** ما انتهى عنده **منتهى الإدراك** بحيث تكون **تبصرة** للمبتدي و**تذكرة** للمنتهي بل **عمدة** لأولى الأبصار و**غاية** لذوي الأفكار.»

English translation of these two passages is from F.J. Ragep, "Shīrāzī's *Nihāyat al-idrāk*," 52-53 and 55, with modifications. It should be noted that for Ṭūsī's *Muʿīniyya*, Shīrāzī uses the revised title *Mughniyya*, which was chosen by Ṭūsī during the course of de-Ismāʿīlīfying revisions of the *Muʿīniyya*. The original title was chosen in honor of Muʿīn al-Dīn, son of the Ismāʿīlī ruler of Quhistān. For further information about Ṭūsī's de-Ismāʿīlīfying revisions of the *Muʿīniyya*, see Sajjad Nikfahm-Khubravan and Hassan Amini, "An Amendment to the Past: Ṭūsī's Revision of the *Muʿīniyya*," to appear.

kitāb al-Qānūn). Shīrāzī also quoted extensively from Muʾayyid al-Dīn al-ʿUrḍī's *Kitāb al-hayʾa* in some of the chapters of Book III of the *Nihāya*, such as chapter 9 on dawn and dusk[131] and chapter 12 on shadows.[132] Shīrāzī's discussion of shadows indicates that he was probably also familiar with Ibn Haytham's *Kitāb al-manāẓir* and Bīrūnī's *Kitāb al-aẓlāl*.[133]

With regard to his citation method, Shīrāzī is very clear when he wants to criticize one of his predecessors. For example, in one section wherein Shīrāzī criticizes Kharaqī, he quotes a full passage from Kharaqī's *Muntahá* and after the quotation he adds: "this is his wording in the *Muntahá al-idrāk*" (*hādhā lafẓuhū fī Muntahá al-idrāk*) or in another case, Shīrāzī starts the quotation with "according to that which has been mentioned by Kharaqī" (*li-mā dhakarahū al-Kharaqī*) and then explicitly indicates where the quotation ends. However, there are exceptions; in general, Shīrāzī never mentions Ṭūsī's name when quoting form his works, and whenever Shīrāzī wants to criticize Ṭūsī, he uses phrases such as: "the statement of whoever asserts such and such is not correct" (*lā yaṣiḥḥu qawlu man qāla…*). Our analysis of Book III also shows that Shīrāzī never cites Jaghmīnī even though he quotes directly from the *Mulakhkhaṣ*, nor does he cite Kharaqī when he does not want to criticize him. In these and other similar cases, Shīrāzī usually tends to quote verbatim, very likely for two reasons that he himself mentioned in the

[131] Cf. Saliba, *Kitāb al-hayʾa*, 322–337.

[132] Cf. Saliba, *Kitāb al-hayʾa*, 54–55, 59–60.

[133] Regarding Shīrāzī's familiarity with Ibn al-Haytham's *al-Manāẓir*, we can refer briefly to some cases in the opening paragraph of the *Nihāya* III.12, entitled "on shadows and their circumstances," in which Shīrāzī seems to be following Ibn al-Haytham: 1) Shīrāzī considers light to be "a quality, the vision of which is not dependent on the vision of another thing," as opposed to Aristotle who takes light to be "the actualized state of the transparent" through which one can see colors (see Richard Sorabji, "Aristotle on Demarcating the Five Senses," *The Philosophical Review* 80, no. 1 (1971), 61, fn. 23); 2) Shīrāzī divides light into primary and secondary, the primary being the light attaining from a self-luminous object and the secondary being the light attaining from an object illuminated by another; 3) Shīrāzī offers a physical definition of shadow as "the secondary light that bears strength and weakness, and its two extremely far limits are light and darkness," as opposed to the geometrical Euclidean definition of shadow. I was made aware of these influences of Ibn Haytham on Shīrāzī by Hossein Masoumi Hamedani in our private correspondence. Future research on this chapter of the *Nihāya* III.12 will shed more light on Shīrāzī's familiarity with or use of Ibn al-Haytham's *al-Manāẓir*.

introduction to his commentary on Suhrawardī's *Ḥikmat al-ishrāq*: in order to preserve the text of his predecessors and in order to save time.[134]

The main divisions of the *Nihāya* and the chapter headings contained within these divisions are almost exactly like those of the *Tadhkira* and, as we have already mentioned, the *Nihāya* actually appears like a mixed commentary on the *Tadhkira*. However, it should be noted that Shīrāzī never mentioned in his introduction to the *Nihāya* that he intended to write a commentary on *Tadhkira*. Rather, Shīrāzī regards himself as an "appraiser (*nāẓir*)," not a commentator. In a passage at the end of chapter 10, Book II of the *Nihāya*, Shīrāzī, who is very proud of his solutions to the problems of the motions of the orbs, says:

> "Praise be to God who did not disappoint the hopes of the author of the *Tadhkira* when he said 'May God give success to the appraiser of this book in thinking up complete solutions to all these problems or to eliminate the remaining flaws in what we have mentioned…,' and [praise be to God who] answered his prayer with regard to me, particularly so that I found solutions to some of those problems, which are more complete than [the solutions] mentioned by our predecessors and contemporaries; and I also eliminated some of the flaws from what [Ṭūsī] has mentioned."[135]

This passage exemplifies Shīrāzī's critical tone throughout the *Nihāya*.

There are multiple versions of the *Nihāya*, and we know that Shīrāzī kept adding material and revising it over a span of two years.[136] Parts of these revisions were being done while Shīrāzī was writing his next *hayʾa* work, the *Ikhtiyārāt*. Even though the *Nihāya* and *Ikhtiyārāt*

---

[134] Najafqulī Ḥabībī, *Ḥikmat al-Ishrāq-i Suhrawardī, bā sharḥ-i Quṭb al-Dīn Shīrāzī, jild-i awwal: manṭiq*, (Tehran: Bunyād-i Ḥikmat-i Islāmī-yi Ṣadrā, 2013), 11:

« فرأيت أن أشرحه شرحاً يُذلِّل من اللفظ صعابه، ويكشف عن وجه المعاني نقابَه، مقتصراً فيه على حلّ ألفاظه وتوضيح معانيه... **حافظاً في نقلِ ما استفدنا منهم** على استعاراتهم، **حذراً من تضييع الزمان في تغيير عباراتهم**.»

[135] The passage reads as follows:

«فهذا نهاية الكلام على الإشكالات الواردة على حركات الأفلاك والأجوبة عنها والحمد لله الذي لم يخيّب صاحب التذكرة في رجائه حيث قال ولعلّ الله يوفّق الناظر في هذا الكتاب أن يستنبط وجهاً تامّاً لحلّ جميع الإشكالات او يزيل الخلل الباقي فيما ذكرناه ... واستجاب دعوته في حقّنا خاصّةً ... حتّى استنبطنا في حلّ بعض المشكلات وجهاً أتمّ ممّا ذكره من تقدّمنا من المتقدّمين ومن عاصرنا من المتأخرين وأزلنا بعض الخلل عمّا ذكر.»

[136] We will discuss this in detail in our introduction to the edition of Book III of the *Nihāya* (2.1 Editorial Procedures).

are similar in many ways, there is a very interesting difference between them in their *hayʾat al-arḍ* section. In the first chapter of the *Nihāya*, a general description of the sphericity of the Earth is followed by a description of the seas, which is almost the same as the very standard description of the seas found in other *hayʾa* works. In the *Ikhtiyārāt*, however, Shīrāzī does not seem satisfied anymore with the standard description of the seas. Furthermore, in the *Ikhtiyārāt*, Shīrāzī is now preparing his work for a patron who, as a military commander, has a vested interest in topography and cartography.[137] So, he decided to scrutinize the descriptions of the seas usually given in *hayʾa* and early *masālik* works and found that coming up with a decent description of the seas is "simple, yet impossible (*sahl-i mumtaniʿ*)."[138] He went even further, saying that the description of the configuration of the orbs, which is more a function of the mind, is easier than the description of the seas and their relations to the land, which is only possible through observation.[139] Shīrāzī then adds that, since he was in a rush to finish the *Ikhtiyārāt*, he will only be able to provide a precise description of the Mediterranean Sea based on a Greek graticule map of this sea, and that he will later write a monograph on this subject for his patron. Shīrāzī's description is based on his careful reading of the map, and since he gives the vertical and horizontal dimensions of the graticule, and reads cell by cell, one can easily reproduce the map. Our following reproduction of the map shows that this map is different from those produced in the Ptolemaic tradition of cartography, especially with regard to the outline of the African coastline of the sea. This coastline in maps of the Ptolemaic tradition has a southward concavity, whereas in this map there is a northward convexity, similar to the

---

[137] He says:

« چه ایشان هر چند بر دقائق علوم قادر بودند اما درین نوع بخصوص مهارتی بیشتر داشتند.»

[138] He says:

«لازم آمد کی در اوضاعی کی دیگران تصور کرده بودند و تقریر و تشکیل کرده چون ارباب صحف مسالک و ممالک و اصحاب کتب هیأت وغیرهم، تأملی کرده آید و چون تأمل کرده شد کار انسان را بی طایل دید و مساعی نامشکور چه اکثر آن اوضاع بر وجهی بود لا تشهد لصحتها عقل ولا نقل و چون خواست کی آنرا اصلاح کند معلوم گشت کی تصور آن کما یجب سهل ممتنع بوده است.»

[139] He says:

«و تصور اوضاع افلاک بر وجهی کی برصد یافته اند ازان حاصل شود آسان تر ازان کی تصور اوضاع دریاها را با زمین چه عقل را در تصور اول مجالی واسع است بخلاف دوم چه تصور آن جز بمشاهدۀ صاحب نظران و اهل اعتبار با نقل صحیح ازیشان صورت نه بندد.»

Mediterranean portolan charts of the same period.[140] However, establishing any relation between this map and the tradition of the Mediterranean portolan charts, which can be an indication of an active geographical exchange between Anatolia and Europe in the 13th century, requires further cartographic analysis of this map.

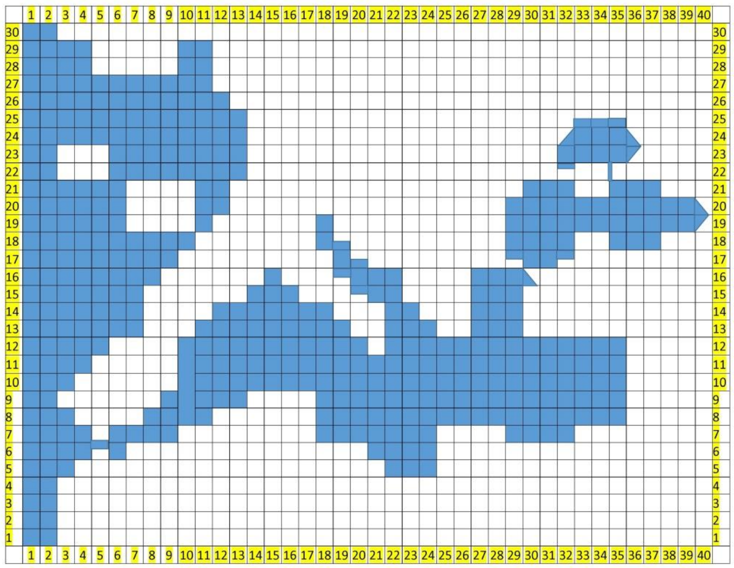


Fig. 1

The map that Shīrāzī showed to Ilkhan Arghūn in 689/1290 in Alataq (see the end of the previous section of this chapter) must be the abovementioned Greek graticule map or its reproduction by Shīrāzī.

Shīrāzī's critical examination of the geographical material of the previous *hayʾa* and *masālik* works is evident in his revisions of chapter 1 of Book III of the *Nihāya*. He went over all the geographical names and information and tried to correct them as much as possible. One of the most interesting examples that shows Shīrāzī's obsession with these geographical revisions is the correction of the name of "the North Sea" as "*baḥr Alamān*" (Mare

[140] According to *Encyclopædia Britannica* (https://www.britannica.com/technology/portolan-chart), "Portolan chart, also called harbour-finding chart, compass chart, or rhumb chart, navigational chart of the European Middle Ages (1300–1500). The earliest dated navigational chart extant was produced at Genoa by Petrus Vesconte in 1311 and is said to mark the beginning of professional cartography. The portolan charts were characterized by rhumb lines, lines that radiate from the centre in the direction of wind or compass points and that were used by pilots to lay courses from one harbour to another."

Germanicus) instead of "*baḥr al-Shām wa-al-Ṣaqāliba*," to avoid confusion with the Mediterranean Sea, which is usually referred to as *baḥr al-Shām wa-*…. It should be noted that German people were called "*Alamān*" in sources of the pre-modern Islamic world, but I have never come across any other references to "*baḥr Alamān*" in the sources that I have seen so far.

Despite its length, the *Nihāya* was widely copied, studied and annotated by scholars, and it was very influential on later commentaries of the *Tadhkira*. In part II a history of the *Nihāya*'s text and an analysis of some of its earliest manuscripts will be presented before the critical edition of the text of its Book III.

1.3 The Formation of the genres of *hayʾat al-arḍ* and *masālik*

As we mentioned earlier in the introduction, *hayʾat al-arḍ* emerged and evolved as a scientific geographical genre within the *hayʾa* tradition. *Hayʾa* works, aimed at presenting the main results of Ptolemy's *Almagest*, without the proofs and within a cosmographical framework, often included a major division called *hayʾat al-arḍ* that provided a general description of the spherical surface of the Earth, the placement of land and water on the Earth, the characteristics of different localities, and geodesy. This division also included discussions of astronomical phenomena, methods, and data that vary with the change of localities and horizons due to the sphericity of the surface of the Earth. However, *hayʾat al-arḍ* only treats those astronomical discussions that operate within the horizontal coordinate system, that is, the altitude-azimuth or declination-ascension coordinates, as opposed to planetary theories that operate within the zodiacal coordinate system and were dealt with in another main section on the configuration of the heavens (*hayʾat al-samāʾ*). In sum, *hayʾat al-arḍ* sections share specific geographical, geodesic and astronomical contents, the composition and arrangement of which may vary from one work to another. Despite the differences exhibited by different *hayʾat al-arḍ* sections of *hayʾa* works, they can still be unified under a coherent genre. To start our description of this genre, we start with its formative period.

Since *hayʾa* works were based on the *Almagest*, some of the material in *hayʾat al-arḍ* had roots in the *Almagest*. Furthermore, in at least four later *hayʾa* works, there is a reference in the *hayʾat al-arḍ* section to an early geographical genre of the pre-modern Islamic world, called *al-*

masālik wa-al-mamālik (roads and kingdoms),[141] which began to take shape at around the same time as the *hayʾa* genre (see table 1 below). Therefore, in this chapter we briefly depict the formative period of the *hayʾat al-arḍ* and *masālik* genres in parallel to provide a better historical context for our study.

Book I of the *Almagest*, starts with "the general preliminary discussion" of the following physical principles: that "the heaven is spherical in shape, and moves as a sphere; the earth too is sensibly spherical in shape, when taken as a whole; in position it lies in the middle of the heavens very much like its center; in size and distance it has the ratio of a point to the sphere of the fixed stars; it has no motion from place to place;" and finally that there are two different primary motions in the heavens.[142] According to Ptolemy, as a result of the Earth's sphericity, "the sun, moon and other stars do not rise and set simultaneously for everyone on earth."[143] This leads to natural phenomena such as proportional longitudinal time differences, different lengths of daylight and night, varying climate, and different celestial maps, *etc*., for different localities on the Earth. In the *Almagest*, after this very general description of the configuration of the heavens and Earth together in Book I, Ptolemy starts Book II with the more detailed discussion of the configuration of the Earth, and leaves the heavens to later books; this is contrary to later *hayʾa* works, in which the part on the configuration of the heavens usually precedes the *hayʾat al-arḍ* part.

Ptolemy's influence is visible in *Jawāmiʿ ʿilm al-nujūm wa-uṣūl al-ḥarakāt al-samāwiyya* (written between 833 and 857)[144] by Aḥmad b. Muḥammad b. Kathīr al-Farghānī (d. after 247/861) and *Kitāb al-zīj al-Ṣābiʾ* by Muḥammad b. Sinān b. Jābir al-Battānī (d. 317/929), in which the detailed discussion of the heavens comes after the Earth. The *Jawāmiʿ* and *al-Zīj al-Ṣābiʾ* are two earliest extant adaptations of the *Almagest* in the pre-modern Islamic era, but in two different directions that eventually led to the formation of two astronomical traditions, namely that of *zīj*es and *hayʾa* works. A summary of the abovementioned preliminary physical discussion of the *Almagest* regarding the shape of the heavens and the Earth and their position

---

[141] For *al-Masālik* as a genre, see: Tibbetts, "The Beginnings," 91.

[142] *Almagest*, 38, 45.

[143] *Almagest*, 40.

[144] S. Ragep, *Jaghmīnī*, 47–48.

with respect to each other, together with their observational proofs, appears in the *Jawāmiʿ*,[145] and is called "*waṣf hayʾat al-samāʾ wa-al-arḍ*" (the general description of the configuration of the heavens and the Earth).[146] This preliminary discussion is absent from Battānī's *Zīj*, which is more focused on the computational/practical side of the *Almagest*. Battānī's *Zīj*, however, contains many overlapping topics with later *hayʾa* works,[147] and was referred to or used by *hayʾa* scholars throughout the pre-modern Islamic era. Even though, Battānī's objective seems quite different from Farghānī's, it should be noted that the boundaries between the *hayʾa* and *zīj* traditions were loose in their formative period.

The earliest extant *masālik* work is that of Ibn Khurdādhbih (d. ca. 300/913), written in 232/846–847.[148] Ibn Khurdādhbih, the son of ʿAbdallāh b. Khurdādhbih, the governor of Ṭabaristān during the reign of caliph al-Maʾmūn (r. 198–218/813–833), was himself an Abbasid official who held positions such as the director of the postal and intelligence services during the caliphate of al-Muʿtamid (r. 256–279/870–892). Ibn Khurdādhbih probably had at his disposal documents related to the topography of the Sassanid Empire and its routes, which might account for his frequent use of the *farsakh*, the Arabized word for *parsang*, an ancient Iranian unit of distance.

There is a reference to Ptolemy in the work of Ibn Khurdādhbih, which appears in the introduction. Since this reference is about the number of cities at the time of Ptolemy, it might be somehow related to Ptolemy's *Geography*. Even though there is apparently no such estimate in the original text of Ptolemy's *Geography*, this reference implies that Ibn Khurdādhbih was aware of Ptolemy's *Geography*, or that Ibn Khurdādhbih's composition of *al-Masālik* might have come shortly after one of the early Arabic translations of Ptolemy's *Geography*. However, one should note that Ibn Khurdādhbih's *al-Masālik* is completely independent of Ptolemy's *Geography* and its Arabic translation/adaptations with regard to content and structure.[149]

---

[145] These topics have been covered in chapters 2–5. These four chapters contain all the physical material of the Book I of the *Almagest* (*Alm.* I 3–8). *Jawāmiʿ* has 30 chapters. It begins with a chapter on different calendars.

[146] Farghānī, *Jawāmiʿ*, 15

[147] S. Ragep, *Jaghmīnī*, 55.

[148] Michael Jan de Goeje, *Kitâb al-masâlik wa'l-mamâlik (Liber viarum et regnorum)* (Leiden: Brill, 1889; reprinted in Bagdad: Maktabat al-Muthanná, 1960z), xx.

[149] See Barthold's preface to the *Ḥudūd al-ʿālam* in: Minorsky, *Ḥudūd*, 14.

Ptolemy's *Geography* was translated at least two times into Arabic, once for/by Yaʿqūb b. Isḥāq al-Kindī (d. 260/874), and once by Thābit b. Qurra al-Ḥarrānī (d. 288/901) during the translation movement.[150] Two extant adaptations of Ptolemy's *Geography* are *Ṣūrat al-arḍ* by Muḥammad b. Mūsá al-Kh^{w}ārazmī (fl. first decade of 3rd/9th century);[151] and *Kitāb ʿajāʾib al-aqālīm al-sabʿa ilá nihāyat al-ʿimāra* attributed to a certain Suhrāb (2nd–3rd/9th–10th centuries).[152]

Two manuscript witnesses of Ibn Khurdādhbih's *al-Masālik* are extant. In one of these witnesses we find an additional introduction before the main body of the text, which De Goeje included in his edition of Ibn Khurdādhbih's *al-Masālik*. This introduction appears right before the actual beginning of Ibn Khurdādhbih's *al-Masālik* in De Goeje's edition, and is stylistically very different from the rest of the text. In this introduction, the author says that, in fulfilment of the desire of his patron (whose name is not mentioned nor is any indication of his position given) to have a map of the Earth based on the ancient maps, he translated the work of Ptolemy, which he found to be the most clear and authentic, then drew a map based on the work of Ptolemy, and wrote a book, which opens with the praising of God.[153] The writing style and

---

[150] Fuat Sezgin, *The contribution of the Arabic-Islamic Geographers to the Formation of the World Map* (Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 1987), 16.

[151] Edited by Hans von Mžik, *Das Kitāb ṣūrat al-arḍ des Abū Ǧaʿfar Muḥammad ibn Mūsā al-Ḫuwārizmī* (Leipzig: Otto Harrassowitz, 1926).

[152] Edited by Hans von Mžik, *Das Kitāb ʿaǧāʾib al-aḳālīm as-sabʿa des Suhrāb* (Leipzig: Otto Harrassowitz, 1930).

[153] De Goeje, *al-Masâlik*, 3:

«... فوجدت بطلميوس قد أبان الحدود وأوضح الحجّة في صفتها بلُغة أعجمية فنقلتها عن لغته باللغة الصحيحة لتقف عليها وقد رسمت رسم لك ... وصنعته كتابا افتتحته بالحمد لله...»

There is also a very striking similarity in the way the dedicatee is being addressed between the abovementioned introduction (de Goeje, *al-Masâlik*, 3):

«أطال الله تعالى بقاءك يا ابن السادة الأخيار والأئمة الأبرار منار الدين وخيرة الله من الخلق أجمعين ... فهمت الذي سألت أفهمك الله جميع الخيرات... من رسم إيضاح مسالك الأرض...»

and the introduction of *Kitāb al-Kindī fī al-ibānat ʿan al-ʿilla al-fāʿila al-qarīna li-al-kawn wa-al-fasād* (Yaʿqūb b. Isḥāq al-Kindī, *al-Rasāʾil al-falsafiyya*, ed. ʿAbd al-Qādir Muḥammad ʿAlī (Beirut: Dār al-Kutub al-ʿIlmiyya, 2017), 70–71):

content of this page bears striking similarities to the beginning of *Kitāb ʿajāʾib al-aqālīm al-sabʿa ilá nihāyat al-ʿimāra* by Suhrāb, which is the only extant Arabic adaptation of Ptolemy's *Geography* that contains one of his map projection methods.[154] Besides this additional introduction, the two extant manuscripts of Ibn Khurdādhbih's *al-Masālik* are considerably different with regard to the arrangement and content. To account for these differences de Goeje proposed that Ibn Khurdādhbih originally composed his geography in two stages: first in 232/846 and then circa 272/885.[155] But, later scholars such a Minorsky regarded this theory as an oversimplification of the "the complex nature of the variants between the surviving manuscripts."[156] This oversimplification had another consequence; in fact, modern consideration of Ibn Khurdādhbih as one of the translators of Ptolemy's *Geography* is a confusion prompted by De Goeje's publication of the additional introduction with the text of Ibn Khurdādhbih's *al-Masālik*.

Ibn Khurdādhbih's introduction indicates only a limited knowledge of the notion of a spherical Earth in the middle of the heavens. He mentions neither Ptolemaic nor Maʾmūnid values for the obliquity and the length of one degree of the circumference of the Earth, but only imprecise common values of 24 degrees for obliquity and 25 *farsakh*s (=75 *mīl*s) for one degree.[157]

Ibn Khurdādhbih was a younger contemporary of Kh^w^arazmī, Farghānī, Kindī and Thābit, and probably an older contemporary of Nayrīzī. All these scholars were pursuing their

---

«أطال الله بقاءك يا ابن السادة الأخيار والائمة الأبرار منار الدين ... وخيرة الله من الناس أجمعين ... ولو لا ما يعرض في إسعافك أسعفك الله بجميع الخيرات بما سألت من إظهار وحدانية الله...»

[154] See Mžik, *ʿAǧāʾib*, 5, where Suhrāb right after *bismillah* start with praising of God:

«إن أحسن ما افتتح به الكلام في كل رغبة ورهبة وحاجة حمد الله تعالى. الحمد لله ...»

[155] De Goeje, *al-Masâlik*, xx.

[156] Travis Zadeh, "Ibn Khurdādhbih," in: *Encyclopaedia of Islam, THREE*, ed. Kate Fleet, Gudrun Krämer, Denis Matringe, John Nawas, Everett Rowson. Consulted online on 24 October 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_30869>. For a recent codicological analysis of these two manuscripts, see Travis Zadeh, "Of Mummies, Poets, and Water Nymphs: Tracing the Codicological Limits of Ibn Khurradādhbih's Geography," in *School of ʿAbbasid Studies*, ed. by Monique Bernards (Warminster: Gibb Memorial Trust, 2013), 20ff.

[157] *Farsakh*, Arabized form of *parsang* or farsang, is an ancient Persian unit for measuring length. Each *farsang* is 3 *mīl*s (Arabian miles).

scholarship in a very important era of the Abbasid caliphate, that is to say an era characterized by the dominance of a military elite and the isolation of the caliph, as a direct result of the shift of the caliphal center from Baghdad to Samarra that eventually led to the militarization of Samarra and the assassination of al-Mutawakkil (r. 232–247/847–861), who tried to overturn the situation, by his Turkish officials in 247/861.

After al-Mutawakkil's death came a decade-long crisis, often referred to as "the anarchy of Sāmarrāʾ." This crisis marked an end to "the sense of the unity of the Islamic world," which could still be felt to a considerable extent in the atmosphere of the caliphate and in the figure of the caliph until 247/861. After this crisis, any recovery was only partial and short-lived, and internal power struggles became the theme of the new era of the Abbasid caliphate. These constant power struggles increasingly disrupted ties between the periphery and centre to the point that, within several years, the provinces were left largely defenseless before ambitious military commanders to be captured forcibly or through peaceful alliance with local elites.[158] Constant decline of caliphal power eventually resulted in a new configuration of politics in the Islamic world: three caliphates at the same time, that is to say, the Abbasid caliphate itself in the east, and those of the Fatimids (from 909 CE) and the Spanish Umayyads (from 929 CE).

This episode in the history of the Abbasid caliphate gave rise to a major development in the field of geography as a result of the expansion of the bureaucratic system, which was responsible for the fiscal administration and intelligence services of a declining caliphate. In such circumstances, there was a constant need for reconquering lost territories to resume power and meet the financial needs of the army and the administration. This was also a very active era of military campaigns and diplomatic missions, either for forging alliances or resolving disputes between the caliphate and emerging states or between two given dynastic states. It is at this time that we see a fair number of the geographical works being produced by chancellors or for chancellery purposes. These works can be mostly categorized under the genres of *masālik* or travelogue.

In particular, the crisis of the 860s had two major consequences: first, the emergence of new dynastic states such as the Samanids, Saffarids, and Tulunids on the periphery, and second,

[158] Michael Bonner, "The Waning of Empire, 861–945," in *The New Cambridge History of Islam*, ed. Chase F. Robinson, 1:305–59 (Cambridge: Cambridge University Press, 2010), 305–309, 314–315.

the military elite's gradual loss of control over the caliphal administration, which served to reinforce the chancellors' (*kuttāb*) visibility and influence. It was in this context that the Abbasids began to rebuild their caliphate with the help of their soldiers and administrators, among whom the technocrats and bureaucrats had the upper hand.[159] By this time, the Abbasid bureaucracy had become highly technical and complex with its numerous *dīwān*s (bureaus). Chancellors elevated to higher ranks within the power hierarchy of these *dīwān*s were accomplished in a wide range of fields from the Arabic language, poetry, history and calligraphy, to arithmetic, accounting and surveying. For the sake of fiscal administration and intelligence services, some of these chancellors were also familiar with the fiscal districts and regional topography.[160]

The powerful Samanid chancellor Abū ʿAbd Allāh al-Jayhānī (d. 313/925) was one of the first to write a voluminous *masālik* work, which is not extant in its original form. Excerpts of this work are quoted by Bīrūnī (d. ca. 440/1048) in his *al-Āthār al-bāqiya ʿan al-qurūn al-khāliya* (The Vestiges of the Past).[161] Bīrūnī also mentions Jayhānī's name in his *Taḥdīd nihāyāt al-amākin li-taṣḥīḥ masāfāt al-masākin* (determination of the coordinates of localities for correcting distances of the regions) where he explains his purpose for writing the text as a "combination of Ptolemy's method in his *Geography* and the method of Jayhānī and others in the *masālik* works in order to bring together the scattered [data], clarify the obscurities and accomplish the science of [geography],"[162] indicating Jayhānī's importance in the *masālik* tradition. Aḥmad b. Faḍlān, who wrote a famous travelogue of his mission to the king of the

---

[159] Bonner, "The Wanning of Empire," 323, 332.

[160] Bonner, "The Wanning of Empire," 333.

[161] Abū Rayḥān Bīrūnī, *al-Āthār al-bāqiya ʿan al-qurūn al-khāliya (the Vestiges of the Past), the Chronology of Ancient Nations*, ed. Parviz Azkaei (Tehran: Mīrāth-i Maktūb, 2001), 283, 328–329, 336, 352, and 393. Referring to Jayhānī, Bīrūnī uses "*dhakara al-Jayhānī*" or "*ḥaká al-Jayhānī fī Kitāb al-masālik wa-al-mamālik*."

[162] Abū Rayḥān Bīrūnī, *Kitāb taḥdīd nihāyāt al-amākin li-taṣḥīḥ masāfāt al-masākin*, ed. P. G Bulgakov (Cairo: Maṭabʿa Lajnat al-Taʾlīf wa-al-Tarjima wa-al-Nashr, 1964), 38; for an English translation, see Abū Rayḥān Bīrūnī, *The Determination of the Coordinates of Positions for the Correction of Distances between Cities: A Translation from the Arabic of Kitāb taḥdīd nihāyāt al-amākin li-taṣḥīḥ masāfāt al-masākin*, trans. Jamil Ali (Beirut: American University of Beirut, 1967), 14.

Bulghārs as the envoy of the caliph al-Muqtadir (r. 295–320/908–932), met Jayhānī, who introduced him to the Samanid *amīr*.[163]

From the same period, we also have *Mukhtaṣar kitāb al-buldān* written by Ibn Faqīh (fl. 289/902), *Kitāb al-kharāj wa-ṣanʿat al-kitāba* (written between 316/928 and 320/932) [164] by Qudāma b. Jaʿfar al-Kātib (d. 337/948),[165] and *al-Aʿlāq al-nafīsa* (written in 310/923) by Ibn Rusta (fl. 300/912). These three works are significant for their inclusion of material such as a physical description of the spherical Earth and a standard brief description of the seas, probably adapted or adopted from the physical/astronomical works of the previous generation of scholars. We do not see similar material in the works of the following generation of *masālik* authors, such as Iṣṭakhrī (fl. ca. 340/951) and Ibn Ḥawqal (d. after 367/978), and rarely do we see them again in the later works concerned with the same material.

We will discuss these overlapping features of *masālik* and *hayʾa* works in the following chapter.With this brief historical overview of the formative period of the study of geography and the *hayʾa* tradition, we now turn to an analysis of the contents of *hayʾat al-arḍ* with a focus on Shīrāzī's text, having introduced the critical works and figures.

---

[163] Aḥmad Ibn Faḍlān, *Risālat Ibn Faḍlān fī waṣf al-riḥla ilá bilād al-Turuk wa-al-Khazar wa-al-Rūs wa-al-Saqāliba Sana 309/921*, edited by Sāmī al-Dahhān (Damascus: al-Maṭbaʿa al-Hāshimiyya, 1959), 76–66:
«ثمّ رحلنا إلى بيكَنْد. ثمّ دخلنا بُخارا، وصرنا إلى **الجيهاني وهو كاتب أمير خراسان**، وهو يدعى بخُراسان الشيخ العميد، فتقدّم بأخذ دار لنا، وأقام لنا رجلاً يقضي حوائجنا ويزيح عللنا في كلّ ما نريد، فأقمنا أياماً، ثم استأذن لنا على **نصر بن أحمد** فدخلنا إليه...»

[164] Only the second half of the *Kitāb al-kharāj* (5th to 8th *manzila*) has survived and is published by De Goeje, *al-Masālik*, 184–266. Paul L. Heck, *Construction of Knowledge in Islamic Civilization: Qudāma b. Jaʿfar and His Kitāb al-kharāj wa-ṣināʿat al-kitāba* (Leiden: Brill, 2002) is a study of this work.

[165] Abū al-Faraj Qudāma b. Jaʿfar al-Kātib al Baghdādī was "philologist, historian, and one of the first scholars to introduce the systematic study of the figures of speech in Arabic literature." His death date is uncertain. Sources mention his death "during the reign of al-Muqtadir" (i.e. not later than 320/932), or in 328/939–940, or 337/948. See: S.A. Bonebakker, "Ḳudāma," in: *Encyclopaedia of Islam, Second Edition*, ed. P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs. Consulted online on 22 October 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_4478>

1.4 Contents of *hayʾat al-arḍ*, with a focus on Book III of the *Nihāya*

The *Nihāya* consists of four books: Book I, an introduction containing the required mathematical and physical principles, axioms and prepositions; Book II, on the configuration of the heavens, *i.e.* planetary models; Book III, on the configuration of the Earth; and Book IV, on the relative sizes and distances of the Earth and heavenly bodies. The exact title of Book III is: "On the configuration of the Earth and its division into inhabited and uninhabited and the [consequences] accruing to it due to the changing positions of the celestial bodies and related matters." This Book contains 13 chapters:

1. A general summary of the configuration and circumstances of the Earth
2. Characteristics of the equator
3. Characteristics in general of locations having latitude, which are called the oblique horizons, and on ortive and occasive amplitude, and on the equation of daylight
4. Characteristics of locations whose latitude does not exceed the complement of the obliquity
5. Characteristics of locations whose latitude exceeds the complement of the obliquity but does not reach one-quarter revolution
6. Characteristics of locations whose latitude is exactly one-quarter revolution
7. Co-ascensions of the zodiacal signs
8. Lengths of the nychthemerons
9. Dawn and dusk

10. Understanding the units of the day, namely hours, and what is composed of days, namely months and years, and what pertains to them, namely intercalation and the calendar
11. Degrees of transit of the stars on the meridian and on their [degrees of] rising and setting
12. Understanding shadows and their circumstances
13. Finding the meridian line, which is also called the noon line, and on the qibla direction

From the title of Book III of the *Nihāya* and its contents, one can discern two types of material in this book: 1) a description of the surface of the Earth or "the configuration of the Earth and its division into inhabited and uninhabited," as referenced in the title of Book III; and 2) different aspects of the astronomical phenomena associated with the shape and position of the Earth in the heavens, or in Shīrāzī's words: "the [consequences] accruing to [the configuration of the Earth] due to the changing positions of the celestial bodies and related matters," as addressed in the title of this Book. The contents related to the first type, which are usually discussed at the beginning of the *hayʾat al-arḍ* section, are more of a geographical nature, whereas the contents related to the second type deal mostly with the astronomical and geodesic aspects of the spherical shape of the Earth. The following table presents a comparison of the structure and contents of the *hayʾat al-arḍ* section of the *Nihāya* with those of a selection of works belonging to the broader *hayʾa* tradition.

Table 1:

		Ptolemy, *Alamgest*	Farghānī (3rd/9th century), *Jawāmiʿ* (Arabic)	Ibn al-Haytham's *Hayʾat al-ʿālam* (Arabic)	Qaṭṭān-i Marvzī (5-6th/11-12th centuries), *Gayhān-shinākht* (Persian)	Kharaqī (6th/12th century), *Muntahá* (Arabic)	Masʿūdī, *Jahān-i dānish* (Persian, written in 549/1154)	Jaghmīnī, *Mulakhkhaṣ* (Arabic, written in 602-603/1205-1206)	Ṭūsī, *Muʿīniyya* (Persian, written in 632/1235)	Ṭūsī, *Tadhkira* (Arabic, written in 659/1261)	Shīrāzī, *Nihāya* (Arabic, written in 680/1281), *Ikhtiyārāt* (Persian, written in 680/1282), *Tuḥfa* (Arabic, written in 684/1285)
	Structure	13 books	30 chapters	15 chapters	3 chapters	3 books	2 books	Intro.+ 2 books	4 books	4 books	4 books
	Hayʾat al-arḍ material/section	Books I–II	Chps. 3–4, 6–11, 23	Chps. 2–8	Chps. 2	Book II	Book II	Book II	Book III	Book III	Book III
	Discussion of the sphericity of the Earth, its being the center of the Universe and at rest	I.4–7	Chps. 3–4	Chp. 2	Chps. 1, 2	I.3–4, II.1	I.4–5, II.1	Intro.	II.1; III.1	II.1; III.1	II.1; III.1
Geography	1. A general summary of the configuration and circumstances of the Earth/reference to the *masālik* works	I.4–7, II.1 N/A	Chps. 3–4, 6, 8–9 N/A	Chps. 3, 4 No	Chp. 2 No	II.1–4 Yes	II.1–2 No	II.1 No	III.1 Yes	III.1 Yes	III.1 Yes
Geography	2. Characteristics of the equator	II.6–7	Chp. 6	Chps. 3, 4	Chp. 2, 3	II.5	II.3	II.2[1]	III.2	III.2	III.2
Astronomy	3. Characteristics of the oblique horizons; ortive and occasive amplitude; and the equation of daylight	II.6–7	Chps. 6–7	Chp. 4, 5, 6, 7	Chp. 1, 3	II.6–8, 11	II.4–6, 8	II.2[2–7, 12], I.4[16]	III.3–5, 7	III.3–6	III.3–6
Astronomy	4. Co-ascensions of the zodiacal signs; the ascendant; and the revolution of the daylight	II.9	Chp. 10	Chp. 8	Chp. 1	II. 9–10	II.7	II.2[8–11], I.4[21]	III.6	III.7	III.7
Astronomy	5 Nychthemerons; hours, months, years, intercalation, and the calendar	III.1, 9; IV.2	Chp. 1, 11	N/A	Chp. 3	III.4–5, 6	II.14	II.3[6–11], I.4[20]	III.9, 10	III.8, 10	III.8, 10
Astronomy	6. Dawn and dusk	N/A	N/A	N/A	Chp. 3	II.16	II.13	N/A	III.9	III.9	III.9

	7. Degrees of transit and rising and setting of stars	VIII.4	Chp. 23	N/A	Chp. 3	II.12	II.9	II.3[1]	III.8	III.11	III.11
	8. Shadows and their circumstances	II.5	N/A	N/A	Chp. 3	II.14	II.10	II.3[2]	III.11	N/A	III.12
Geodesy	9. Finding the meridian line, and the qibla direction	N/A	N/A	N/A	Chp. 2	II.13, 15	II.11–12	II.3[3–5], I.4[19]	III.12	III.12	III.13
	10. Sizes and distances	V.15–16, …	Chps. 21–22	N/A	Earth only: chp. 2	II.17	I.23	N/A	Book IV	Book IV	Book IV

As it is clear in the table above, starting from *Gayhān-shinākht* of Qaṭṭān Marvzī, we can identify separate major divisions in *hayʾa* works, at least one of which is devoted to *hayʾat al-arḍ*. Contrary to the *Almagest* and *Jawāmiʿ*, *Gayhān-shinākht* and later *hayʾa* works start with the configuration of the heavens, followed by a section on *hayʾat al-arḍ*. If we divide the material of the *hayʾat al-arḍ* section into three more general categories of geographical, astronomical and geodesic, from the table above we can see that in almost all works the *hayʾat al-arḍ* section opens with geographical material.

The geographical part of the *hayʾat al-arḍ* section is, in general and especially for the *Nihāya*, a bit more complicated compared to the astronomical and geodesic parts since it usually includes a range of different topics from a variety of sources. In the *Nihāya*, this part makes up approximately one-third of Book III and is longer than the entire Book III of the *Tadhkira*. Since Shīrāzī places significant emphasis on this geographical material in the *hayʾat al-arḍ* section of the *Nihāya*, and because this geographical part has attracted less attention in the secondary literature compared to the astronomical and geodesic parts, in this study we focused on the contents and sources of the geographical part of the *Nihāya* III. Thus, in the following sections of this chapter we compared different *hayʾa* works, highlighted similarities and traced the contents back to their original sources with respect to five major geographical topics: 1) conception of the shape of the Earth, 2) land-water relation, 3) description of the seas, 4) seven climes and 5) temperate zone. In the final section of this chapter we present a rather interesting case of similarity between some of the analyzed *hayʾat al-arḍ* contents and their parallels in a specific Latin tradition of cosmographical textbooks.

Analyzing the content of *hayʾat al-arḍ* helps provide us with a better picture of *hayʾat al-arḍ* as a distinct genre and its evolution. In this study, *hayʾat al-arḍ* as a genre is not understood as a rigid mould into which the works must fit but, rather, as something of a pattern that is based on similarities—whether of subject matter, purpose, form, contents, *etc*.—shared by a group of texts. In other words, based on these shared similarities one can develop patterns and relationships that identify different texts as being similar. We take these patterns and relationships to constitute the genre. With this conception, genre is understood not as, for example, a form into which the content is fashioned, but rather as the relationship between similar forms and contents. Such a dynamic concept of genre is especially apt for evolving literary traditions, such as *hayʾa*, in which particular features of texts undergo change according to a variety of factors such as the purpose and process of writing or the needs of the target audience.

1.4.1 Conception of the shape of the Earth

Shīrāzī opens Book III of the *Nihāya* with the following paragraph: "It was shown in the first part of Book II that the apparent surface of the Earth is spherical and parallel to the concavity of the [celestial] orb, and together with the apparent surface of the water are analogous to the surface of a sphere." The importance of this phrase lies in the way the shape of the Earth is described. We see that Shīrāzī confines his description of the sphericity of the Earth to its apparent surface. In ancient and medieval times, there were two general ways of describing the shape of the Earth: 1) describing the Earth as a solid sphere, like in the *Almagest*, Farghānī's *Jawāmiʿ*, Qaṭṭān's *Gayhān-shinākht*, Kharaqī's *Muntahá* and Ṭūsī's *Muʿīniyya*; or 2) describing only its surface as spherical, as in Battānī's *Zīj*, Ṭūsī's *Tadhkira*, and the *Nihāya*. The first approach, in which the Earth was regarded as a solid sphere, sometimes led to an inconsistency with the Aristotelian concentric order of the elements in physics.[166] According to the Aristotelian theory of the elements, the Earth would be completely surrounded by water, which, in fact, does not occur in reality. As Aristotle himself states in *On Generation and Corruption*, these elements can change into one another in the world of generation and corruption and that is why we find fire and water within the Earth.[167] It is likely that this issue was also addressed in the Aristotlian *Meteorologica* tradition by the late antique commentators. In one of the earliest Arabic versions of Aristotle's *Meteorologica*, which was prepared by Ibn Biṭrīq for Caliph al-Maʾmūn, we find that "fire, air, water and earth generate, corrupt and change to each other… proof of which is the existence of land and water together on the surface of the Earth."[168]

---

[166] For a history of this confusion in Latin works, see Randles, "Classical Models," 8–10, 22–35.

[167] See Ibn Rushd, *Kitāb al-āthār al-ʿilwiyya*, ed. Suhayr Faḍlallāh Abū Wāfiya and Suʿād ʿAlī ʿAbd al-Razzāq (Cairo: al-Majlis al-Aʿlá li-al-Thaqāfa, 1994), 15–16:

«وتبيّن هنالك [يعني كتاب *السماء والعالم*] أن الأرض في مقعر الفلك. وظهر أيضاً في كتاب *الكون والفساد* أنها يوجد بعض في بعض على جهة الاختلاط وعلى جهة التجاور و بخاصة الأرض فإنّه يظهر للحسّ وجود الاسطقسات الثلاثة فيها أعني النار والهواء والماء...»

See also Casimir Petraitis, *The Arabic Version of Aristotle's Meteorology: A Critical Edition with an Introduction and Greek-Arabic Glossaries* (Beirut: Dār al-Mashriq, 1967), 14–15.

[168] Petraitis, *Aristotle's Meteorology*, 14–15:

Explicit reference to the fact that land and water together form the sphere of the Earth or the spherical surface of the Earth can be found in different descriptions of the shape of the Earth following both approaches. Ptolemy in the *Almagest* (I.4) says “that the earth, too, taken as a whole, is sensibly spherical,”[169] however, he does not explicitly mention water. Farghānī seems to be trying to clarify Ptolemy’s statement by saying “that the Earth in all its parts, land and sea, is sensibly spherical.”[170] Ptolemy in his *Geography* (I.2) comes up with another description of the shape of the Earth: “…it has already been determined that the continuous surface of land and water is spherical.”[171] Shīrāzī seems to have a preference for this description, as he is among a few *hayʾa* scholars who decided to only talk about the surface of the Earth, probably to detour the physical issue of the concentric order of the elements and discussions related to it, like the natural locus of every element. One does not need physics to prove the sphericity of the surface of the Earth since it can be proved mathematically, as Ptolemy mentioned. Before Shīrāzī, his master, Ṭūsī, in the *Tadhkira* also decided to take the same detour. Ṭūsī uses the adjective *mustadīra* to describe the sphericity of the Earth. In Arabic *mustadīr* and *kuriyy* both mean spherical but there is a critical difference between the two terms. *Mustadīr*, which can also mean circular or generally curved, usually is an attribute of lines, planes or motions. Thus when *mustadīr* is used to describe a body, it means that the body has a spherical or curved surface, whereas *kuriyy* applies to the whole body. Therefore, Ṭūsī’s choice of *mustadīra* indicates that he only refers to the sphericity of the surface of the Earth. Battānī seems to be the first who used *mustadīra* to describe the sphericity of the Earth.[172] Kharaqī in his *Muntahá* describes the Earth as a sphere formed from the elements earth and water and thus has to address the Aristotelian concentric order of the elements and all related discussions from the *Meteorologica* tradition.[173]

«إنّ النار والهواء والماء والأرض تتكون و تفسد ويستحيل بعضها إلى بعض... والبرهان على ذلك: البحار والمياه المستقرّة في الأرض على وجهها.»

169 *Almagest*, 40.

170 Farghānī, *Jawāmiʿ*, 11:

«وكذلك أجمعت العلماء أنّ الأرض بجميع أجزائها من البرّ والبحر على مثال الكرة.»

171 J. L. Berggren, and Alexander Jones, *Ptolemy’s Geography: An Annotated Translation of the Theoretical Chapters* (Princeton: Princeton University Press, 2000), 60.

172 Battānī, *Zīj*, 25.

173 Ghalandari, “*Muntahá*,” 2: 157–158.

Another issue arising from the Aristotelian theory of the elements is the relative volume of the four elements. This issue manifests itself in the relative area of land and water on the surface of the Earth, a topic we examine closely in the next section.

1.4.2 Land-water relation

The land-water relation on the surface of the Earth was one of the most important problems of ancient and medieval natural philosophy, astronomy and geography. It was generally accepted that one-fourth of the surface of the Earth is land and the rest is covered by water. This one-fourth was called "the populated quarter" or "*al-rubʿ al-maskūn*" in Arabic. *Hayʾa* authors were well aware of the extension of the inhabited part of the Earth beyond the customary boundaries of *al-rubʿ al-maskūn*, not only on account of Ptolemy's *Geography*, but also because of the vastness of the Islamic world and active commercial and diplomatic contacts between the Islamic world and neighboring nations whose lands were clearly beyond these boundaries. Still, the term "*al-rubʿ al-maskūn*" remained in use in theoretical discussions, not used in a literal sense. For them the question of the existence of habitation in the other parts of the Earth regardless of the climatic situation also remained open.

Shīrāzī describes the customary boundaries of the populated quarter in the *Nihāya* III.1[2] as follows:

> "… the Earth is divided by the equator… into two halves, northern and southern… And [the Earth is divided] by another great circle on its surface that passes through the two poles of the first [great circle, *i.e.*, the equator], into two halves, upper and lower. Therefore **the Earth will be divided by them into fourths. One of the two northern [fourths] is the populated quarter, and** circumstances of **the others** are unknown…"

Shīrāzī then tries to explain why, in theory, the populated quarter has been considered to be one fourth of the surface of the Earth, in the *Nihāya* III.1[3]:

> **"The inhabited world has been determined to be a quarter because observations of celestial phenomena, such as lunar eclipses, have been found [to occur] for those living in the farthest eastern [regions] 12 hours ahead [of their occurrence] for those in the farthest western regions**, not more than that… Indeed Ptolemy **determined** firstly **that [this] quarter is in**

the north because he satisfied himself that **the shadows** of the gnomons **at noon for the equinoxes** all over the populated world are toward north, and not **any of them** are toward south. This was his opinion when he wrote the *Almagest*, since at that time he did not know the amount of the width of the inhabited world. Later, he became aware of the inhabited areas beyond the equator to the south up to the [latitude of] 16 degrees and a quarter and a sixth [of a degree]. Thus, in his book entitled *Geographia* he said that the initial latitude of the inhabited world from the south is where the altitude of the southern pole is 16 degrees and a quarter and a sixth [of a degree], these being **populated regions at the farthest reaches of *Zanj* region, Abyssinia [*al-Ḥabasha*], and some other [areas]** that **have been reported to be southerly**."

In *Nihāya* III.1[4], Shīrāzī quotes a passage from his teacher's *Tadhkira* regarding the fact that the sea surrounds most sides of the populated quarter of the Earth. According to Ṭūsī, it is well-established that this sea surrounds "the western side, the north, and most of the south, especially the eastern part of the populated quarter," but as for the southwest side of the populated quarter, there are reports of travelers in the direction of the sources of Egypt's Nile who have reached localities whose southern latitude exceeds 16° and saw mountains from which arise the headwaters of the Nile at a distance to their south but they did not reach any body of water. Ṭūsī then adds "likewise we do not have definitive knowledge about the sea in the northeast [of the populated quarter]."

Shīrāzī presents his opinion about the inhabited part of the Earth being one fourth of its surface as follows in *Nihāya* III.1[2]:

"… [it is] not [true] that [the other three-fourths] **are either submerged in the sea and not populated or their circumstances are unknown** since the division [into either submerged in the sea or unknown] is false. Nor [is it true] that they are submerged in water, as it is said. [Nor is it true], proceeding from [these premises], that the totality of the elements are inevitably balanced in their volumes and [that], if the water does not encompass the three other quarters [of the Earth], then it would be much less than the whole earth, since what we see from them in their exposition of these premises is an error, let alone a proof. Therefore, it is possible that in the other quarters there are many inhabited lands we are not aware of, since there are drowning seas and towering mountains between us and them."

In the passage above, Shīrāzī refers to a doctrine about the proportional volumes of the elements. This doctrine might have been formed within the late antique tradition of Aristotelian *Meterologica*. In the Islamic period, one can find a reflection of this doctrine in the *Ṭabīʿiyyāt* of the *Shifāʾ*. According to Ibn Sīnā, there was this "prevalent idea that there must be several times more water than earth in the universe; if an element were to change completely into another, this must result in a quantity equal to the actual quantity of that other element; when water changes into earth its volume decreases, therefore there must be less earth than water."[174] Ibn Sīnā considers the fact that the other quarters of the earth are water as the only proof.[175] On the other hand, in the Latin tradition we find a similar doctrine, attributed to Aristotle, that the volumes of the elements were inversely proportional to their densities, which led to the

---

[174] Paul Lettinck, *Aristotle's* Meteorology *and Its Reception in the Arab World: With an Edition and Translation of Ibn Suwār's Treatise on Meteorological Phenomena and Ibn Bājja's* Commentary on the Meteorology (Leiden: Brill, 1999) 196. This idea is probably from Aristotle's *On Generation and Corruption*, II.6 (333a17-333a35) where Aristotle argues against Empedocles' theory that "the elements of body are more than one, so that they are not transformed into one another." Aristotle starts his counterargument by trying to explain in what sense it is open to Empedocles and those who agree with him to maintain that the elements are comparable:

"If it is meant that they are comparable in their amount, all the comparables must possess an identical something whereby they are measured. If, e.g., one pint of Water yields ten of Air, both are measured by the same unit; and therefore both were from the first an identical something. On the other hand, suppose they are not comparable in their amount in the sense that so much of the one yields so much of the other, but comparable in power of action (a pint of Water, e.g., having a power of cooling equal to that of ten pints of Air); even so, they *are* comparable in their amount, though not *qua* amount but *qua* having power. Instead of comparing their powers by the measure of their amount, they might be compared as terms in an analogy: e.g., 'as *x* is hot, so *y* is white.' But 'as', though it means equality in quantity, means similarity in quality. Thus it is manifestly absurd that the bodies, though they are not transformable, are comparable not by analogy, but by a measure of their powers; i.e. that so much Fire is comparable with many times that amount of Air, as being equally or similarly hot. For the same thing, if it be greater in amount, will, since it belongs to the same kind, have its *ratio* correspondingly increased." (Jonathan Barnes, *The Complete Works of Aristotle: The Revised Oxford Translation*, vol.1 (Princeton: Princeton University Press, 1984), 554. Accessed January 14, 2019. http://library.nlx.com/goto.cfm?loc=&infobase=pmari.nfo&depth=2.)

[175] Lettinck, *Aristotle's* Meteorology, 196.

conclusion that the volume of the element water must be several times more than that of the element earth.[176] It is not clear at which point the Islamic and Latin tradition coincide, but significant differences between the two traditions contradicts the possibility of a direct Avicennan influence. It is probable, however, that both traditions can be traced back to late antique commentators of Aristotle.

We saw above that Shīrāzī, considering the belief that three-fourths of the surface of the Earth is submerged in water to be uncertain, argues that there cannot be any logical relation between this and the theory of proportional volumes of the elements. Shīrāzī's first criticism is against Ṭūsī who says in the *Tadhkira* that the other three-fourths "are either submerged in the sea and not populated or else their circumstances are unknown." According to Shīrāzī, this categorization is false. He does not mention any reason for this but perhaps his reason was that one of the two categories, *i.e.*, the unknown circumstances, is more general than the other, *i.e.*, being submerged in the sea, and the two categories stand to each other in the relationship of absolute generality and peculiarity. He goes on to say that if we suppose that one-fourth is land and three other fourths are submerged in water, as has been said by his other predecessors, we cannot proceed from that to the theory of the inversely proportional volumes of four elements. Shīrāzī's argument proceeds as follows:

Premises:

(1) The Earth is divided by the equator and another great circle on its surface that passes through the two poles of the equator into fourths.

(2) One of the two northern fourths is the populated quarter

(3) The other three fourths are submerged in the sea

Conclusion:

The volumes of the four elements are [inversely] proportional [to their densities].

This conclusion means that the volume of water must be several times more than the earth, or as Shīrāzī quotes from the sources: "If the water does not encompass three fourths [of the surface of the Earth], then its volume would be much less than the whole [volume of the element] earth." Shīrāzī's objection here is that "the circumstances of the other [three-fourths] are unknown" and "it is possible that in other [three] fourths there are many inhabited lands we

[176] Randles, "Classical Models," 9–10.

are not aware of." Therefore, premises 2 and 3 are false and one cannot use them as a proof for the theory of the volume of the elements.

It should be noted that later in the *Nihāya* III.1[6a] Shīrāzī tries to prove that the southern hemisphere is mostly covered by water. In this paragraph Shīrāzī presents his reason for the northern region to be uncovered from water as opposed to the southern region. As we discussed in the previous sections, there was this physical principle that the Earth should be completely surrounded by water. Even though Shīrāzī here does not want to drag the discussion into the physics, and only wants to explain why it is the northern region that is uncovered and not the southern region, it will be helpful if we start with the discussion of the temperate zone in the *Ṭabīʿiyyāt* section of the *Shifāʾ*,[177] to which Shīrāzī makes a presumed reference. Ibn Sīnā starts his discussion by saying that according to a physical principle the earth should be completely surrounded by water but this does not occur in reality and the existence of the dry land does not conform to this, and does not conform to what is natural for the earth and water, but conform to what is natural according to the order of the universe (*niẓām al-kull*).[178] He then talks about the theory of the transformation of the elements into one another as one of the principals of the order of the universe. He also briefly refers to heavenly causes as one of the major causes of the accumulation of water on certain parts of the Earth. He finally says that as a result of all this land and water exist together inevitably on the Earth. Ibn Sīnā relates this to the Divine wisdom (*ḥikam ilāhiyya*), which provides the land animals who are alive by the air with a natural place to live on.[179] After this, Ibn Sīnā says that astronomers found out that almost one quarter of the surface of the Earth is land, and this quarter is in the northern hemisphere. According to Ibn Sīnā, there is no clear proof that the other quarters are submerged in water, except one that most

---

[177] Chapter 6 (entitled *fī aḥwāl al-maskūna wa-amzijat al-bilād*, which means "on the circumstances of the populated land and the temperament of the localities") of the first Book (entitled *fī mā yuḥdathū min dhālika bi-nāhiyat al-arḍ*, which means "on what occurs on the Earth as a result of [the meteorological phenomena]) of the fifth section (on the mines and meteorology) of the *Ṭabīʿiyyāt*.

[178] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 24:

«إنّا كنّا قد أشرنا فيما تقدم إلى أن الواجب بحكم طبيعة الماء والأرض أن تكون الأرض في ضمن الماء، ويكون الماء محيطاً بها من جميع الجوانب؛ ولكن الوجود ليس على ذلك، وليس على ما هو طبيعي للأرض والماء، بل ما هو طبيعي لنظام الكلّ.»

[179] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 24–25.

likely is entailed by the necessity of the Earth being surrounded by water.[180] Ibn Sīnā then briefly refers to another proof that is related to the fact that the southern hemisphere is hotter, due to the nearness of the Sun to it, and rejects it. In order to understand Ibn Sīnā's counterargument, let us have look at Shīrāzī's account of this proof:

> "The southern [region] is hotter, due to the nearness of the Sun to it, and its farness from the northern [region], since the Sun's perigee is in the southern zodiacal signs, and its apogee is in the northern ones; its being near [makes] its rays more intense than its being far, and the heat associated with the more intense ray is stronger and sharper than the one associated with the less intense."[181]

Even though Shīrāzī agrees with Ibn Sīnā on this proof being incorrect, he does not accept his counterargument. Shīrāzī, first, quotes Ibn Sīnā's counterargument in Ṭūsī's words from the *Tadhkira*:

> "The difference between the smallest size of the Sun from its being at the apogee and its largest size from being at the perigee is imperceptible to the senses; thus it is far-fetched that its effect would reach an extent whereby one of two similarly positioned locations with respect to the heavens, *i.e.*, the southern and northern hemispheres of the Earth, would be populated, while the other would not be populated."[182]

According to Shīrāzī, "this reasoning, even though convincing with respect to habitation being exclusively in the northern hemisphere rather than the southern one, is not convincing with respect to being exclusively in one of the two northern quarters rather than the other." He then brings his points up, saying:

---

[180] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 25:

«ثمّ لم يقم برهان واضح على أنّ الأرباع الأخرى مغمورة بالماء، إلّا ما يوجبه أغلب الظنّ بسبب وجوب غمور الماء للأرض. إذ الماء بحسب غالب الظنّ أكثر لا محالة من الأرض أضعافاً، لأنّه يشبه أن يكون كلّ عنصر بحيث لو استحال بكلّيته إلى عنصر آخر كان مثله، والماء يتصغّر حجمه عند الاستحالة أرضاً.»

[181] *Nihāya* III.1[6a]

[182] *Nihāya* III.1[6a]; see also Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 26:

«فليس ذلك ممّا يقع به تفاوت بعيد فإنّ خروج الشمس عن المركز ليس بالكثير، وليس ممّا يوجب جزم القول بأنّ العمارة لا تحتمل أن تكون عنده.»

"… [W]e do not accept either the equivalence of the situation of Earth's southern and northern hemispheres with respect to the heavens… or the characterization of one of the two northern quarters as inhabited but not the other inasmuch as the other could possibly be populated but reports of them have not reached us, as discussed before. [We also do] not [accept] that the effect of the difference between the smallest size of the [Sun's] body and its largest, if it were perceptible to the senses, could reach the required extent, as the context indicates; this is because the influencing factor [*al-muʾaththir*] is the actual size as the matter of truth [*nafs al-amr*], not according to the senses."

After his critiques, Shīrāzī concludes the discussion by stating "that the reason for the lack of habitation in the southern region is its being hotter," according to his own reasoning at the beginning of the paragraph *Nihāya* III.1[6a], and that is as follows:

"Be aware that the reason for the northern region to be uncovered, after divine providence and heavenly causes, such as star conjunctions and similar astrological matters, is the attraction of most of the water to the southern region due to its being hotter than the northern region, together with heat's nature to absorb moisture, as can be seen in the lamp, and the fact that the more intense [the heat], the more absorbent it gets."

We do not know what Shīrāzī's source for this reasoning is. Therefore, while for Shīrāzī the possibility of the existence of land and habitation in the other northern quarter remains open, the southern hemisphere seems to be covered mostly by water and thus inhabitable.

1.4.3 Description of the seas

In several *hayʾa* works from Qaṭṭān Marvzī's *Gayhān-shinākht* to Shīrāzī's *Nihāya*, we encounter a very standard account of the seas. This description contains details about the five major seas as given in ancient and medieval accounts: 1) the Indian Ocean and its three gulfs (Gulf of Barbary, the Red Sea, the Persian Gulf and the Gulf of India); 2) the Atlantic Ocean; 3) Mediterranean Sea; 4) the Black Sea; and 5) the Caspian Sea. Some, including Shīrāzī, also mention the Baltic Sea. The details about these well-known seas include their dimensions, regions surrounded by these seas or regions surrounding them, important rivers that discharge into them, and important islands in them. However, regarding the arrangement of the contents, one can recognize two slightly different accounts. The first account finds its earliest Arabic exemplar in Battānī's *Zīj* (written after 306/918).[183] This account has no parallel in the extant Greek sources. Farghānī's *Jawāmiʿ*, as the oldest instance of the *hayʾa* tradition in the Islamic period, does not include any description of the seas. The oldest source with an account similar to that of Battānī is a Syriac work on Christian theology and cosmology entitled *Hexaemeron* (the six days of Creation) by Jacob of Edessa (d. 708 CE), the distinguished Christian scholar and bishop of Edessa during the early days of Islam. This work was written in the very last years of his life and completed after his death by his friend George, Bishop of the Arabs (d. 724 or 726 CE). The *Hexaemeron* contains a significant amount of scientific material, with the third chapter of the geography section presenting a description of the seas that is different from the Greek sources known to us, including the works of Ptolemy, although the names of the seas are Syriac transcription of the Greek names.[184]

Jacob of Edessa's account of the seas is very similar to Battānī's account, especially with regard to the dimensions of the well-known seas, expressed in mile units.[185] Among the geographical works that were produced for chancellery purposes around the time Battānī was active, *al-Aʿlāq al-nafīsa* (written in 310/922) of Ibn Rusta and *Kitāb al-kharāj* (written between 316/928 and 320/932) of Qudāma b. Jaʿfar contain the same account of the seas as Battānī's.[186] It is in Ibn Rusta's account that we find the earliest rearrangement of the contents of the first account that resulted in the formation of what we may identify as the second account. Table 2 below shows how these two accounts are different. Ibn Rusta's general account of the seas is followed by a report of the sea state[187] for the Persian Gulf and the Indian Ocean, most of which can also be found in Abū Maʿshar's (d. 272/886) *al-Madkhal al-kabīr*

---

[183] This *zīj* is based on Battānī's observational activities between 264/877 and 306/918. For more information see S. Ragep, *Jaghmīnī*, 54. For the description of the seas, see: Battānī, *Zīj*, 26–27.

[184] For the Latin translation of the Syriac text, see: Arthur Hjelt, *Etudes sur l'*Hexaméron *de Jacques d'Edesse, notamment sur ses notions géographique contenues dans le 3ième traité* (Helsingfors: Frenckell, 1892), LXIII-LXVII.

[185] It is not clear what kind of mile was meant by Jacob of Edessa or his sources.

[186] For Ibn Rusta's account, see Michael Jan De Goeje, *Ibn Rusta's* Kitāb al-aʿlāq al-nafīsa *and* Kitāb al-buldān *by al-Yaʿqūbī* (Leiden: Brill, 2014), 83–86; and for Qudāma's account, see De Goeje, *al-Masālik*, 230–231.

[187] "Sea state" refers a general description of the condition of a certain sea and its turbulances during different seasons of the year.

with reference to *ʿulamāʾ al-baḥriyyīn*.[188] Ibn al-Faqīh's *Mukhtaṣar kitāb al-buldān* (written in 289–290/902–903) has a very brief account of the seas which is quite different from the account of Battānī/Qudāma (account 1) or that of Ibn Rusta (account 2).

Among *hayʾa* works, Kharaqī's *Muntahá* contains account 1 with additional geographical details[189] while the Persian account in Qaṭṭān Marvzī's *Gayhān-shinākht* and Ṭūsī's *Muʿīniyya* is closer to account 2 with all dimensions expressed in *farsang* units.[190] Sharaf al-Dīn Masʿūdī—who used Qaṭṭān'a *Gayhān-shinākht* and Kharaqī's *Muntahá* in the composition of his Arabic work on *hayʾa, i.e., al-Kifāya fī ʿilm al-hayʾa*, and in its Persian translation, *Jahān-i Dānish*—seems to be inspired by *Gayhān-shinākht* in his choice of the arrangement of the contents and unit of dimensions for the account of the seas; however, he added many details from Kharaqī and other sources like Bīrūnī. In both works, Masʿūdī expresses all dimensions in *farsakh* and *farsang* units in the Arabic and Persian texts respectively.[191] Similarly, Shīrāzī has a preference for account 2 and adds details from Kharaqī, Masʿūdī and other sources. In table 2 we present a comparison of the accounts of the seas in different *hayʾa* works with that of Jacob of Edessa's *Hexaemeron*, the accounts of Battānī/Qudāma and of Ibn Rusta.

Among other early geographical works of the Islamic period, Kh^{w}ārazmī's account of the seas in his *Ṣūrat al-Arḍ* is not similar to either of the two accounts discussed above, but the book has separate chapters for each one of the five important seas.

Shīrāzī ends his accounts of the seas by saying: "These were the examples of the situation of the seas based on the account given by Jayhānī, and other experts on the locations of the seas and their extensions. But there are many details, most of them mentioned in the books on roads and kingdoms [*al-masālik wa-al-mamālik*], so whoever wants a thorough examination should refer to those books."

---

[188] De Goeje, *al-Aʿlāq*, 86–88; Abū Maʿshar, *al-Madkhal al-Kabīr*, ed. Charles Burnett and Keiji Yamamoto (pre-print version) 246–250.

[189] Ghalandari, "*Muntahá*," 2: 321–325. Kharaqī's *Tabṣira* does not contain any account of the seas.

[190] ʿAyn al-Zamān Ḥasan ibn ʿAlī Qaṭṭān-i Marvzī, *Gayhān Shinākht* (Qum: Kitābkhāna-yi Buzurg-i Ḥaḍrat-i Āyatullāh Marʿashī-yi Najafī, 2000), 188–193; Amini, "*al-Risāla al-Muʿīniyya*," 138–142.

[191] Sharaf al-Dīn Masʿūdī, *Jahān-i Dānish*, ed. Djalīl Akhavān Zandjānī (Tehran: Mīrāth-i Maktūb, 2003), 133–136; Sharaf al-Dīn Masʿūdī, *al-Kifāya fī ʿilm al-hayʾa*, MS Hafid Efendi 154, ff. 138a–138b.

Kharaqī has the same reference with the exact same phrase, “Jayhānī and other experts on the locations of the seas and their extensions,” at the beginning of his account of the seas.[192] Since Jayhānī’s work did not come down to us, we are not sure if Shīrāzī really consulted it or if he just copied the citation from Kharaqī. The answer to this question requires more research on the early geographical texts of the pre-modern Islamic world. It is interesting to note, however, that the account of the seas of Bīrūnī, who certainly had access to Jayhānī’s work, in his *al-Tafhīm* is not similar to the standard accounts in *hayʾa* works and does not contain the dimensions of the seas. Yāqūt Ḥamawī (d. 626/1229), the author of the great geographical dictionary, *Muʿjam al-buldān*, calls Bīrūnī’s account the best account he could find and quotes it directly. In general, we can claim that, aside from the early works of Ibn Rusta and Qudāma, we could not find the standard account of the seas as it appears in *hayʾa* works in other geographical writings of the Islamic period. In this sense, we might say that this account can be considered a unique characteristic of the *hayʾat al-arḍ* genre. At the same time, it should be noted that Shīrāzī himself found this account to be out of date and, thus, excluded it from his later *hayʾa* works, namely *Ikhtiyārāt* and *al-Tuḥfa*.

[192] Ghalandari, “*Muntahá*,” 2: 321.

Table 2:

		Jacob of Edessa's *Hexaemeron*	**Battānī's Zīj/Qudāma, *Kitāb al-kharāj***	**Ibn Rusta, *al-Aʿlāq***	**Qaṭṭān's *Gayhān-shinākht***	**Kharaqī's *Muntahá***	**Masʿūdī's *Jahān-i dānish***	**Ṭūsī's *Muʿīniyya***	**The *Nihāya***
Account (arranged by the number of the seas)[193]		3, 4, 5, 1, 2	1, 2, 3, 4, 5 (Account 1)	1, 3, 2, 4, 5 (Account 2)	1, 3, 2, 5, 6	1, 2, 3, 4, 5 (Account 1)	1, 2, 3, 6, 5	1, 3, 6, 5	1, 3, 2, 6, 4, 5 (Account 2)
Mentions 5 great seas?		No	No	Yes	No	Yes	No	No	Yes
Sea/dimensions	**1**	8000×2700 miles	8000×2700 *mīl*s (1900 of it below the equator)	8000×2700 *mīl*s (1900 of it below the equator)	2660×900 *farsang*s (330 of it above the equator)	8000×2700 *mīl*s (1700 of it below the equator)	2360×? *farsang*s (360 of it above the equator)	2660×900 *farsang*s (330 of it above the equator)	2660×900 *farsang*s (330 or 360 of it above the equator)
	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	5000×~400 miles	5000×600 to 800 *mīl*s	5000×600 to 800 *mīl*s	1600×3 to (?) *farsang*s	5000×600 to 800 *mīl*s	1300×3 to 260 *farsang*s	1600×3 to 260 *farsang*s	1600×3 to 260 *farsang*s
	4	~1300×300 miles	1600×300 *mīl*s	1300×300 *mīl*s	N/A	1300×300 *mīl*s	N/A	N/A	4033×? *farsang*s
	5	Circumference=~1800 miles, width=~600 miles	800×600 *mīl*s	1800×600 *mīl*s	260×200 *farsang*s	800×600 *mīl*s	260×200 *farsang*s	260×200 *farsang*s	260×200 *farsang*s
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100×33 *farsang*s

[193] 1) the Indian Ocean and its three gulfs (Gulf of Barbary, the Red Sea, the Persian Gulf and the Gulf of India); 2) the Atlantic Ocean; 3) Mediterranean Sea; 4) the Black Sea; 5) the Caspian Sea; and 6) the Baltic Sea.

Gulfs/dimensions of Sea 1	Indian Ocean (8000×>2700 miles), Red Sea (1400×200 to 400 miles); Persian Gulf (1400×700 miles)	Gulf of Barbary (500×100 *mīl*s); Red Sea (1400×200 to 700 *mīl*s); Persian Gulf (1400×150 to 500 *mīl*s); Gulf of India (1500 *mīl*s)	Barbary (500×100 *mīl*s); Red (1400×200 to 700 *mīl*s); Persian (1400×150 to 500 *mīl*s); India (1500 *mīl*s)	Barbary (160×35 *farsang*s); Red (460×60 to 200 *farsang*s); Persian (460×180 *farsang*s); India (500 *farsang*s)	Barbary (500×100 *mīl*s); Red (1400×200 to 700 *mīl*s); Persian (1400×150 to 500 *mīl*s); India (1500 *mīl*s)	Barbary (160×35 *farsang*s); Red (460×60 to 200 *farsang*s); Persian (460×180 *farsang*s); India (500 *farsang*s)	Barbary (160×35 *farsang*s); Red (460×60 to 200 *farsang*s); Persian (460×180 *farsang*s); India (500 *farsang*s)	Barbary (160×35 *farsang*s); Red (460×60 to 200 *farsang*s); Persian (460×54 to 180 *farsang*s); India (500 *farsang*s)
Islands of Sea 2	the Islands of the Eternals (*sex insulae in numero insularum Beatorum, quae appellantur*), *Γάδειραν* (Gádeiran)	the Islands of the Eternals; *Ghadīra* island; the Islands of Britannia	the Islands of the Eternals; *Ghadīra* island; the Islands of Britannia	the Islands of the Eternals	the Islands of the Eternals; *Ghadīra* island; the Islands of Britannia	the Islands of the Eternals	N/A	the Islands of the Eternals; *Ghadīra* island; the Islands of Britannia
Reference to *al-masālik wa-al-mamālik* books	N/A	No	N/A	No	Yes	No	Yes	Yes

1.4.4 Seven climes

Ptolemy and his Greek predecessors were well aware of the fact that all localities with the same latitude have the same length of daylight. Based on this fact, the notion of "clime" (*lit*. inclination)[194] was introduced during the Hellenistic period, which defined a set of parallels (usually seven) on the surface of the Earth whose values of longest daylight form an arithmetic progression.[195] In the course of its evolution, this notion was gradually adapted to mean a set of parallels with a definite sequence of values of the longest daylight.[196] As we will see later, in *hayʾa* works this notion gained a special geographical connotation, which represents a final phase in its evolution. In these works, this notion of clime did not have any computational significance; in other words, although the astronomical/geodesic data associated with climes is included in *zījes*,[197] they were not meant to be used in practical calculations. Instead, geographical coordinates were used to solve practical problems. In order to understand the abovementioned shift in the notion of clime, we need to have a closer look at the usage of the term by Ptolemy and the authors of *hayʾa* works.

According to Neugebauer, the Geek notion of "clime" originates from a Hellenistic generalization of Babylonian arithmetical methods for the determination of the length of daylight. Babylonian astronomers knew that the length of daylight is a function of the rising times of consecutive zodiacal arcs. Then, around the second or third century B.C., that is, the time of early Alexandrian science, the Greeks became aware of the significance of the fact that the longest daylight varies with latitude and thus coined the term clime to represent a parallel on the surface of the Earth with the same value of the longest day for all the localities that lie on that parallel.[198]

The system of seven parallels with their value of the longest days ranging from 13 hours to 16 hours is commonly known as the "seven climes." The seven climes were conventionally

---

[194] *κλίμα* (also *ἔγκλιμα*, Latin *clima*). In an astronomical context, according to Neugebauer (*HAMA*, 725), "it means the inclination of the earth's axis with respect to the plane of the local horizon, directly observable by the *ἔξαρμα πόλου*, the 'elevation of the pole.'"

[195] *HAMA*, 333–334, 725.

[196] *HAMA*, 334, 727.

[197] For an example of such data see Dallal, "al-Biruni," 14–17.

[198] *HAMA*, 334, 727–728.

associated with the following geographical locations which testify to the Hellenistic-Alexandrian origin of the pattern: [199]

Clime/parallel	longest daylight (hours; minutes)	passing through
I	13	Meroe
II	13;30	Syene
III	14	Lower Egypt
IV	14;30	Rhodes
V	15	Hellespont
VI	15;30	Mid-Pontus
VII	16	Borysthenes

Table 3

The number and the interval between the parallels seem, from the outset, to have been associated with Babylonian arithmetical methods.[200]

Ptolemy, in *Alm*. II.6 on general characteristics of the northern quarter of the Earth,[201] increases the number of these parallels to 33, ranging from the equator where the longest daylight is 12 hours to the latitude where the longest daylight is 24 hours. He starts with 25 parallels with a time interval of a quarter of an hour, continues with four parallels with an interval of half an hour, and finally finishes with four parallels with an interval of one hour. For each parallel, Ptolemy mentions one geographical name. Also, in a table in the *Alm*. II.8, the rising times are given for 11 parallels with half-hour time intervals.[202]

---

[199] *HAMA*, 725.

[200] Some scholars tried to establish an astrological relation between the canonical number seven and the seven planets, but there seems to be no compelling textual evidence for it (*HAMA*, 727).

[201] *Almagest*, 82–89.

[202] *HAMA*, 725. Ptolemy not only increases the number of parallels, but he also decreases them to five in his *Phaseis* (*HAMA*, 335, 726).

Despite this increase in the number of parallels to 33, the notion of "seven parallels/climes" is still present in the *Almagest*. In a set of seven large tables in *Alm*. II.13, the angle between the zodiacal and the meridian is calculated for each one of the traditional seven climes, beginning with Meroe where the longest daylight is 13 hours (latitude = 16; 27) and proceeding with intervals of half an hour up to 16 hours (Borysthenes, latitude = 48;32). Later in *Alm*. VI.11, Ptolemy refers to this table and the computation method he used and then adds: "To provide a means of readily surveying these, instead of a table, we drew a diagram consisting of 8 concentric circles, conceived as lying in the plane of the horizon, to contain the [various] distances and nomenclature for the 7 climata." This is the only place in the *Almagest* where Ptolemy explicitly mentions the "seven climes."[203]

The geographical material in the *Almagest* is limited to general characteristics of the 33 parallels discussed in *Alm*. II.6, in which he only mentions one geographical name of a representative locality within each parallel. Gerald Toomer, the editor of the *Almagest*, sees the information provided in this chapter in line with "the traditional topics of Hellenistic geography" and "irrelevant to the rest of the *Almagest*."[204] Ptolemy himself does not seem to have the same opinion and at the end of *Alm.* II.13. on "geographical coordinates," he confesses that for the calculation of the celestial phenomena, it is necessary to at least determine the coordinates of important cities; however, he continues, "the discussion of this subject belongs to a separate, geographical treatise… in which we shall use the accounts of those who have elaborated this field to the extent which is possible."[205] Here, Ptolemy is referring to his later work, the *Geography*.[206] He then adds that, for the time being, he takes the locations of the cities for granted and whenever he needs to calculate the time difference between two localities, he will use the data of standard places and the longitudinal/latitudinal difference between the given place and the standard place.[207] From Ptolemy's explanation, it is clear that if he had the

[203] *Almagest*, 315; for the diagram, see *Almagest*, 320, fig. 6.7. Ptolemy uses "seven climes" in tables for oblique ascensions, and tables for parallaxes in the Handy Tables, as well (*HAMA*, 335, 726).

[204] *Almagest*, 82, fn. 20.

[205] *Almagest*, 122, 130.

[206] Original Greek title is "Γεωγραφικὴ ὑφήγησις," meaning "guide to drawing a world map. See Berggren and Jones, *Geography*, 3–4; Sezgin, *The contribution*, 6.

[207] *Almagest*, 130.

authentic geographical data of the important cities at the time of the composition of the *Almagest*, he would have included them. This is also the sense we get from the authors of *zījes* and *hayʾa* works who tried to rectify this problem in Ptolemy. Relying on extensive geographical information that became available to them as a result of the vast territories of the Islamic world and the translation and appropriation of the geographical works from different languages, they incorporated considerable amount of geographical material into their works, as we will see later.

Ptolemy's *Geography* is, for the most part, a catalogue of important cities and their coordinates and a map-making guide. Ptolemy has sorted out his geographical catalogue based on regional divisions. For his map-making guide, he gives a list of 23 latitudinal parallels to be used along with the meridian lines as the map grid.[208] There is no particular mention of the seven climes in the *Geography*.

Khʷārazmī's (fl. first decade of 3rd/9th century) *Ṣūrat al-arḍ* starts immediately with the lists of names and geographical coordinates of principal cities of the seven *iqlīms*. It should be noted that in this context, climes were not just parallels, but latitudinal divisions between two parallels, with a middle parallel. Thus, each clime contains 3 parallels, two that demarcate the beginning and end of this division, and one that demarcates its middle. In other words, each clime now has a width, within which it contains geographical locations that experience more or less similar astronomical/meteorological phenomena.

We see this usage of the notion of clime in Suhrāb's (2nd–3rd/9th–10th centuries) *al-Aqālīm al-sabʿa* as well, which, has a rather thorough introduction, adapted from the introduction of Ptolemy's *Geography*.[209] Besides furnishing all kinds of corrections on the coordinates and measurements of the climes—as a direct result of Maʾmūnid scientific activities—there is yet

---

[208] Berggren and Jones, *Geography*, 84–85. This list contains the 14 parallels with quarter an hour difference in the length of their longest day, from the parallel with the longest day of 12 ¼ hours to the one with 15 ½ hours, to be followed by the ones with half an hour difference, from the one with the longest day of 18 hours to the one with 20 hours. He then adds to more parallels south of the equator with half an hour difference. These parallels cover latitude –16;25° up to +63°.

[209] For an English translation of this introduction, see E.S. Kennedy, "Suhrāb and the World-map of Maʾmūn," in *From Ancient Omens to Statistical Mechanics, Essays on the Exact Sciences Presented to Asger Aaboe*, ed. J.L. Berggren and B.R. Goldstein (Copenhagen: University Library, 1987).

another difference between Ptolemy's *Geography* and these two particular Arabic adaptations: the replacement of Ptolemy's regional catalogue by a seven-climes based catalogue. This indicates that the notion of seven climes as a geographical concept was very present in the milieu of the translation movement, probably due to a local influence, or a mixed influence, of active Persian, Indian or Syriac traditions. The seven climes in this geographical sense found its way to *hayʾa* works and became a distinctive element of this genre. The computational aspect of seven climes did not become extinct however and survived as a distinctive feature of the *zīj* genre. *Kitāb al-kharāj* by Qudāma b. Jaʿfar (d. 337/948) contains the notion of seven climes, as used by Greeks, that is, seven parallels.

Interestingly, *hayʾa* writers did not use Ptolemy's 33 parallels for the description of celestial phenomena for different terrestrial regions. Instead they used another kind of division that bundles parallels together with similar celestial phenomena. For this purpose, they considered three major categories, *i.e.*, 1) the equator (sphaera recta), 2) the pole, and 3) the regions between the equator and pole or oblique horizons (sphaera obliqua). Based on the latitude, oblique horizons are divided into five categories: 1) whether the latitude/elevation of the pole is less than the obliquity, or 2) equal to it, or 3) greater than it, and less than its complement, or 4) equal to its complement, or 5) greater than the complement of the obliquity and less than 90°.[210]

Now the question is whether one can find the notion of parallels or climes in *hayʾa* works or not? The answer is yes. This notion is often present in *hayʾa* works in a merely geographical context in a chapter (usually the first chapter) that deals with the description of the inhabited part of the Earth. The first appearance of the seven climes in the *hayʾa* tradition is in Farghānī's *Jawāmiʿ*.[211] Farghānī in chapter 8 of the *Jawāmiʿ*, which is about the calculation of the area of

---

[210] See, for example Farghānī, *Jawāmiʿ*, 24–29.

[211] Jacob of Edessa in *Hexaemeron* apparently describes seven standard parallels in its Book IV dealing generally with astronomy where he discusses sunrise and sunset times and length of days and nights for different places but not in its Book III, which deals with terrestrial realm. For the contents of Book III, see P. Martin, "L'Hexaméron de Jacques d'Edesse," *Journal Asiatique* VIIIe sér. t. XI (1888), 421, geographical excerpts of its original Syriac text, 426–443, and a French translation and analysis, 444-457; for the contents of Book IV, 457–459, and for the seven-climes related material 459–462. Since Book IV has not been published, we cannot compare its content with Farghānī's *Jawāmiʿ* to see if he uses the notion of the clime as parallels or latitudinal divisions.

the surface of the Earth and the division of its inhabited part into seven climes, describes seven standard climes not as parallel lines, but as parallel bands with a certain width. The middle lines of these climes correspond with the seven parallels of the Greek. For each clime, Farghānī provides the reader with the length of the longest daylight and the elevation of the pole (*i.e.*, the latitude) for the initial and final limit and the middle line of that clime. Then, he mentions the width of the clime in *mīl* units.[212] Since the final limit of each one of the climes I-VI is the same as the initial limit of the next clime, later *hayʾa* authors just mentioned the initial limit and middle line for each clime. Farghānī, in the following chapter on the names of well-known countries and cities on the Earth and what of them is contained by each clime, mentions the names of famous countries and cities of each clime.[213] Later *hayʾa* authors combined the material of these two chapters and mentioned the names of important localities of each clime right after its technical description.

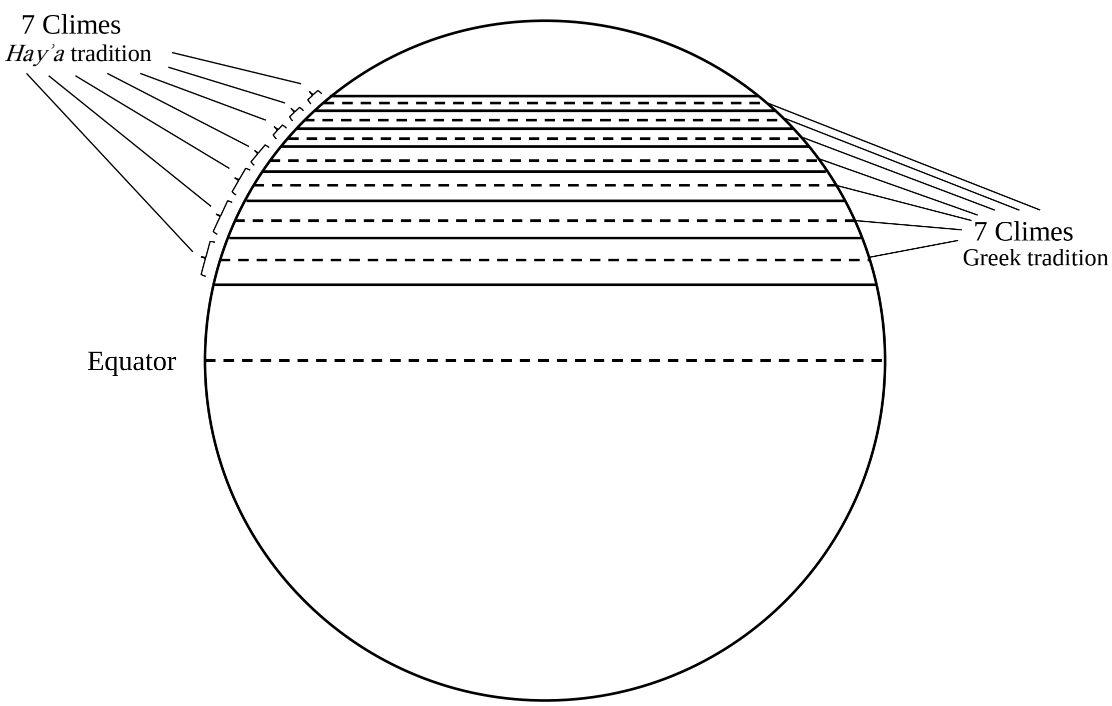


Fig. 2

Shīrāzī's definition of "the clime" is very precise:

[212] Farghānī, *Jawāmiʿ*, 32–34

[213] Farghānī, *Jawāmiʿ*, 35–39

> “**The practitioners of this science have divided** most of the prosperous part of the populated quarter **into seven** divisions **lengthwise so that each clime is beneath a day-circle, the conditions of the places in it then being similar…** and named each division a clime, which is a part of the [surface of the] Earth containing some localities, bounded by two parallel half-circles… that are [also] parallel to the equator.”[214]

Shīrāzī then indicates a resemblance between the shape of a clime and a half tambourine, and continues by saying that the length of climes decreases by their distance from the equator:

> “**Thus each clime extends from east to west in longitude** in the shape of a half tambourine, one of its two sides more contracted than the other since climes are different in length. So the one at the equator is longer than the one next to it and the length of a singular clime is longer in its southern side than in its northern side, the shortest being the one next to the timpani-shaped uninhabited zone.”[215]

In the last sentence above, Shīrāzī mentions “the timpani-shaped uninhabited zone.” In order to understand this description, it should be noted that, following the Aristotelian *Meteorologica* tradition, the scholars of the Islamic period divided the Earth into five sections: two habitable temperate sections, two uninhabitable frigid sections and one uninhabitable torrid section. The habitable sections and the torrid section were described as “the three tambourine-shaped sections,” (*thalāthata quṭūʿ duffiyya*) and the two frigid sections as “the two timpani-shaped sections” (*qiṭʿatayn ṭabliyyatayn*) (see figs. 3–5 below).[216] We will discuss this further in the next chapter.

---

[214] *Nihāya* III.1[7e]

[215] *Nihāya* III.1[7e]

[216] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt, al-maʿādin wa-al-āthār al-ʿilwiyya*, ed. ʿAbd al-Ḥalīm Muntaṣir, Saʿīd Zāyid, and ʿAbd Allāh Ismāʿīl (Cairo: 1965) 26–27; Fakhr al-Dīn Rāzī, *Sharḥ mushkilāt kitāb al-Qānūn*, ed. Najafqulī Ḥabībī (Tehran: Kitābkhāna-yi Majlis Shūrā-yi Islāmī, 2018), 91.

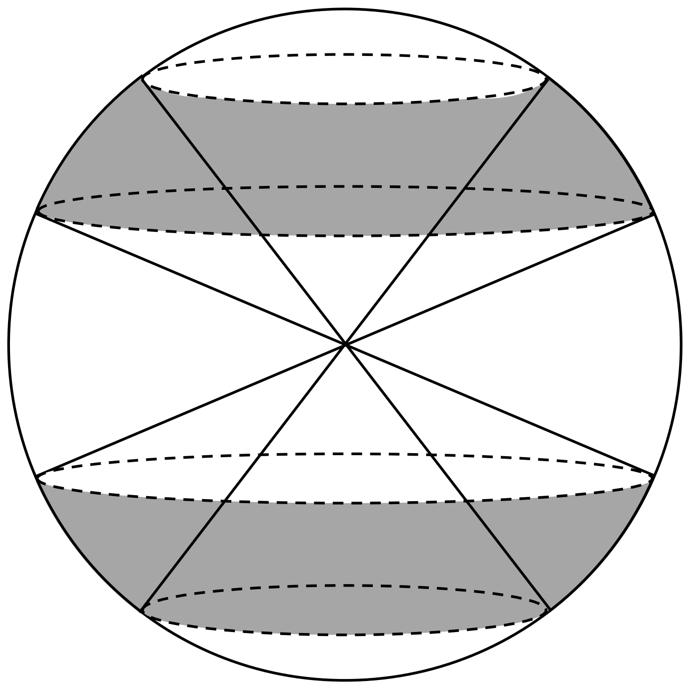


Fig. 3

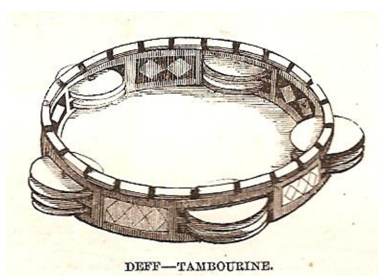


Fig. 4 (W. M. Thomson, *The Land and the Book: or Biblical Illustrations Drawn from the Manners and Customs, the Scenes and Scenery of the Holy Land*, vol. III (New York: Harper, 1910), 393. Accessed January 6, 2019. https://babel.hathitrust.org/cgi/pt?id=uc1.31158001277093;view=1up;seq=52)

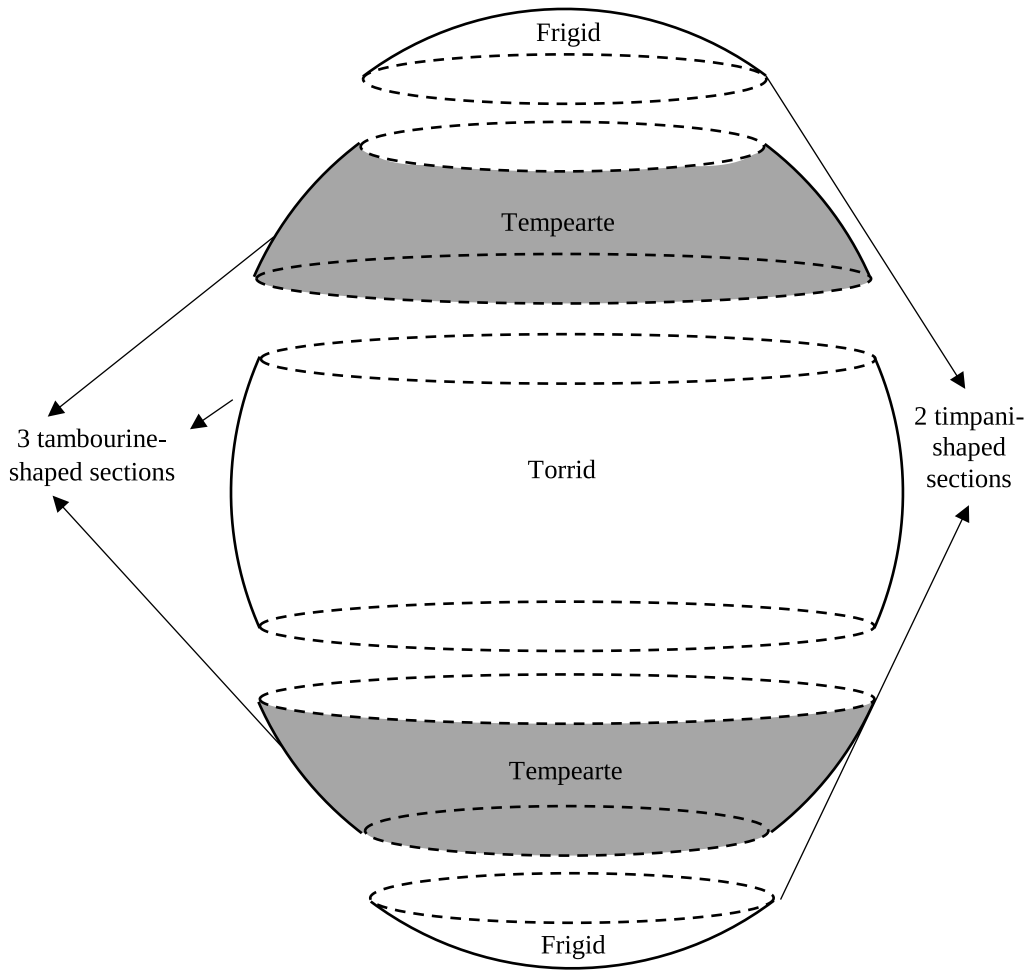


Fig. 5

Shīrāzī then mentions the initial/final limits and middle line of each clime in terms of latitudes and longest daylight. For each clime, he recounts the names of important localities, such as regions, provinces, cities, islands, rivers, seas etc. and adds valuable information from other geographical sources. Although his account of the climes is very similar to Kharaqī's account in the *Muntahá*, Shīrāzī's description includes names of localities that cannot be found collectively in any other source. His reference to the North Sea among the localities of the 7th clime in the *Nihāya* III.1[8g] is, to best of my knowledge, the only reference to this sea in the known geographical sources of the pre-modern Islamic world.[217] His stated purpose for including this amount of geographical details can be found at the end of his account: "This was a reference to some of the localities of the climes to awaken the eagerness of the learners."[218]

1.4.5 Temperate zone

In the second chapter of Book III of the *Nihāya*, entitled "on the characteristics of the equator," Shīrāzī provides the reader with a detailed history of the question of the temperate zone of the Earth. In ancient and medieval times, the question of the temperate zone was always regarded as important in various fields of knowledge like philosophy, medicine, geography, meteorology, etc. The physicians and philosophers believed that the human body, like any other body in the world, was composed of the four elements which were associated with the four qualities of cold, dryness, humidity and heat. The human temperament depends on the balance between these elements and their qualities. Thus, the necessity of keeping the temperament of patients balanced was regarded as crucial by the physicians, since any "imbalance" could be potentially an illness. Ibn Sīnā, among other philosopher-physicians of the pre-modern Islamic world, developed his theory of temperament with an emphasis on certain external factors such as climate.[219] That is why we find the discussion of the temperate zone in Ibn Sīnā's *Canon of Medicine* in a chapter on the temperaments.

---

[217] This is where he says: "[the 7th clime] then passes through [the region of] the Bulgarians, Russians and Slavs, and across the Sea of Germans and Slavs [*Baḥr Alamān wa-al-Ṣaqāliba*], and ends at the Ocean." We do not know to what extent Germans were dealt with in different sources of the Islamic period. The fact that in all but one manuscript of the *Nihāya*, which was corrected by Shīrāzī himself, the name of this sea has been recorded as *Baḥr al-Shām wa-al-Ṣaqāliba* [Sea of Syria and Slavs], suggests that "*Alamān*" was not a widely-known name in the Arabic literature. So far, I could only find one other mention of *Alamān* in *Muʿjam al-buldān* where Yāqūt describes Rome (*al-Rūmiyya*) and says its king is the King of Germans (*malik Alamān*; see Yāqūt al-Ḥamawī, *Muʿjam al-buldān*, vol. 3 (Beirut: Dār Ṣādir, 1995), 100):

«وهي اليوم بيد الأفرنج، و ملكها يقال له ملك ألمان...»

[218] *Nihāya* III.1[8j]

[219] F. Sanagustin, "Mizādj," in *Encyclopaedia of Islam, Second Edition*, ed. P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs. Consulted online on 09 January 2019 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_8829>

Being a physician with a good grasp of Ibn Sīnā's *Canon* and its commentaries, Shīrāzī tries to cover, as much as possible, different discussions related to the temperate zone question in his complex account in the *Nihāya* III.2[2–4]. Since, in his account, Shīrāzī brings up the arguments and counter arguments of various scholars such as Ibn Sīnā, Ṭūsī and Fakhr al-Dīn Rāzī, and criticizes them at times, it is very important for the reader to at least be familiar with the history of the temperate zone question in different contexts prior to Shīrāzī's time. To provide such a history, we have consulted the *Almagest*; a text attributed to Thābit b. Qurra in the pseudo-Aristotelian *Problemata* tradition; Ibn Sīnā's *Shifāʾ* and *Canon of Medicine*; Rāzī's commentary on the *Canon* of Ibn Sīnā; and Ṭūsī's *Tadhkira*.

As we mentioned in the previous part, in the Aristotelian *Meteorologica* tradition the Earth was divided into five sections, two of them being inhabitable. The three uninhabitable sections consist of two frigid zones around the poles and one torrid zone between the tropics. This view was well-known in the Islamic period. Ibn Sīnā mentions this division in a specific chapter of the first Book of the fifth section (on the mines and meteorology) of the *Ṭabīʿiyyāt* of the *Shifāʾ*. In this chapter, entitled *fī aḥwāl al-maskūna wa-amzijat al-bilād* (on the circumstances of the inhabited world and the temperament of the localities), Ibn Sīnā rejects the Aristotelian division of the Earth into five habitable and inhabitable sections, stating that "there are inhabited regions whose latitude is less than the obliquity where the Sun is directly overhead several times; furthermore, not only have regions been discovered near the equator, but trustworthy people have written down the circumstances of the regions located along the equator, like Sri Lanka."[220] Ibn Sīnā then argues that the equator is the most temperate zone.[221] Ibn Sīnā is not the first scholar to consider the equator temperate. Ptolemy in *Alm.* II.6, which is on the characteristics of different regions of the Earth parallel by parallel, where he discusses the equator, says:

---

[220] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 27:

«فهذا قول قدماء المشائين، وليس التحقيق والوجود على ما حكوه. فإنّ هاهنا بلاداً عروضها أقلّ من الميل، والشمس تسامت الرؤوس فيها مراراً، وهي عامرة. وقد وجدت بلاد تقرب من خطّ الاستواء، بل قد دوّن الثقات أحوال بلاد موضوعة في خطّ الاستواء ومنها سرنديب.»

[221] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 27:

«والقياس يجوّز بل يوجب أن تكون بقعة خطّ الاستواء أصلح المواضع للسكنى وأولاها بالاعتدال.»

> "It is said that the regions beneath the equator could be inhabited, since the climate must be quite temperate. For the sun does not stay long in the neighbourhood of the zenith, since its motion in declination is swift round about the equinoctial points, and hence the summer would be temperate; furthermore, it is not very far from the zenith at the solstices, so the winter would not be harsh. But what these inhabited regions are we have no reliable grounds for saying. For up to now they are unexplored by men from our part of the inhabited world, and what people say about them must be considered guesswork rather than report."

Before analyzing Ibn Sīnā's argument about the equator being the most temperate zone, let us go back to Shīrāzī's account. Shīrāzī starts his account by stating that there is a general agreement that localities beneath the day-circles of the two solstices (tropics) are the hottest localities in the summer, "if terrestrial causes do not work against it by reducing the temperature."[222] He then points out that "there is disagreement on where the most temperate locality is." After mentioning Ibn Sīnā's position, Shīrāzī informs us that according to Fakhr al-Dīn Rāzī the fourth clime is the most temperate zone. Before starting his analysis of these two arguments, Shīrāzī brings up an introduction, which had been originally put together by Rāzī in his commentary on Ibn Sīnā's *Canon of Medicine*. One interesting point about this introduction is that it basically consists of the preliminaries used by Ibn Sīnā in favor of the equator being the most temperate, and Rāzī rephrased and rearranged them for his own argument. In the following tables (4–6) one can follow the rephrasings and rearrangements of Ibn Sīnā's preliminaries by Rāzī and Shīrāzī. We could trace back some of these preliminaries to a treatise entitled *Masāʾil qarībat al-maʾkhadh wa-jawābātuhā allafahā Thābit ibn Qurra al-Ḥarrānī wa-jamaʿahā min aqāwīl Arisṭūṭālīs wa-ghayrihī*. As has been mentioned above, this work belongs to the pseudo-Aristotelian tradition of the *Problemata*. These works contain various problems of physics, meteorology, etc. together with their responses. The first problem of Thābit's work and its reply contain some of the abovementioned preliminaries.

Table 4 contains different versions of the two propositions which have been used by Ibn Sīnā, Rāzī and Shīrāzī for their arguments; table 5 the *limmī/propter quid* proof of these

[222] *Nihāya* III.2[2a]

propositions; and table 6 their five *innī/quia* proofs. "*Innī* proofs" were meant to prove facts based upon observations and "*limmī* proofs" were meant to prove reasoned fact based on physical or metaphysical principles.[223]

[223] For a discussion of *innī*/*limmī* proofs, see F.J. Ragep, *al-Tadhkira*, 39, 41–42.

Table 4: Propositions

1. The intensity of heat may be due to the power of the heat-maker and may also be due to the continuity of heating, even if the heating is weak.				
Thābit, f. 45b[224]	Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 28–29	Ibn Sīnā, *al-Qānūn fī al-ṭibb*, 1:122	Rāzī, *Sharḥ mushkilāt kitāb al-Qānūn*, 91–92	Shīrāzī, *Nihāya* III.2[2a]
The strength of the heat in an object that is being heated may be due to the intensity of the heat production of the heating object, and may also be due to the continuity of its heat production for days and for the length of its stay in the heat…	It is not only the Sun's being overhead that makes the weather hot… In fact, it does not have much of an influence, but it only becomes influential by continuity.	The celestial cause of heating there is a single cause, which is the Sun being directly overhead. Being directly overhead, in and of itself, does not have much of an influence, but it is the continuity of being directly overhead that is influential.	The intensity of the heat produced in a thing may be due to the power of the heat-maker and may also be due to the continuity of heating, even if the heating is weak.	The intensity of heat may be due to the power of the heat-maker and may also be due to the continuity of heating, even if the heating is weak.
... أنّ الحرّ في الشيء الذي يحمى قد تكون قوّته لشدّة إسخان الشيء المسخن له وقد تكون لدوام إسخانه أيّام وطول لبثه في الحمي فإن [...؟]	لكن ليس كلّ ما يسخن الجوّ من الشمس إنّما هو بهذه المسامتة... فإنّها لا تؤثر تأثيراً كبيراً، وإنّما تؤثر بالمداومة.	وذلك أن السبب السماوي المسخن هناك هو سبب واحد، هو مسامتة الشمس للرأس، وهذه المسامتة وحدها لا تؤثر كثير أثر، بل إنّما تؤثر مداومة المسامتة.	وهي أنّ شدة تسخُّن الشيء قد تكون لقوّة المسخّن وقد تكون لدوام إسخانه وإن كان ضعيفاً.	هي أنّ شدّة السخونة قد تكون لقوّة المسخن وقد تكون لدوام إسخانه وإن كان ضعيفاً.
2. The effect of a weak influencing factor will be stronger if the duration of its influence is longer than the duration of influence of a strong factor.				
			The influence of a strong [factor] may be less than the influence of a weak [factor] if the latter lingers.	The effect of a weak influencing factor will be stronger if the duration of its influence is longer than the duration of influence of a strong factor.

224 Thābit, *Masāʾil qarībat al-maʾkhadh wa-jawābātuhā allafahā Thābit ibn Qurra al-Ḥarrānī wa-jamaʿahā min aqāwīl Arisṭūṭālīs wa-ghayrihī*, Microfilm no. 1559, University of Tehran, Yaḥyá Mahdawī's collection.

والمؤثّر الضعيف قد يصير أثره أقوى إذا كان زمانه أكثر من زمان المؤثّر القوي.	وقد يكون تأثير القوي أقلّ من تأثير الضعيف إذا كان الضعيف أدوم.	

Table 5: *limmī/propter quid* proof

<table>
<tr><td colspan="2">The limmī proof is that the influencing factor produces one effect in the first [interval of] time and another effect is added to it in the second [interval of] time; there is no doubt that the combination of the two effects is stronger than one single effect. [In other words,] since the effector produces an effect in the first [interval of] time, if it continues to the second [interval of] time, the propensity will be more intense and the effect stronger.</td></tr>
<tr><td align="center">Rāzī, Sharḥ mushkilāt kitāb al-Qānūn, 91–92</td><td align="center">Shīrāzī, Nihāya III.2[2a]</td></tr>
<tr><td>The factor produces an effect in the first [interval of] time; if it continues to the second [interval of] time, it produces another effect; and if the factor stays longer, the accumulated effects become greater and inevitably the effect will be stronger. In other words, the factor produces one effect in the first [interval of] time and another effect is added to it in the second [interval of] time; there is no doubt that the combination of the two effects is stronger than the effect of the factor alone.</td><td>(1) The influencing factor produces one effect in the first [interval of] time and another effect is added to it in the second [interval of] time; there is no doubt that the combination of the two effects is stronger than one single effect. (2) [In other words,] the influencing factor produces an effect in the first [interval of] time, if it continues to the second [interval of] time, the propensity will be more intense and the effect stronger.</td></tr>
<tr><td dir="rtl">فهي أنّ السبب يُفيد في الوقت الأول أثراً فإذا بقي إلى الوقت الثاني أفاد أثراً جديداً ومتى كان ذلك السبب أطول بقاءً كانت الآثار المجتمعة أكثر؛ فلا جرم كان الأثر أقوى. ومن وجه آخر: وهو أنّ السبب في الوقت الأول إذا أفاد أثراً انضمّ ذلك الأثر إلى السبب، فصار المجموع مقتضياً لأثر آخر؛ ولا شكّ أن تأثير المجموع أقوى من تأثير السبب وحده.</td><td dir="rtl">(1) هي أنّ المؤثّر في الزمان الأوّل يفيد أثراً وينضمّ إليه في الزمان الثاني أثر آخر ولا شكّ أنّ مجموع الأثرين أقوى من أثر واحد. (2) أو لأنّ المؤثّر يفيد في الوقت الأوّل أثراً فإذا بقي إلى الوقت الثاني اشتدّ الاستعداد، فكان الأثر أقوى.</td></tr>
</table>

Table 6: *innī/quia* proofs

<table>
<tr><td colspan="5">1. The Sun's heat being greater when it is in Leo, in spite of its being afar from zenith, than its heat when it is in the summer solstice, despite its being close to zenith.</td></tr>
<tr><td>Thābit, Risāla mā bāl, ff. 45b–46a</td><td>Ibn Sīnā, Shifāʾ, Ṭabīʿiyyāt, al-maʿādin wa-al-āthār al-ʿilwiyya, 28–29</td><td>Ibn Sīnā, al-Qānūn fī al-ṭibb, 1:122</td><td>Rāzī, Sharḥ mushkilāt kitāb al-Qānūn, 91–92</td><td>Shīrāzī, Nihāya III.2[2a]</td></tr>
<tr><td>The weather is hotter in Tammūz when the Sun has started [its] depression and distancing from our zeniths, and [when] the daylight has been decreasing from its maximum length, compared to Ḥazirān when the Sun is in its maximum closeness to our zeniths and the day is in its maximum length.</td><td>Otherwise the heat would be greater when the Sun is in Cancer than when it is in Leo,[225] but this is not so.</td><td>(2) For this, the Sun's heat when it is in the end of Cancer and beginning of Leo is less than [its heat] when it is in the maximum declination.</td><td>(1) The heat produced by the Sun when it is in Cancer is weaker than its heat production when it is in Leo despite its closeness to the zenith when it is in Cancer; this is only because when it is in Leo the duration of its heat production is longer.</td><td>(1) The Sun's heat being greater when it is in Leo, in spite of its being far from us, than its heat when it is in the summer solstice, despite its being close to us.</td></tr>
<tr><td>الجوّ في التموز، وقد أخذت الشمس في الانحطاط والتباعد عن سمت رؤوسنا ونقص النهار عن منتهى طوله، أشدّ حرّاً منه في حزيران و الشمس في غاية قربها من سمت رؤوسنا والنهار في غاية طوله.</td><td>وإلّا لكان الحرّ والشمس في نقطة السرطان أشدّ منه وهي في نقطة الأسد، وليس كذلك.</td><td>(2) ولهذا ما يكون الحرّ والشمس في آخر السرطان وأوائل الأسد أشدّ منه إذا كانت الشمس في غاية الميل.</td><td>الأوّل أنّ تسخين الشمس عند كونها في السرطان أضعف من تسخينها عند كونها في الأسد مع أنّ قربها من سمت الرأس حين ما تكون في السرطان أشدّ وما ذاك إلّا لأنّها حين ما تكون في الأسد تكون مدّة تسخينها أطول.</td><td>الأوّل زيادة حرّ الشمس عند كونها في الأسد مع بعدها عنّا عليه وهي في المنقلب مع قربها منّا.</td></tr>
<tr><td colspan="5">2. The Sun's heat being greater when it is in Leo and Virgo than when it is in Taurus and Aries.</td></tr>
<tr><td></td><td>Otherwise the heat would be the same when the Sun is in Gemini and in Leo and also when it is in Taurus and in Virgo,[226] but this is not the case.</td><td>(3) That is why the Sun produces greater heat when it departs from the head of Cancer to the point whose declination is less than [the head of Cancer], than when the Sun is at the same declination point and has not reached the head of Cancer.</td><td>(2) The heat is stronger when the Sun is in Leo and Virgo than when it is in Gemini and Taurus, in spite of their having similar distances from where the Sun is directly overhead.</td><td>(2) The Sun's heat being greater when it is in Leo and Virgo than when it is in Taurus and Aries.</td></tr>
</table>

[225] English translation from Lettinck, *Aristotle's* Meteorology, 197.

[226] English translation from Lettinck, *Aristotle's* Meteorology, 197.

	وإلّا لكان الحرّ والشمس في نقطة الجوزاء مساوياً للحرّ وهي في نقطة الأسد، والحرّ وهي في نقطة الثور مساوياً للحرّ وهي في نقطة السنبلة، وليس الأمر كذلك.	(3) ولهذا تكون الشمس إذا انصرفت عن رأس السرطان إلى حدّ ما هو دونه في الميل أشدّ تسخيناً منها إذا كانت في مثل ذلك الحدّ من الميل، ولم يبلغ بعد رأس السرطان.	الثاني أن الحرّ عند كون الشمس في الأسد والسنبلة أقوى منه عند كونها في الجوزاء والثور مع أن البعد من المسامتة سِيّان وما ذلك إلّا لما قلنا.	الثاني زيادته عند كونها في الأسد والسنبلة عليه وهي في الثور والحمل.
3. The Sun's heat being greater two hours after noon than its heat two hours before noon, even though its distance from us is the same in both states.				
After noon, the weather is hotter than noon.	That is why in the summer, the after noon heat is greater than the heat before [noon], while the relative [distance of the Sun to the meridian] is equal.	That is why the heat is greater after noon prayer than the heat at noon.	(4) The after noon heat is greater than the before noon heat, even though the relative [distance of the Sun to the meridian] is equal.	(3) The Sun's heat being greater two hours after noon than its heat two hours before noon, even though its distance from us is the same in both states.
... أنّ حرّ الجوّ بعد الزوال أشدّ منه في [وقت؟] الزوال.	ولهذا ما تكون الحرارة بعد زوال الشمس في الصيف أشدّ منها قبله، والنسبة واحدة.	(1) ولهذا ما يكون الحرّ بعد الصلاة الوسطى أشد منه في وقت استواء النهار.	الرابع أنّ الحرّ بعد الزوال أشدّ منه قبل الزوال مع أنّ النسبة واحدة.	الثالث زيادته بعد الزوال بساعتين عليه قبله بساعتين مع تساوي بعدها عنّا في هاتين الصورتين.
4. The heat of a body that has been in a weak fire for a while being greater than its heat when it was in a strong fire for a moment.				
The heat of the iron, for example, is greater if it is heated in a mild fire for a good amount of time, than its being heated in a (?) fire.	This is like a fire falling into a certain house suddenly, so it does not have much of an influence, it only becomes influential by continuity.		(3) The heat produced in iron [heated] in a mild fire for a long time is more intense than the heat produced in it when [heated] in a stronger fire for a short time.	(4) The heat of a body that has been in a weak fire for a while being greater than its heat when it was in a strong fire for a moment.
لو أسخن الحديد مثلاً في نار ليّنة مدّة صالحة لسخن أكثر من سخونته في نارٍ...	وهذا مثل النار التي تدخل بيتاً ما دفعة، فإنّها لا تؤثر تأثيراً كبيراً، وإنّما تؤثر بالمداومة.		الثالث أنّ تسخُّن الحديد في نار ليّنة مدّة طويلة أشدّ من تسخّنه في نار قوية ساعة لطيفة.	الرابع زيادة حرّ الجسم في نار ضعيفة ساعة عليه وهو في نار قويّة لحظة.
5. The cold in the early morning being greater than at midnight, even though the Sun is farther away at midnight.				
… The cold in the early morning, when the Sun is about to rise, is more intense than at midnight, when the sunrise is later.			(5) The cold in the early morning being more intense than at midnight, even though the Sun is farther from the lower mid-heaven at that time compared to morning time.	(5) The cold in the early morning being greater than at midnight, even though the Sun is farther away at midnight.

الخامس زيادة البرد في الأسحار عليه في نصف الليل مع أنّ الشمس حينئذ أبعد.	الخامس أن البرد في الأسحار وهو قرب طلوع الشمس أشدّ منه في نصف الليل مع أنّها في ذلك الوقت أبعد من وتد السماء منها في وقت الصبح.			... أنّ البرد في الأسحار وقد قرب طلوع الشمس، أشدّ منه في وقت نصف الليل وهو أبعد.

The core of proposition 1 is that the duration of influence of a factor makes its influence stronger, while the core of proposition 2 is that the influence of a weak factor can be greater than the influence of a strong factor if the duration of influence of the former is longer. So, according to Shīrāzī, the *limmī/propter quid* proof is in favor of the first proposition while the *innī/quia* proofs 1, 4 and 5 in which we see the weak/strong influencing factor dichotomy, support the second proposition. Shīrāzī believes that *innī/quia* proofs 2 and 3 are not in favor of either these propositions, but it is clear that they support proposition 1, as evidenced by Ibn Sīnā's application of these two proofs in his *Shifāʾ* and *Canon*.

Ibn Sīnā uses the abovementioned preliminaries to show how the atmosphere is heated by the Sun and to discuss that the heating of the atmosphere depends not only on the Sun being directly overhead but also on the duration of Sun's position. Then, on the grounds that at the equator the Sun reaches the zenith suddenly and moves away from it quickly—at which point the Sun's motion in declination is at its fastest and thus it does not linger there long at the zenith—and that daylight and night at the equator are equal, Ibn Sīnā argues that neither the heat nor the cold becomes very extreme and it is always temperate at the equator.[227]

Ibn Sīnā's discussion of the temperate zone in the *Kulliyyāt* section of his *Canon* is more brief but very similar to the discussion in the *Shifāʾ*:

> "The statement of whoever says that the localities beneath the equinoctial are close to temperateness should be deemed credible. This is because the cause of celestial heating there, which is the Sun's being directly overhead, is a singular cause, and this alignment [of the Sun and zenith] in and of itself cannot produce much of an influence, and what matters is the duration of the alignment. That is why the [Sun's] heat after the *ʿaṣr* prayer is greater than its heat at noon… In the localities along the equator the Sun is directly overhead for a few days, then moves away from zenith quickly etc."[228]

---

[227] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 29:

«وأمّا فى خطّ الاستواء، فإنّ الشمس تبلغ المسامتة دفعة، لأنّ الميول هناك تكثر وتتفاوت تفاوتاً لا يؤثّر إلّا أثر المسامتة والمغافصة، ثمّ تبعد عن سمت الرؤوس بسرعة، ولا تلحّ عليها،وتأخذ كلّ ساعة تزداد بعداً إلى أن يبعد الميل كلّه،غير ملحّة ولا لجوج، ويكون النهار مساوياً لليل فى الطول و القصر. ثمّ لا تعود إلى سمت الرأس عن قرب، بل إلى نصف السنة. ثمّ تكون المسامتة خفيفة على الجملة المذكورة. ثمّ تأخذ في البعد، فلا يشتدّ الحرّ جدّاً، لما قلناه، ولا يشتدّ أيضاً البرد.»

[228] Ibn Sīnā, *al-Qānūn fī al-ṭibb*, 1:122:

With regard to Ibn Sīnā's reasoning for the equator being the most temperate, Fakhr al-Dīn Rāzī distinguishes two different aspects of temperateness: 1) a uniformity in climatic condition (*tashābuh aḥwāl*); and 2) general temperateness of the weather (*iʿtidāl fī al-ḥarr wa-al-bard*).[229] Rāzī completely agrees with the first aspect but, as for the second, he says the equator can be the hottest locality depending on the position of the Sun's apogee, even though he admits that in his time the equator is extremely temperate.[230] Still, Rāzī raises objections against Ibn Sīnā's reasoning. Rāzī discusses this issue in a couple of other works. In his *al-Maṭālib al-ʿāliya min al-ʿilm al-ilāhī*, Rāzī claims that the third and fourth climes are the most temperate with regard to temperament, due to their temperate weather.[231]

In *hayʾa* works, Kharaqī simply states that the equator is extremely temperate with a brief reasoning similar to Ibn Sīnā's main argument in the *Shifāʾ* that the Sun does not linger there long at the zenith. Ṭūsī briefly discusses both Ibn Sīnā and Rāzī's views and adds at the end that "if one means by temperate a uniformity in the conditions, then there is no doubt that it is most so at the equator, but if one means by it a balancing of the two [extreme] weather conditions, then there is no doubt that it is more so in the fourth clime." Shīrāzī raises objections against both Ibn Sīnā and Rāzī, but at the end he seems satisfied with Ṭūsī's judgement.

«ويجب أن يصدق قول من يرى أن البقعة التي تحت دائرة معدل النهار قريبة إلى الاعتدال، وذلك أن السبب السماوي المسخن هناك هو سبب واحد، هو مسامتة الشمس للرأس، وهذه المسامتة وحدها لا تؤثر كثير أثر، بل إنما تؤثر مداومة المسامتة. ولهذا ما يكون الحرّ بعد الصلاة الوسطى أشد منه في وقت استواء النهار. ولهذا ما يكون الحرّ والشمس في آخر السرطان وأوائل الأسد أشد منه إذا كانت الشمس في غاية الميل. ولهذا تكون الشمس إذا انصرفت عن رأس السرطان إلى حدّ ما هو دونه في الميل أشدّ تسخيناً منها إذا كانت في مثل ذلك الحدّ من الميل، ولم يبلغ بعد رأس السرطان. والبقعة المسامتة لخط الاستواء، إنما تسامت فيها الشمس الرأس أياماً قليلة، ثم تتباعد بسرعة، لأن تزايد أجزاء الميل عند العقدتين، أعظم كثيراً من تزايدها عند المنقلبين، بل ربما لم يؤثر عند المنقلبين حركة أيام ثلاثة وأربعة وأكثر أثراً محسوساً، ثم إن الشمس تبقى هناك في حين واحد متقارب مدة مديدة، فيمعن في الإسخان، فيجب أن يعتقد من هذا أن البلاد التي عروضها متقاربة للميل كله هي أسخن البلاد، وبعدها ما يكون بعده عنه في الجانبين القطبيين مقارباً لخمس عشرة درجة، ولا يكون الحرّ في خط الاستواء بذلك المفرط الذي يوجبه المسامتة في قرب مدار رأس السرطان في المعمورة، لكن البرد في البلاد المتباعدة عن هذا المدار إلى الشمالي أكثر.»

229 Rāzī, *Sharḥ*, 93.

230 Rāzī, *Sharḥ*, 95–96.

231 Fakhr al-Dīn Rāzī, *al-Maṭālib al-ʿāliya min al-ʿilm al-ilāhī*, ed. Aḥmad Ḥijāzī al-Saqqā (Beirut: Dār al-Kutub al-ʿArabī, 1987), 338; see also Fakhr al-Dīn Rāzī, *Asrār al-tanzīl wa-anwār al-taʾwīl*, ed. ʿAbd al-Raḥmān ʿUmayra and ʿAbd al-Munʿim Faraj Darwīsh (Cairo: Dār Rikābī li-al-Nashr wa-al-Tawzīʿ, 2000), 476.

1.4.6 Parallels in the Latin tradition of the Sphere

A Latin tradition of cosmographical writings appeared in the early 13th century that in some ways resembled the *hayʾa* tradition. One of the earliest known exemplar of these writings is the *Sphere* of Johannes de Sacrobosco. Lynn Thorndike, who published and studied Sacrobosco's *Sphere*, describes it as "the clearest, most elementary, and most used textbook in astronomy and cosmography from the thirteenth to the seventeenth century."[232]

Sacrobosco composed the *Sphere* while he was teaching at the University of Paris. He was familiar with Farghānī's *Jawāmiʿ* through its widely read Latin translations by John of Seville and Gerard of Cremona. Sacrobosco mentioned Farghānī's name five times throughout the rather short text of the *Sphere* and referred to him by saying "dicit Alfraganus."[233] References to Farghānī can be found in Sacrobosco's discussions of the sphericity of the heavens, the insignificant size of the Earth compared to the heavens, temperateness of the summer and winter at the equator, and rising and setting of the zodiacal signs in the localities whose latitude is equal to the complement of obliquity. However, some of the medieval commentators on Sacrobosco's *Sphere*, like Michael Scot, believed the text to have simply been drawn from the works of Ptolemy and Farghānī, and thus regarded Sacrobosco more as a "compiler."[234] Saccrobosco, like Farghānī and other *hayʾa* authors, left out Ptolemy's proofs of the *Almagest* and took only what suited his purpose, which was the composition of an introductory textbook of cosmography. As the number of manuscripts and commentaries indicate, the *Sphere* gradually overtook the Latin translations of the *Jawāmiʿ* and became quite prevalent.[235]

Compared to the *Jawāmiʿ*, the *Sphere* is even more condensed as Sacrobosco rearranged the contents of the *Jawāmiʿ* according to his pedagogical purposes.[236] The *Sphere* is divided into four chapters: Chapter one is on the definition of the sphere, meaning orb in this context, number of the orbs and the configuration of the world in general. Chapter two concerns the

---

[232] Lynn Thorndike, *The Sphere of Sacrobosco and Its Commentators* (Chicago: University of Chicago Press, 1949), 1.

[233] Thorndike, *The Sphere*, 81, 84, 104, 108.

[234] Thorndike, *The Sphere*, 14–18.

[235] Thorndike, *The Sphere*, 19.

[236] Thorndike, *The Sphere*, 15.

important circles conceived on the orbs and the Earth. Chapter three is on the rising and setting of the signs and the ascensions for different localities, and the division of the habitable quarter into seven climes. The fourth chapter deals with the configuration of the heavens very briefly.

In order to draw parallels between the Earth-related contents of the *Sphere* and the contents of the *hayʾat al-arḍ* genre, we need a closer look at the contents covered in the previous chapter, that is, the shape of the Earth, land-water relation on the surface of the Earth and description of the seas, climes and temperate zone. As for the shape of the Earth, in chapter one of the *Sphere* Sacrobosco treats the sphericity of the Earth and the surface of sea separately. His proof of the sphericity of the Earth is very similar to that of Ptolemy, Farghānī and *hayʾa* scholars. Sacrobosco describes the Earth as "round" and the water as "approximately round" with a "bulge."[237] In his commentary on the *Sphere* written in 1271 CE, Robertus Angelicus does not have more to say on the shape of the Earth; however, he differentiates "spherical (*spericum*)" from "round (*rotundum*)" by stating that "there is a difference between "spherical" and "round," since anything spherical is round and not vice versa; for something may be round like an egg, yet it is not spherical unless it is completely so."[238] This might be related to the difference between *mustadīr* and *kuriyy*, discussed in the previous chapter, and it seems that the *rotundum* (round) is the Latin equivalent of the Arabic *mustadīr*.

In the *Sphere*, the question of the emergence of land out of water is discussed within the section on the four elements, which precedes the discussion of the shape of the Earth. Sacrobosco opens his discussion of the four elements saying:

> The machine of the universe is divided into two, the ethereal and the elementary region. The elementary region, existing subject to continual alteration, is divided into four. For there is earth, placed, as it were, as the center in the middle of all, about which is water, about water air, about air fire, which is pure and not turbid there and reaches to the sphere of the moon, as Aristotle says in his book of *Meteorology*. For so God, the glorious and sublime, disposed. And these are called the "four elements" which are in turn by themselves altered, corrupted and regenerated. The elements are also simple

237 Thorndike, *The Sphere*, 121.

238 Thorndike, *The Sphere*, 145, 201.

bodies which cannot be subdivided into parts of diverse forms and from whose commixture are produced various species of generated things. Three of them, in turn, surround the earth on all sides spherically, except in so far as the dry land stays the sea's tide to protect the life of animate beings.[239]

In the same context, after talking about the four elements and their natural locus and order, Robertus Angelicus says in the second chapter of his commentary on the *Sphere*:

> Third, note that all the elements surround the earth in all directions spherically except water, for which exception three reasons may be suggested. One, divine will to save animal life. Another, the dryness of earth absorbing parts of the water, as is stated in *On Generation and Corruption*,[240] unless earth were mixed with water, it would crumble to dust. Third is the influence of the stars so that some conjunction above a part of the earth made it dry, a sign of which is that places which were once full of water are now dried out.[241]

Michael Scot, in his commentary on the *Sphere*, explains the contradiction between the Aristotelian concentric order of the elements and the emergence of land out of water by adducing another reason: the priority of the perfection of the universe (*perfectionem universi*), or the order of the universe (*niẓām al-kull*) as Ibn Sīnā puts it, over the concentric order of the elements.[242] According to both Ibn Sīnā and Scot, if this were not the case then "warm blooded living creatures and plants would have no dry land on which they could survive."[243] Campanus de Novara (1205–1269 CE) in his *Tractatus de Sphaera*, which belongs to the same Latin tradition, after a short account of Aristotelian concentric order of the elements, explains the

---

[239] Thorndike, *The Sphere*, 119.

[240] II.8 (335a1–2): "…Earth has no power of cohesion without the moist. On the contrary, the moist is what holds it together; for it would fall to pieces if the moist were eliminated from it completely."

[241] Thorndike, *The Sphere*, 205.

[242] Randles, "Classical Models," 24. See also Thorndike, *The Sphere*, 267; Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt, al-maʿādin wa-al-āthār al-ʿilwiyya*, 24.

[243] Randles, "Classical Models," 24. See also Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt, al-maʿādin wa-al-āthār al-ʿilwiyya*, 25:

«فإذا كان كذلك، لم يكن بدّ من أن يكون برّ وبحر، وفي ذلك حِكَم إلهية لولاها لم يكن للحيوانات الأرضية التي تعيش بالنسيم مكان طبيعي.»

emergence of land as the result of "a higher final cause providing living creatures with dry land to live on"[244] Like Ibn Sīnā, Campanus relates this cause to Divine Providence.[245]

With regard to the land-water relation, at the beginning of the description of the seven climes, Sacrobosco defines the "habitable region/region," which is equivalent to the populated quarter (*al-rubʿ al-maskūn*) of *hayʾa* works:

> Let a circle be imagined on the earth's surface directly under the equinoctial. And suppose another circle on the earth's surface passing from east to west through the poles. These two circles will intersect in two places at right spherical angles and divide the whole earth into four parts, one of which is our habitable region, namely, that which is intercepted between the semicircle drawn from east to west along the equator and the semicircle carried from east to west through the Arctic pole.[246]

Sacrobosco's account of the division of the populated quarter into seven climes is very similar to that of Farghānī, although he does not cite him. The similarity between the two accounts is mostly regarding the numerical values, such as the length of the longest day and latitude for each clime. Even for the width of each clime, Sacrobosco used Farghānī's values while disregarding the fact that these were calculated based on the Maʾmūnī value of the length of one terrestrial degree, which was abandoned by Sacrobosco in favor of the Greek value in an earlier section entitled 'measuring the Earth's circumference.'[247] Sacrobosco explains the division of the populated quarter into seven climes, with a reference to the Aristotelian five zones as follows:

> Nor is that quarter entirely habitable, since parts of it near the equator are uninhabitable because of too great heat, and parts near the pole because of too great cold. Suppose, then, a line parallel to the equator dividing the parts uninhabitable on account of heat from those habitable parts toward the north. And suppose another line equidistant at all points from the Arctic pole dividing the parts which are uninhabitable for cold from the habitable parts toward the

[244] Randles, "Classical Models," 29.

[245] Randles, "Classical Models," 29; Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 25.

[246] Thorndike, *The Sphere*, 138–139.

[247] Thorndike, *The Sphere*, 16–17, 122–123.

> equator. Between these two extreme lines suppose six lines parallel to the equator, which, with the two former, divide the whole **habitable quarter** into seven parts which are called the "seven climes."[248]

As for the geographical details of climes, Sacrobosco does not follow Farghānī in providing a list of localities for each clime, only mentioning the name of one locality per clime. Sacrobosco's statement about the uninhabitability of the localities beyond the seventh clime, "there may be a number of islands and some human habitation north of the limit of the seventh clime, whatever there is, since living conditions are bad, is not reckoned under a clime,"[249] sounds very strange given that he was a native of Britain, which is located beyond the seventh clime.[250] Robertus Anglicus' comment on this statement implies that Sacrobosco quoted the statement from the ancient sources:

> And the last clime ends, as is said in the text and as Alfraganus states, where the altitude is 50 degrees, and this is hardly across the English Channel, so that almost all England is outside a clime. And the reason for this is not because it is unfit to live in, as some will have it, but it is because it was not inhabited at the time of the division into climes.[251]

It should be noted that, in his commentary, Robertus Angelicus felt the need to clarify the notion of clime in order to highlight its astronomical significance for the reader. As such, he first defines clime to be "as much space of earth as that within which a clock made to tell the hours varies sensibly."[252] Then, in order to help the reader "imagine the climes," he says:

> Be it known, then, that if anyone was at the equator and had a quadrant or astrolabe and observed the pole, the pole would be at the bottom of his vision. And if the same person moves north in a straight line as far as where the pole is raised above the horizon by 12 ½ degrees and a quarter of one, then he will be at the beginning of the first clime, and this can be observed by the aforesaid quadrant or astrolabe. And if afterward the same person proceeds farther until

---

[248] Thorndike, *The Sphere*, 139.

[249] Thorndike, *The Sphere*, 140.

[250] Thorndike, *The Sphere*, 2.

[251] Thorndike, *The Sphere*, 236.

[252] Thorndike, *The Sphere*, 236.

> he sees the altitude of the pole at 27 ½ degrees and a quarter of one part, and so on continuously proceeding northward, he can know at what place on earth the climes begin.[253]

In this explanation by Angelicus one can recognize a certain bent toward the original Greek meaning of clime. The Latin tradition of *Sphere* failed to appropriate the geographical aspect of clime, probably because there was not at their disposal clime-oriented geographical information about the regions of interest to them and, most notably, because their home lands were beyond the boundaries of the standard seven climes, as was the case with Angelicus.

Sacrobosco deals with the temperate zone problem in two different sections of his work. In one case, at the end of chapter two on the important circles conceived on the orbs and the Earth, he gives an account of the Aristotelian division of the surface of the Earth into five habitable and inhabitable sections with regard to the relative position of each section with respect to the Sun.[254] Then, in the middle of chapter three, after describing the yearly relative motion of the Sun with respect to the equator and changes of the seasons at the equator, Sacrobosco concludes that even though the Sun seems to be almost at the equinox for the dwellers at the equator, "they will have in the course of a year four solstices,[255] two high and two low," and thus "have two summers when the sun is in either of the equinoctial points or nearly so, and likewise two winters when the sun is in the first points of Cancer and Capricorn or thereabouts."[256] Then, referring to Farghānī, Sacrobosco adds "this is why Alfraganus says that for them summer and winter are of one and the same complexion."[257] Sacrobosco's "of one and the same complexion (*unius et eiusdem complexionis*)[258]" is an equivalent of Farghānī's "temperate in the sense of a uniformity in the conditions (*muʿtadil fī al-mizāj*)."[259] Because of the importance of this paragraph in terms of the narration, we quote it here in full:

---

[253] Thorndike, *The Sphere*, 236.

[254] Thorndike, *The Sphere*, 129.

[255] It should be noted that by 'solstice,' Robertus Angelicus here means generally the beginning of summer/winter, and not specifically the first points of Cancer and Capricorn.

[256] Thorndike, *The Sphere*, 134–135.

[257] Thorndike, *The Sphere*, 135.

[258] For the Latin, see Thorndike, *The Sphere*, 104, line 22.

[259] Farghānī, *Jawāmiʿ*, 21:

Moreover, it is to be noted that in the case of those whose zenith is in the equinoctial the sun twice a year passes directly overhead, namely, when in the beginning of Aries and in the beginning of Libra; and then there are two high solstices for them when the sun passes directly overhead. Again there are two low solstices for them when the sun is in the first points of Cancer and Capricorn, and they are called "low" because then the sun is farthest removed from their zenith. From what has been said it is clear that, while they always have equinox, they will have in the course of a year four solstices, two high and two low. It also is evident that they have two summers when the sun is in either of the equinoctial points or nearly so, and likewise two winters when the sun is in the first points of Cancer and Capricorn or thereabouts. And this is why Alfraganus says that for them summer and winter are of one and the same complexion, since those two seasons which are winter and summer for us are for them two winters…[260]

The manner in which Robertus Angelicus raised the question of the habitability of the equator reveals his familiarity with the history and literature of this heated debate among the scholars of the Islamic world:

> But now, in connection with what has been said in this part, two questions may be raised. The first is whether the equatorial region is habitable. The second is whether that part of the earth which is under us is habitable or not. Concerning the first, one might reason thus, first on the authority of Avicenna, who says in the *Canon* that it is most temperate and that men there are of most temperate constitution, so it is very habitable… The same is held in canons of astronomy and in many authentic works, where it is said that the latitude of a city called Arim[261] is nil because it is located on the equator.[262]

«ويكون ميل الشمس عن سمت الرأس في ناحيتي الشمال والجنوب بقدر واحد **فيكون الصيف والشتاء هناك معتدلين في المزاج**...»

[260] Thorndike, *The Sphere*, 134–135.

[261] Originally spelled as *Arīn* or *Ujjayn* (أرين، أُزين) in Arabic and Persian, was the cupola or midpoint of the Earth, located on the intersection between the equator and the great circle that divides the populated quarter into eastern and western halves.

Robertus Angelicus then provides the reader with a nice summary of Ibn Sīnā's arguments, very likely from his *Canon of Medicine*:

> The same conclusion is reached by natural reason, since that place is equidistant from either pole, wherefore the heat of the sun in that place is tempered because of its equidistance from the cold which exists at both poles. If, therefore, a place is habitable by withdrawing from the middle toward one pole such as the north, then much better, as it seems, will be habitation in the middle place which is at the equator, since anything temperate is a mean between extremes. Also in that place the nights are ever equal to the days, and such equality is the cause of temperateness; for the chill of night tempers the heat of day, so it seems that there is a habitable place. It likewise seems to be necessarily proved that there is a habitable place, because the cause of heat is twofold, namely, approach of the sun to the zenith and delay of the sun at the zenith or thereabouts. And the first cause is accidental compared to the second, since nearness is not a cause of heat except slightly compared to duration of the same, just as it is clear that the sun is nearer the zenith at noon than after noon and yet heat is far greater in the afternoon than at noon. Similarly, the sun is nearer the zenith in the beginning of Cancer than in the beginning of Leo by 4 degrees; and yet the heat is greater when the sun is in the beginning of Leo than when it is in the beginning of Cancer, and the whole reason for this is clearly because delay of the sun more disposes to heat than does nearness. It is then the case that when the sun is in Cancer and in Gemini it approaches the zenith of those who live under the Tropic of Cancer, and it stays there ten times longer than when the sun is in the beginning of Aries or Libra at the equator with respect to those who live at the equator. And this is evident because, when the sun is at the equator, it, as it were, suddenly crosses the equator and declines from it because of the obliquity of the zodiac; but when it is in Cancer or in Gemini it stays near the Tropic of Cancer for practically two months. Therefore, there will be a far stronger cause of heat at the Tropic of Cancer

---

[262] Thorndike, *The Sphere*, 237.

> than at the equator. But it is clear that at the Tropic of Cancer there is habitable space and even beyond, as all astronomers hold, since that place is in the second clime. Hence much more is there habitable place at the equator.[263]

Robertus then mentions counterarguments against Ibn Sīnā, first on the authority of poets, such as Ovid and Virgil, arguing that no report has come from anyone who lives or used to live at the equator, and so it must be that there is no habitation there; and then on the authority of "Alfraganus, Ptolemy, and other astronomers… who all begin the first clime this side of the equator, which is an indication that the equatorial region is not habitable."[264]

Robertus then clarifies his position with regard to the question of the habitability of the equator, saying: "To that question I respond and say that the equatorial region is habitable and not merely habitable but fine to live in, and I say with Avicenna that there men are of a most temperate constitution."[265] He then supports his statement by summarizing seven reasons:

1) the equal distance from either pole;

2) the equality of day and night all year long;

3) the shortness of summer and winter;

4) the brevity of the delay of the sun in the zenith of those living at the equator;

5) the elevation of many vapors from the southern sea and from the rivers there, which have the effect of tempering the heat;

6) the abundant reflection of rays and their concourse at the equator, since generation is caused by the approach of the sun and other planets to us and corruption by their withdrawal and since the equator is the place where there is the greatest approach of the sun and of other planets, it would seem evident that the equator should be the place most adapted to life;

7) the quality of the vegetation.[266]

Reasons 2–4 are clearly from Ibn Sīnā and reason 5 is probably from the *Shifāʾ* where Ibn Sīnā argues that the sea can cool down the land next to it if the Sun rays are not intense.[267]

---

[263] Thorndike, *The Sphere*, 237–238.

[264] Thorndike, *The Sphere*, 237–238.

[265] Thorndike, *The Sphere*, 239.

[266] Thorndike, *The Sphere*, 239–240.

[267] Ibn Sīnā, *Shifāʾ*, *Ṭabīʿiyyāt*, *al-maʿādin wa-al-āthār al-ʿilwiyya*, 31.

Robertus' counterarguments against those who disagree with the temperateness of the equator are also important and worth quotation:

> [1] To the opposing arguments I reply and say that one proceeds from false premises when one says that no report has reached us from those living at the equator, since the city of Arim, which is in India, is said to be situated on the equator, as is a large part of India.
>
> [2] To that which is objected on the authority of Alfraganus and Ptolemy, who suppose the first clime to begin this side of the equator, I say that… the philosophers of that time… divided only land which was publicly and notoriously habitable and to which access and return was open.
>
> [3] To another argument be it said that it may be that land is found uninhabitable because it is too far from the sun, as at either pole; yet it does not follow that any is uninhabitable from closeness to the sun, since, while cold is deadening, heat is vivifying and the principal cause of life. So nature can better endure excess of heat than excess of cold; nor does it follow that at the equator there is excessive heat but temperate, as is clear from the aforesaid.
>
> [4] To another argument be it said that reflection of rays falling perpendicularly on the surface of a mirror and of rays falling perpendicularly on the earth's surface is not the same thing. For, since a mirror is a smooth and polished body, all rays falling perpendicularly on its surface, if it is a plane surface, are reflected back whence they came and do not come together at any one point with one perpendicular, wherefore fire is never generated by the reflection of rays in such a mirror. But if the surface of the mirror is convex, much less will the rays come together at a point. If, however, the mirror is concave, what is said is true; but then it is irrelevant, since the earth at the equator is not concave, so the argument is worthless.[268]

What is most important about Robertus Angelicus' discussions above is the strikingly similar delineation of the debate with Shīrāzī's treatment of the issue in the *Nihāya*, which actually post-dates Robertus Angelicus' commentary on the *Sphere*. We

[268] Thorndike, *The Sphere*, 240–241.

must leave it to future research on the sources available to Robertus Angelicus to shed light on the reasons behind this similarity.

1.4.7 Conclusion

We started this chapter with the contents of the *hayʾat al-arḍ* section of the *Nihāya* and presented, in table 1, a comparative analysis of the structure of the *hayʾat al-arḍ* sections of *hayʾa* works. A brief overview of our general definition of *hayʾa* and *hayʾat al-arḍ*, together with the contents of the aforementioned table, indicate that the following statements can be made regarding the *hayʾat al-arḍ* sections:

1) The subject matter is the spherical surface of a physical body called Earth, which is at rest at the center of the universe with its axis inclined with respect to the zodiacal axis.

2) There is a specific set of geographical contents that provide a general description of the spherical surface of the Earth and characteristics of different localities on it, with references to some physical problems arising from the shape of the Earth and its relation to the cosmos.

3) This geographical part usually precedes an astronomical part, and sometimes a geodesic part, dealing with the phenomena, methods, and data that vary with the change of localities and horizons, and thus operate within the horizontal coordinate system, that is, the altitude-azimuth or declination-ascension coordinates.

Our analysis of some of the geographical contents of the *hayʾat al-arḍ* section of the *Nihāya* and comparison with similar material of other *hayʾa* works indicates the complexity of this part with regard to its formative sources and variety of topics, compared to the astronomical and geodesic parts of this section. The constituents of this geographical part were put together from a variety of sources produced over several centuries. For this analysis, we selected and highlighted two different kinds of material from the geographical part of the *hayʾat al-arḍ* section: 1) descriptive material, which includes the seven climes and a description of the seas, and 2) physical and mathematical material, including the shape of the Earth, land-water relation, and the temperate zone problem. In each case, we discussed the initial sources that formed the grounding of the genre and then found similarities between a selection of available texts to show the evolution of the genre. We also indicated that the composition and arrangement of material in *hayʾat al-arḍ* sections varies from one work to another.

With regard to the descriptive material and its sources, we saw that the standard account of the seven climes first appeared in Farghānī's *Jawāmiʿ* and the standard account of the description of the seas in Battānī's *zīj*. These two accounts were then transmitted to the *masālik* works and appeared together there. Starting from *Gayhān-shinākht* in the 5–6th/11–12th centuries, we see these two accounts presented together in *hayʾa* works. This means that, despite the reference to *masālik* works in later *hayʾa* works, these materials were probably first transmitted from astronomical works to *masālik* works. However, these two accounts of the climes and seas might have appeared 'together' in the *masālik* works for the first time. Besides this, we could not trace any major influence of other geographical genres of the pre-modern Islamic era on *hayʾat al-arḍ*.

With regard to the physical material, we saw the influence of the Aristotelian theory of the elements on the treatment of some geographical problems of *hayʾat al-arḍ*, that is: 1) conception of the shape of the Earth and 2) land-water relation. These two problems relate to the general description of the surface of the Earth. We also noted that the degree of engagement with the physical aspect of these issues varies among *hayʾa* authors. In the rather complex problem of the temperate zone, the influence of the Aristotelian *Meteorologica* tradition, the pseudo-Aristotelian *Problemata* tradition, Ibn Sīnā's natural philosophy and medicine, and Fakhr al-Dīn Rāzī's ideas were highlighted. The logical reasoning in the treatment of the problem of the temperate zone was an important feature of this physical-geographical part of the *hayʾat al-arḍ* sections of later *hayʾa* works. The presence of all or a combination of some of these descriptive and physical contents in a work constitutes a unique set of material that indicates their influence on the given work.

All the *hayʾa* works that we analyzed treated at least one of the descriptive geographical aspects, either the seven climes or the description of the seas. They also included at least one of the physical contents, namely the shape of the Earth, followed by some of the astronomical contents related to the observer's position on the Earth. We consider this combination as the *hayʾat al-arḍ* genre if the material is presented within an astronomical context, in a coherent order. It is in virtue of the common sources and the similarity of subject matter, general structure and content that *hayʾat al-arḍ* constitutes a distinct genre of geography. Of course, there may be modifications resulting from developments in astronomy and physics, varying physical approaches of different authors, and rearrangements of the material according to the need of target audience; however, this can be accounted for within the general contours of the genre. Analyzing the sources of this genre, and its contextualization within the *hayʾa* tradition, has given us an understanding of how some of the constituents of this genre were put together over centuries. Our goal in the different chapters of this introduction was to uncover a pattern based on the similarities shared by the *hayʾat al-arḍ* sections of *hayʾa* works, so that these sections could be identified as being similar. Such a dynamic concept of *hayʾat al-arḍ* as a genre especially suits its evolving nature, due to which particular features of texts undergo change according to a variety of factors such as the purpose and process of writing or the needs of the target audience. It also allows for finding parallels in related traditions, regardless of differences such as culture, language, etc.

Part II

Critical Edition of Book III of *Nihāyat al-idrāk fī dirāyat al-aflāk*

2.1 Editorial Procedures

2.1.1 A history of the text

We already mentioned that Shīrāzī revised the *Nihāya* several times and that parts of these revisions were done during the course of the composition of the *Ikhtiyārāt*, which was finished three months after the appearance of the first version of the *Nihāya* in mid Shaʿbān 680/late November 1281. However, we know that revisions of the *Nihāya* continued after the completion of the *Ikhtiyārāt* on 9 Dhū al-Ḥijja 680/22–23 March 1282, since the latter was referred to in revised versions of the *Nihāya*. Since we know that Shīrāzī left Tabriz on 19 Jumādá al-Ūlá 681/25–26 August 1282 for Egypt as a member of a diplomatic mission from the Ilkhan Aḥmad Tegüder to the Mamlūk Sulṭān of the time,[1] his preliminary revisions of the *Nihāya* might have been done before his involvement in the mission, *i.e.*, between mid Shaʿbān 680/late November 1281, the date of composition of the first version of the *Nihāya*, and Rabīʿ al-Thānī 681/ July 1282, considering the time Shīrāzī needed to arrive in Tabriz before his departure for Cairo on 19 Jumādá al-Ūlá 681/25–26 August. From one of the manuscripts of the *Nihāya* we know that Shīrazī was back in Sivas by the beginning of 683/March–April 1284 at which point he launched a new series of revisions that lasted for at least 10 months (see below).

[1] This mission was part of a series of measures taken by Aḥmad Tegüder right after his ascension to the throne in 13 Rabīʿ al-Awwal 681/21–22 June 1282. He dispatched an army to Anatolia in 4 Rabīʿ al-Thānī 681/12–13 July 1282 to safeguard its territory, especially from sporadic Mamlūk encroachments. He then decided to make peace with the Mamlūk Sulṭān, and dispatched his envoys to him.

Investigation of the earliest available manuscripts of the *Nihāya*, revealed that Shīrāzī was reading and discussing it with various scholars or his students in order to revise and improve the text. Shīrāzī was so committed to revising the *Nihāya* that he himself took care of it in several copies. To be clear, in most of the early manuscript witnesses of the *Nihāya*, the corrections and revisions were completely or partially done by Shīrāzī himself and in his hand, or under his supervision. Moreover, various collation and study notes on our early witnesses can be considered as additional evidence for his personal commitment to these revisions. This led to the production of very precise manuscript witnesses that facilitate the production of a critical edition of the *Nihāya*'s Book III, which is provided below.

A thorough examination of the revisions of Book III has shown that the revising process was being done stage by stage. Fortunately, this phased process of revisions resulted in different manuscript witnesses of the *Nihāya* each of which can be considered as representatives of various revision phases. Unfortunately, none of the extant manuscripts represents the first version of the *Nihāya*. Therefore, in order to understand what the very first version of the *Nihāya* looked like, we tried to produce a hypothetical first version of the Book III by isolating and removing all revisions. Having this hypothetical version, and using codicological analysis, we tried to understand the revision process and distinguish its phases. As can be seen below, we could distinguish four series of revisions. It should be noted that our findings are just based on our analysis of Book III of the *Nihāya* and our historical analysis cannot be complete without a thorough examination of the rest of the text.

2.1.2 Manuscripts of the *Nihāya*

Despite its length, the *Nihāya* was being copied continuously from the appearance of its first version until the end of $14^{th}/20^{th}$ century. So far, we could find the record of 49 witnesses of the *Nihāya* in manuscript catalogues, of which we have access to the images of 21 manuscripts (see appendix 1). From catalogue listings and our own investigation, we know that at least eleven manuscripts were copied during Shīrāzī's life time. These manuscript witnesses are:

1. Berlin, Staatsbibliothek, MS Petermann I 674
2. Istanbul, Topkapı Sarayı, MS Ahmed III 3336
3. Istanbul, Köprülü, MS Fazıl Ahmed Paşa 957

4. Tehran, University of Tehran, MS 7070

5. Istanbul, Süleymaniye, MS Laleli 2145

6. Leiden, MS Or. 203

7. Istanbul, Köprülü, MS Fazıl Ahmed Paşa 956

8. Tabriz, Ḥusayn Nakhjavānī Library, MS 56

9. Istanbul, Millet, MS Feyzullah Efendi 1349

10. Patna, Khuda Bakhsh Oriental Public Library, MS 2452

11. Patna, Khuda Bakhsh Oriental Public Library, MS 2453

We have images of the eight out of eleven (nos. 1, 3–8 and 10), one of which is a partial autograph and six have various kinds of notes, revisions in the margins and within the body, and/or corrections in Shīrāzī's hand. However, the problem is that five of the earliest manuscripts do not have a copy date. But since the revisions were done in stages, we could at least put the undated manuscripts in a reasonable chronological order using codicological evidence.

One crucial criterion for distinguishing different phases of the revisions is related to the mentioning of the *Ikhtiyārāt* (written in 9 Dhū al-Ḥijja 680/22–23 March 1282) in some versions of the *Nihāya*. In Book II, Chapter 8 of the *Nihāya*, where he discusses why the moon's alignment point is not applicable to other planets, Shīrāzī refers the reader to the *Ikhtiyārāt*.[2] Thus, the completion of the *Ikhtiyārāt* occurred only after the completion of the first version of the *Nihāya* and while the latter was being revised. The existence of this reference to the *Ikhtiyārāt* in the manuscript witnesses of the *Nihāya*, whether within the body of the text or in the margin, is a key criterion for putting the undated manuscripts of the *Nihāya* in order.

The reference has been inserted after "وضوحاً" in the following sentence of chapter 8, Book II:

[2] I would like to gratefully thank Sajjad Nikfahm-Khubravan for drawing my attention to this very important note.

« وأما الذي ذكر بحسب اختلاف المحاذاة فغير وارد لكون المحاذاة نحو النقطة التي بحسبها تتشابه الحركة وفي التقرير الذي سبق آنفاً في اتحاد الاختلافين إيماءٌ على أنه غير وارد وهذا أيضاً واضح خفى ونزيده وضوحاً»

The addition starts with the following phrase:

«إن وقع لنا التفات إليه في المستقبل إن شاء الله»

In some manuscripts it is followed with the reference to the *Ikhtiyārāt*:

«وسببه الحقيقي التشابه لأنّ كلّ كرة تتشابه حركة مركزها حول نقطة فبالضرورة يحاذي أبداً قطر من أقطار الكرة المتحرّكة تلك النقطة سواء كانت تلك النقطة مركزاً لمدار مركزها أو لم يكن وقد بيّنتُه مفصلاً في **الاختيارات المظفريّة** فعليك بالالتفات إليه إن أردت الاطلاع عليه»

Our oldest manuscript, MS Petermann I 674, Staatsbibliothek, Berlin (hereafter MS **B**), was copied by two copyists: an anonymous copyist (hereafter copyist *x*) and Shīrāzī himself. Chapter 8 of Book II of this manuscripts is entirely in Shīrāzī's hand and on folio 84b, where in later manuscripts of the *Nihāya* the aforementioned reference to the *Ikhtiyārāt* has been added in the margin or exists within the text, there is a marginal note in Shīrāzī's hand that only contains the first phrase ("*in waqaʿa lanā iltifāt ilayhi fī al-mustaqbal in shāʾa Allāh*"), and not the additional phrase (starting with "*wa-sababuhū al-ḥaqīqī…*") where the *Ikhtiyārāt* is mentioned. This most likely indicates that this marginal note, which lacks the reference to the *Ikhtiyārāt*, must have been added to MS **B** before the composition of the *Ikhtiyārāt*. Therefore we can reasonably claim that the parts of MS **B** that are in Shīrāzī's hand were copied between mid Shaʿbān 680/late November1281, the date of composition of the first version of the *Nihāya*, and 9 Dhū al-Ḥijja 680/late March 1282, the date of composition of the *Ikhtiyārāt*.

The next oldest MS Köprülü-957 (hereafter MS **K**), copied in 681, has the abovementioned reference to the *Ikhtiyārāt* in the margin on folio 72a in Shīrāzī's hand. An undated but early manuscript, namely MS Tehran 7070 (MS **T** hereafter), has the two parts of the reference in its copyist's hand (f. 79b), although they were apparently added in different times.

We can reasonably place MS Laleli-2145 (hereafter MS **L**) after MS **K** and MS **T**, as it has the first part within its text but the part with the reference to the *Ikhtiyārāt* in the margin (f. 79b). By 682–683/1282–1283, both parts were incorporated into the text of MS Leiden Or. 203

(f. 67b), copied in 682/1282; MS Koprulu-956 (MS **R** hereafter) (f. 58a–b), copied in 683; MS Khuda Bakhsh-2452 (f. 81a–b)[3]; and MS Tabriz-56 (f. 89a).

Now that we have reviewed the manuscript evidence in order to ascertain the different phases of the *Nihāya*'s revisions, we are able to choose MSs **B**, **K**, **L** and **R** for establishing the edition of the Book III. We excluded MS **T** and MS Leiden Or. 203 because they are incomplete. Despite its importance, MS Khuda Bakhsh-2452, which was, according to the library catalogue, studied and annotated by the renowned scholars Jalāl al-Dīn Dawānī (d. 1502 CE) and Ghiyāth al-Dīn Manṣūr Dashtakī (d. 1541 CE), had to be excluded too because our digital copy was incomplete and unreadable in parts. MS Tabriz-56 was only consulted to check if the final revisions found their way to later copies or not. Certain technical characteristics of MSs **B**, **K**, **L** and **R**, description of which will follow, convinced us that they should suffice for establishing a precise edition of the Book III. Obviously, an edition of the entire *Nihāya*, taking into account the complications of the Book II in particular, will definitely need more manuscript witnesses.

The comparison of MSs **B**, **K**, **L** and **R** with our hypothetical first version of Book III of the *Nihāya* showed that chapters 10, 11 and 13 were never revised. We could also distinguish, with a high degree of certainty, two phases of revisions: a preliminary phase in 680/1281–1282 (before the Egypt mission) and a final phase in 683/1284–1285 (after the Egypt mission). We found that chapter 12 was revised only after Shīrāzī's mission to Egypt. Furthermore, within the preliminary and final phases, we could mark the boundaries of still smaller episodes. So, altogether, at least four phases of major revisions could be recognized. By major revisions we mean the ones that somehow are reflected in all four MSs **B**, **L**, **K** and **R**.

---

[3] Our images are produced from the microfilm 2278 of Jaber al-Ahmad Central Library, Kuwait University (http://library1.kuniv.edu.kw/manuscript/Scriptslist.asp?cmd=resetall). This manuscript has autograph note on ff. 98a, 108a; autograph chapter heading on ff. 176a, 181a; an autograph collation note on f. 163b and one on f. 212b, dated 690. According to Khuda Bakhsh Library catalogue (22: 43), it was studied and annotated by renowned scholars, Jalāl al-Dīn Dawānī and Ghiyāth al-Dīn Manṣūr Dashtakī.

1. Preliminary phase (15 Shaʿbān–Dhū al-Qaʿda 680/December 1281–February 1282), applicable to chapters 1–9 of the Book III.
    a. First revisions: added in the margin, or over/under the line, etc. in **B** and **K**, but within the text of **R** and **L**. Such revisions occur in all chapters except in chapters 2 and 7.
    b. Second revisions: added in the margin, or over/under the line, etc. in **B**, **K** and **L**, but within the text of **R**. These second revisions occur in all chapters with the excetion of chapter 6.
2. Final phase (683/1284 onwards), applicable to chapters 1–9, and 12 of Book III.
    a. Third revisions: added within the text, in the margin or over/under the line, etc. in **K** and **L**, but always within the text of **R**. These third revisions occur in all chapters, with the exception of chapter 3. However, in MS **B**, these revisions do not occur in the parts copied by Shīrāzī. The fact that they are within the text in chapter 12 of MS **B** suggests that chapter 12 of MS **B** is probably another version, different from the parts of MS **B** in Shirazi's hand.
    b. Final revisions: added in the margin or over/under the line, etc. in **K**, **L** and **R** (and sometimes **B**), usually by Shīrāzī himself. These final revisons have been incorporated into the text of chapter 12 of **B**, which was later copied and added to **B**. Such revisions only occur in chapters 1, 8, 9 and 12.

2.1.3 On establishing the edition

MS **R** is a very precise and early witness written from beginning to end in one hand, containing all major revisions within the body. According to its colophon (see below) it was collated with Shīrāzī's original manuscript and read to him. Therefore, it is safe to claim that Shīrāzī was content with its text and it can be considered a good representative of the final version of the *Nihāya*. Furthermore, we can assume that this is the *Nihāya* that was in circulation from 683 onwards and, in most cases, was being taught and commented upon by scholars. This suffices to persuade us to base our critical edition on MS **R**. In order to provide the most comprehensive account of the stages of the revisions, we chose MSs **B**, **L** and **K** as our comparator witnesses. The beginning and end of revisions incorporated within the text of **R** will be marked by slashes in the critical edition, and superscripted symbols *, †, and ‡ after the slash denote respectively each of the three phases of the revision. Variants related to these revisions will be reflected in footnotes at the bottom of the page whereas the critical apparatus at the end will only contain other, non-revision related variants.

There are also a few post-final revisions/corrections that occur only in the margin of MSS **L** and **R**. These revisions occur only in chapters 1, 3, 4, 6, 7, 9 and 12 of Book III. Since these revisions have not been incorporated into the body of our base manuscript, MS **R**, during the original copying period, we decided not to incorporate them into our critical edition and only mention them in footnotes. A superscripted symbol § next to the footnote number in the edited text denotes revisions of this post-final phase. In order to be as precise as possible in distinguishing these revisions, we consulted the Tabriz manuscript, which was copied before this post-final stage of revision and in which all revisions were incorporated within the body of the text of Book III, except these post-final revisions.

Given that Book III of the *Nihāya* contains almost 75% of Book III of the *Tadhkira*, we decided to distinguish the transmitted text of the *Tadhkira* within our critical edition of the Book III of the *Nihāya* using bold font.

2.1.4 Technical Description of the Manuscripts Used for the Critical Edition

MS B (ب): Berlin, Staatsbibliothek, Petermann I 674

This manuscript is not dated but contains the oldest extant parts of the *Nihāya* in Shīrāzī's hand. Most likely these parts were copied sometime between 15 Shaʿbān of 680 and 9 Dhū al-Ḥijja of the same year. The rest is in the hand of the copyist *x* who is also the copyist of MS **R** as well as the copyist of the oldest known manuscript of Shīrāzī's other important astronomical work, *al-Tuḥfat al-shāhiyya* (see appendix 2).[4] There are also revised parts added to MS **K** in copyist *x*'s hand. In Book III of MS **B**, Chapters 1–9 are in Shīrāzī's hand and contain the first and second series of revisions in the margin, also in Shīrāzī's hand. Chapters 10–13 have been copied by copyist *x*. Chapter 12, which is very likely a later version, contains a final series of revisions within the body of the text.

[4] Paris, Bibliothèque national, Manuscrits-Orient Arabe, MS 2516, copied in Rajab 684/September 1284 in Sivas.

There is a study note on the title page of this manuscript written by Majd al-Dīn Ibrāhīm b. Muḥammad al-Ījī[5] that says he read this manuscript of the *Nihāya* in the presence of Burhān al-Dīn al-ʿIbrī[6] (d. 743/1343).[7] This study must have taken place during Shīrāzī's lifetime, as the manuscript's title, which has been written in the same hand and ink, states:[8]

رسالة الهيئة من كلام مولانا قطب الدين شيرازي ادام الله ظلال جلاله

A treatise on *hayʾa* consisting of the speech of our master, Quṭb al-Dīn Shīrāzī, may God prolong the shadows of his glory

The prayer "*adāma Allāh ẓilāl jalālih*" (may God prolong the shadows of his glory) implies Shīrāzī was alive at the time.

Incipit:

بسم الله الرَّحمن الرَّحيم ربّ انعمتَ فزد

قال مولانا واستاذنا افضل الورى علامة العالم سيد فضلاء بني آدم قدوة المحققين سلطان العلما فى العالمين حجة

[5] According to Ziriklī (1: 29), Majd al-Dīn Ibrāhīm b. Muḥammad al-Ījī was a theologian from Īj who wrote a commentary on *Ṭawāliʿ al-anwār* of ʿAbd Allāh al-Bayḍāwī (d. ca. 685/1286).

[6] For Burhān al-Dīn al-ʿIbrī's biography and Shīrāzī's certificate to him, see Gacek, Adam, "The Osler Codex of Nasīr al-Dīn al-Ṭūsī's Commentary on Avicenna's *al-Ishārāt wa-al-tanbīhāt*," *Journal of Islamic Manuscripts* 1 (2010) pp. 3-17; and Reza Pourjavady and Sabine Schmidtke, "Qutb al-Dīn al-Shīrāzī (d.710/1311) as a teacher: an analysis of his *ijāzāt*", *Journal Asiatique* (2009): 297: 21–23.

[7] The note says:

«بر مولانا معظم افضل المحققين برهان الحق و الدين خوانده شد و چهارده ورق ماند مجد[الدين؟] ابراهيم بن محمد الايجي»

[8] Here I transcribe what is in the witnesses, without editing or following modern Arabic orthographic conventions.

الحق على الخلق اجمعين مفخر افاضل الانام ملك القضاة والحكام قطب الملة والحق والدين محمود بن مسعود

الشيرازي ادام الله ظلال جلاله ومتع الله المسلمين بفضله وافضاله اما بعد...

In the name of God the Beneficent, the Merciful
Lord, you have been gracious; may you grant additional bounty
Our master and teacher, the most excellent of men, the most learned of the world, the lord of mankind's eminences, the model of the verifiers, the sultan of the learned in the worlds, the touchstone of truth over all creation, the source of pride for the most worthy of humanity, the king of justices and judges, the pole of the faithful community, of truth and religion, Maḥmūd b. Masʿūd al-Shīrāzī—may God prolong the shadows of his glory and may God allow the Muslims to enjoy his favor and his bestowal of benefits—said…

Colophon:

فلنختم الكتاب حامدين لله تعالى على الآية العظام ونعمائه الجسام ومصلين على زبدة الليالي والأيام محمد خير الانام

وعلى اله البَرَرة الكرام مصابيح الظلام ومفاتيح الكلام

Let us then end the book, praising God Almighty for His enormous blessings and His copious grace, and praying for the essence of the nights and the days, Muḥammad, the most excellent of mankind, and upon his family, the righteous, the noble, the illuminators of darkness and the keys to the Word.

MS K (ك): Istanbul, Köprülü, MS 957

This manuscript was copied in 681. There is a note on its title page in Shīrāzī's hand that certifies a certain Muḥammad Jājarmī has studied it with him. It contains revisions in the hand of its copyist, Shīrāzī and also the copyist *x*.

Shīrāzī's certificate on title page:

بحث معي هذا الكتاب الإمام الفاضل قدوة الأماثل [... الـ]علماء ملك الحكماء شرف المدرسين محمد بن محمد بن

محمد الجاجرمي دام فضله و[...] بحيث اطلع على دقائق هذا الكتاب ومقاصده وكتب [...] مؤلف الكتاب أحوج

خلق الله إليه محمود بن مسعود الشيراز[ي ختم الله له بـ]الحسنى وذلك في شهر الله الأصم الأصب رجب سنة

[...]

The eminent Imām, the model of the models, [… of the] scholars, the king of the philosophers, the honor of the teachers, Muḥammad b. Muḥammad b. Muḥammad al-Jājarmī—may his grace be prolonged—has studied this book with me such that he came to know the subtelties of this book and its purposes. The author of the book, the neediest of God's creation, Maḥmūd b. Masʿūd al-Shīrāz[ī—may God make his end be] good—wrote […], and this occurred in the sacred and blessed month of God, Rajab, of the year […]

Incipit:

بِسم الله الرّحمن الرّحيم رَبّ اَنْعمتَ فَزِدْ

يقُول احوجُ خلق الله إليه محُودُ بن مَسْعُودِ الشّيرَازيُّ خَتَمَ اللهُ لَهُ بالحُسْنَى أمَّا بعدَ...

In the name of God the Beneficent, the Merciful

Lord, you have been gracious; may you grant additional bounty

The neediest of God's creation, Maḥmūd b. Masʿūd al-Shīrāzī—may God make his end be good—states…

Colophon:

وَفُرغ من كتابته يَومَ الاربعا عشرين جمادى الأولى سَنة احدى وثمانينَ وَستمائةٍ هجرية وَالحَمْدُ لله اولاً وآخراً

Its copying finished on Wedenesday 20th of Jumādá al-Ūlá of the Hijrī year 681—praise be solely to God.

MS R (ر): Istanbul, Köprülü, MS 956

The scribal colophon has been changed for an unknown reason. According to this newly rewritten colophon, the manuscript was copied from Shīrāzī’s original copy while being read to him. The copy date is the beginning of Muḥarram 683. There is also a collation note next to the colophon in the copyist’s hand that indicates the collation of the manuscript with Shīrāzī’s copy and that it was read to him, completed in 10 Shawwāl 683. As far as Book III is concerned, the first, second and third series of revisions have been incorporated into the text of this manuscript.

Incipit:

بسم الله الرّحمن الرّحيم ربّ سهل وتمّم بالخير

قال مولانا واستاذنا افضل الورى علامة العالم [سيد فضلاء بني آدم: شا] قدوة المحققين سلطان العلما فى العالمين

حجة الحق على الخلق اجمعين مفخر افاضل الانام مالك القضاة والحكام قطب الملة والحق والدين محمود بن مسعود

الشيرازي ادام الله ظلال جلاله ومتع الله المسلمين بطول بقائه اما بعد...

In the name of God the Beneficent, the Merciful
Lord, may You ease [my affair] and make it end in a good manner
Our master and teacher, the most excellent of men, the most learned of the world, [<the lord of mankind’s eminences> crossed out], the model of the verifiers, the sultan of the learned in the worlds, the touchstone of truth over all creation, the source of pride for the most worthy of humanity, the king of justices and judges, the pole of the faithful community, of truth and religion, Maḥmūd b. Masʿūd al-Shīrāzī—may God prolong the shadows of his glory and may God allow the Muslims to enjoy his favor and his bestowal of benefits—said…

Colophon:

فرغ المُصَنّفُ ادَام الله ظلال جَلاله من تأليفه ليلة النصف من شعبان سنة ثمانين وستمائة والكاتب /احسَن الله خاتمة احواله من كتبه لنفسه نقلاً من نسخة الاصل للمصنّف ومن قرائته عليه في اوائل محرّم سنة ثلث وثمانين وستمائة هجريّة بمدينة سيواس في المدرسة الصاحبية الشمسية/

The author—may God prolong the shadows of his glory—completed its composition during the night of mid-Shaʿbān, in the year 680, and the copyist/— may God ends his affairs in a good manner—[completed] his copy that was penned for himself from the original copy of the author and [also completed] its reading to [the author] in the beginning of Muḥarram of the Hijrī year 683 in the city of Sīwās in the madrasa al-Ṣāḥibiyya al-Shamsiyya/.

Collation note:

وقد وقع الفراغ من العراض والمقابلة مع المصنف ادام الله ظله بنسخته وقرائته في عاشر شوال سنة ثلث وثمانين وستمائة هجرية

The presentation and collation [of this copy] with [the author's] copy in the presence of the author—may God make his shadow lasting—and its reading [to him] completed on 10th of Shawwāl of the Hijrī year 683.

MS L (ل): Istanbul, Süleymaniye, Laleli, MS 2145

Copied by Muḥammad b. al-Shyakh Khalīl al-Sīwāsī, probably in 681 in Sivas. It has the first series of revisions in the body of the text, with the second, third and final series in the margin. It has been vocalized by Shīrāzī and all marginal revisions and in-text corrections are by Shīrāzī himself. The second series of revisions are distinguishable since they were written with brown ink and clearly look older than other marginal notes. The third and final revisions were written with black ink. This manuscript is the most authenticated manuscript of the *Nihāya* since it was evidently being used by Shīrāzī in order to record his revisions.

Note (on title page):

وجدت مكتوباً على ظهر [...] اخبرنا الشيخ ابو سعيد سعد انصاري [...] ان ابا نصر سعيد بن خدر[؟] الاسترابادي اخبرهم اخبرنا ابو عبد الله بن احمد القاضي اخبرنا ابوالفرج محمد بن احمد بن احمد بن علي بن سلام [...] مستنداً الى عليّ بن ابي طالبٍ رضي الله عنه [...] كنت مع رسول [الله] صلى الله عليه وسلم في مسجد وكان يذكر ان فقراء أُمَّتي يدخلون الجنة قبل الاغنيا بنصف يوم القيامة وهو خمسمائة عامٍ ثم قال أفيكم من ينشدنا فقال واحد منهم:

قد لَسَعَت حيَّة الهوى كبدي فلا طبيب لها ولا راقٍ

إلا الحبيب الذي شغفت به فعنده رُقيتي وترياقي

فتواجد رسول الله صلعم وتواجد الاصحاب معه حتى سقط ردائه عن منكبيه وآوى كل واحد منهم إلى مكانه قال معوية ما أحسن لعبكم فقال رسول الله صلعم يا معوية ليس بكريم من لم يهتزّ عند السَّماع فقُطع رداء رسول الله صلعم باربعمائة قطعة واقسم بينهم وبين سائرهم صدق الله وصدقت رسول الله[٩]

I found this written on the back of …: Al-Shaykh Abū Saʿīd Saʿd Anṣārī… has related to us that Abū Naṣr Saʿīd b. Khidr [?] al-Astarābādhī told them that

[9] Probably Shīrāzī is quoting from Suhrawardī's *ʿAwārif al-maʿārif*, although their *isnāds* are different. However, this *hadith* was used by *Ṣūfī*s as a witness for permissibility of *Samāʿ*, in general.

Abū ʿAbd Allāh b. Aḥmad al-Qāḍī has related to us that Abū al-Faraj Muḥammad b. Aḥmad b. Aḥmad b. ʿAlī b. Sallām… on the authority of ʿAlī b. Abī Ṭālib—may God be pleased with him— [that] "I was with the Messenger [of God]—may God bless him and give him peace—in a mosque and he was mentioning that "the poor of my people will enter Paradise earlier than the rich by half of the Day of Resurrection day, which is five hundred years." Then he said: "Would one of you recite verses to us?" One said:

"The snake of lust has stung my liver
There is neither a physician nor an enchanter
Only the beloved of whom I am enamored
Has for me charm and antidote"

Then, the Messenger of God—may God bless him and give him peace—became thrilled, which made the Companions thrilled to the extent that [Prophet's] mantle fell down from his shoulders, and everyone went back to his place. Muʿāwiya said: "How fun is your diversion!" The Messenger of God—may God bless him and give him peace—said: "O Muʿāwiya! It is not nice if one does not tremble during listening." Then, the mantle of the Messenger of God—may God bless him and give him peace—was cut into four hundred pieces and distributed between them and between others—God has spoken the truth; may I not utter truly to the Messenger of God a saying/may I not speak truth to the Messenger of God."

Incipit:

بِسم الله الرَّحْمَنِ الرَّحِيم ثقتي باللهِ تعالى

يقول أحوج خَلق اللهِ إليهِ محمود بن مسعود الشيرازي ختم الله له بالحُسْنى اما بعد...

In the name of God the Beneficent, the Merciful
In God, the Almighty, is my trust
The neediest of God's creation, Maḥmūd b. Masʿūd al-Shīrāzī—may God

make his end be good—states…

Colophon:

فرغ من تعليق هذا الكتاب احوج خلق الله الى رحمة ربه الجليل محمد بن الشيخ خليل السيواسي غفر الله له

ولجميع المسلمين والحمد لله وحده وصلى الله على نبيه محمد وآله الطيبين الطاهرين وسلم تسليماً

The neediest of God's creation to his Lord's majestical mercy, Muḥammad b. al-Shaykh Khalīl al-Sīwāsī—may God forgive him and all Muslims. Praise be to God and may God bless His Prophet, Muḥammad, and his pure noble progeny and give [them] salutation.

2.1.5 Signs and conventions

For the Arabic edition, the following conventions have been used:

1. The orthography and rules for *hamza* follow modern conventions.
2. The dotting of ي follows the rules used by printers in Syria and Lebanon.
3. *Tanwīn* is generally added (but not on feminine ending: ة).
4. *Shadda*s have been supplied (except for sun letters and *nisba*s).
5. Short vowels have been provided sparingly as aids to the reader and/or to avoid ambiguity.

For critical apparatus, the following signs and abbreviations have been used:

[	Separates reading in edition from any variant
:	Separates variant and manuscript sigla
+	Added in
–	Missing from
=	Indicates another variant
(…)	Editor's comments

ب (B) Berlin, Staatsbibliothek, MS Petermann I 674

ر (R) Istanbul, Köprülü, MS Fazıl Ahmed Paşa 956

ك (K) Istanbul, Köprülü, MS Fazıl Ahmed Paşa 957

ل (L) Istanbul, Süleymaniye, MS Laleli 2145

تا	تحت السطر في (under the line in)
شا	مشطوب في (crossed out in)
طا	مطموس، غير مقروء، إلخ (smudged, unreadable, etc.)
فا	فوق السطر (above the line in)
ها	في الهامش (in the margin in)

2.2 Arabic Edition of Book III of the *Nihāya*

المقالة الثالثة

في هيئة الأرض وقسمتها إلى العامر والغامر **وما يلزمها بحسب اختلاف أوضاع العلويات** ونحوه

وهي أيضاً ثلاثة عشر باباً

الباب **الأوّل**

في جملـة من هيئة الأرض وأحوالها

[١] قد سبق في صدر المقالة الثانية أنّ السطح الظاهر من الأرض مستدير و**موازٍ لمقعر الفلك**، وهو مع[١] السطح الظاهر من الماء بمنزلة سطح كرة، **وأنّ الواقف عليها** في أيّ موضع كان **رأسه إلى ما يلي المحيط وهو الفوق ورجله إلى ما يلي المركز وهو التحت. والسائر على الأرض يجب أن يصير سمت رأسه في كلّ وقت جزءاً آخر من** المحيط. **ولو كان السير على جميع** السطح الظاهر من **الأرض** والماء **ممكناً، ثمّ فرض تفرّق ثلاثة أشخاص عن موضع، فسار أحدهم نحو المغرب والثاني نحو المشرق وأقام الثالث حتّى دار السائران دوراً** تاماً ـــ **ورجع السائر** إلى الغرب **إليه من الشرق والسائر** إلى الشرق إليه **من الغرب ـــ نقص من الأيّام التي عدّوها جميعاً للـمغربي واحد وزاد للـمشرقي واحد** لأنّ زمان يوم وليلة للمغربي أكثر منه للمقيم بقدر حركته، وللمقيم أكثر منه للمشرقي بقدر حركته. لأنّ ما بين نصفي النهارين للمغربي أكثر منه للمقيم بقدر حركته، وللمقيم أكثر منه للمشرقي بقدر حركته،[٢] وتلك الزيادات في دور يكون يوماً بليلته موزّعاً على جميع الأيّام، فينقص من حساب المغربي يوم ويزيد للمشرقي يوم. **وهذا أيضاً ممّا يُسأل عنه،** ويُقال: هل يجوز أن يختلف عدد أيّام السنة[٣] الشمسية بالنسبة إلى ثلاثة أشخص، حتّى يكون بالنسبة إلى أحدهم ثلاثمائة وخمسة وستّين يوماً وربع يوم، كالمقيم مثلاً، وإلى الثاني ثلاثمائة وأربعة وستّين وربع يوم، كالمغربي، وإلى الثالث ثلاثمائة وستّة وستّين يوماً وربع، كالمشرقي؟ أو هل يجوز أن يكون[٤] يوم معيّن بالنسبة إلى شخص الجمعة، مثلاً كالمقيم، وإلى آخر الخميس، كالمغربي، وإلى ثالث السبت، كالمشرقي؟ أو هل يجوز أن يَعُدّ ثلاثة أشخاص أيّاماً من مبدأ معيّن إلى منتهى معيّن، فيكون لأحدهم أربعة أيّام، ولآخر ثلاثة، وللثالث خمسة؟ فيُجاب بالجواز **ويُستغرب.** ولا يخفى أنّ في الجواب الأوّل يجب أن تفرض حركتهما بحيث يتمّان الدور في مقدار سنة شمسية

للمقيم، وفي الثالث بحيث يتمّانه في أربعة أيّام، وفي الثاني لا يجب شيء منهما لأنّه يصحّ بكلّ منهما. فالواجب العامّ في جواب الجميع أن يتمّا الدور في مقدار زمان حسبه المقيم. /ولا يخفى بعد الإحاطة بما ذكرنا أنّه لو فرض حركتهما مساوية للحركة الشرقية حتّى يتمّا الدورة[٥] في مقدار يوم بليلته، كان الزمان الذي من الافتراق إلى الاجتماع للمقيم يوماً بليلته، وللمشرقي[٦] يومين، وللمغربي الوقت الذي اتّفق فيه الافتراق، حتّى لو كانت[٧] وقت الطلوع كان فيه إلى أن يصل إلى المقيم إذ الشمس لا ترتفع عن أفقه إذ بمقدار ما يتحرّك المغربي إلى المغرب[٨] تتحرّك الشمس نحوه أيضاً فلهذا لا يتغيّر الوضع[٩] المفروض بينهما وكذا أيّ وضع فرض بينهما وهذا أعني كون الشمس على أفق الشرق لشخصٍ[١٠] مقدار يوم بليلته بل شهراً أو سنة أو إلى الأبد لو تحرّك هكذا أبداً غريب أيضاً أو[١١] أغرب ممّا تقدّم لاستلزامه كون مقدار يومين عند المشرقي كقدر[١٢] آنٍ عند المغربي وهو ظاهر./[*] [i]

[٢] وإذا عرفت ذلك فاعلم أنّ الأرض تنقسم بخطّ الاستواء ـــ أعني بالدائرة العظيمة الحادثة على بسيط الأرض من توهّم قطع سطح معدّل النهار العالمـ بنصفين شمالي وجنوبي وإنّما سمّيت خطّ الاستواء لاستواء الليل والنهار عند سكّانها أبداً. وبعظيمة أخرى على بسيطها مارّة بقطبي الأولى إلى نصفين /فوق وأسفل./[+] [ii] فتنقسم **الأرض بهما أرباعاً. أحد الشماليين هو الربع المسكون، والباقية** غير معلومة الأحوال؛ لا أنّها **إمّا غامرة في** البحر **غير مسكونة وإمّا غير معلومة الأحوال،** لأنّ التقسيم فاسد، ولا أنّها غامرة في الماء، على ما قيل، مصيراً منهم إلى أنّ كلّيات العناصر لا بدّ وإن تكون متعادلة في الحجمية، ولو لم يكن الماء محيطاً بالأرباع الثلاثة لكان أقلّ بكثير من كلّية الأرض. لأنّا ما رأينا لهم في تقرير هذه المقدّمة

[i] ولا يخفى... وهو ظاهر] هاب، هاك

[ii] فوق وأسفل] هاب، هاك، هال

شبهة، فضلاً عن حجّة. فعلى هذا يحتمل أن يكون في الأرباع الباقية عمارات كثيرة لم يصل إلينا خبرهم لما بيننا وبينهم من البحار المغرقة والجبال الشاهقة. ثمّ إذا توهّمت عظيمة ثالثة على بسيط الأرض مارّة بأقطاب الأوليّين، نصّفت الربع المسكون إلى شرقي وغربي، ونقطة التقاطع بين الثالثة والأولى /في النصف الفوقاني/[†] [iii] تسمّى قبّة الأرض وقبّة أرين ووسط الأرض. وبين القبّة وكلّ من تقاطعي الثانية والأولى ربع الدور. ويُقال للدائرة الثالثة نصف نهار القبّة ووسط الأرض، وللثانية أفقها، لا لأنّهما هما، بل لأنّهما في سطحها. ويُقال للثانية أيضاً أفق خطّ الاستواء، وهو، وإن صحّ من حيث أنّها في سطح أفقه، لكنّه لا يحسن حسن الأوليّين، لأنّ أفق خطّ الاستواء أعمّ من الثانية، أي يوجد دونها، بخلاف نصف نهار القبّة وأفقها فإنّهما لا توجدان دون الثالثة والثانية. **وينبغي أن يتوهّم تجزئة سطح الأرض طولاً بحسب تجزئة معدّل النهار وعرضاً إلى القطبين بحسب تجزئة دوائر الميول. وتتوهّم عليه مدارات محاذية للمدارات اليومية بعينها لتمكّن امتياز**[١٣] **بعض المواضع عن بعض. وتُقدّر المسافات والمقادير كما على الفلك.**

[٣] وإنّما حُكم بأنّ المعمور ربع لأنّه وُجد **في أرصاد الحوادث الفلكية كالخسوفات تقدّم** في **ساعات الواغلين في المشرق على ساعات الواغلين في المغرب** بـ**اثنتي عشرة ساعة،** ولم يوجد أكثر منها. فعُلم منه **أنّ طول المسكون لا يزيد على نصف دور الفلك،** أعني نصف دور الأرض وهو مائة وثمانون جزءاً لأنّ كلّ ساعة خمسة عشر جزءاً. **وإنّما حكم** بطلميوس أوّلاً **بأنّ الربع شمالي لأنّه** ثبت عنده أنّ **أظلال** المقاييس في **أنصاف نهار الاعتدالين** في جميع المسكونة تقع نحو الشمال،[١٤] **ولا يقع شيء منها** نحو الجنوب. وهذا رأيه عندما صنّف *المجسطي*، إذ لم يكن مقدار عرض المعمور[١٥] معلوماً عنده حينئذ. ثمّ بعد ذلك أحاط علماً بالعمارات التي وراء خطّ الاستواء من جهة الجنوب إلى ستّة عشر جزءاً وربع وسدس. فقال في كتابه

[iii] في النصف الفوقاني] هاب، هاك، هال

الموسوم بـ*جَغْرافيا* أنّ أوّل عرض المعمورة من جهة الجنوب حيث يكون ارتفاع القطب الجنوبي ستّة عشر جزءاً وربع وسدس، وهي **مساكن على أطراف الزنج والحبشة وغيرها حُكي أنّها جنوبية.** وآخره في الشمال حيث يكون ارتفاع القطب الشمالي ستّة وستّين جزءاً، وما بعده لا يمكن أن يُسكن فيه لشدّة البرد اللازم من بعد الشمس عن سمت الرأس هناك. فعرض المعمورة على هذا اثنان وثمانون جزءاً وربع وسدس، وطوله، على ما ذُكر هناك أيضاً، مائة وسبعة وسبعون جزءاً وربع. وقال فيه أيضاً وإنّما اختصّ ما دون خطّ الاستواء بالذكر لأنّ الربع الشمالي حاوٍ لما هو الأشهر من المساكن وأجلّها فصار كالحاصر لما هو المعمور من الأرض. ولأنّ ما بين طرفي العمارة، على ما هو المشهور، نصف دائرة، فكلّما غربت الشمس في أقصى عمارة المشرق طلعت في أقصى عمارة المغرب، وذلك عند مجاوزة الشمس عن نصف نهار القبّة فوق الأرض، وبالعكس وذلك عند مجاوزتها عنه تحتها. فأفق القبّة نصف نهارهما وبالعكس، إلّا أنّ النصف الظاهر من الفلك ومن نصف النهار أيضاً لأحدهما، هو الخفي للآخر، وبالعكس. ومن ههنا يسهل تصوّر تفاوت الأيّام المعدودة للأشخاص المذكورة في السؤال المستغرب. وكانت لما ذكرنا أيضاً أقدام سكّان أحد الطرفين منتصبة على أقدام سكّان الطرف الآخر، وعلى طرفي قطر من أقطار العالم. هذا إن قام شخصان على النهايتين، فإن قاما على محيط دائرة فيما دون النهايتين، كان الخطّان الخارجان من مركز العالم إلى أقدامهما[١٦] كساقي مثلّث منفرج الزاوية، إن كان البعد بينهما أكثر من ربع دائرة، وقائمها إن كان الربع، وحادّ الزوايا إن كان أقلّ منه. ومن ههنا يتأكّد تصوّر ما قلنا في أوّل الكتاب أن البعد بين رؤوس الأشخاص القائمة على الأرض أكثر من البعد بين قواعدها، لكن هذا إنّما يظهر في شخصين متباعدين جدّاً ولا يظهر في متقاربين هذا.

[٤] وأمّا **البحر** فهو **محيط بأكثر جوانب القدر المذكور من الأرض. أمّا من جانب المغرب والشمال وأكثر الجنوب، لا سيّما الشرقي منه**[١٧]، **فمعلوم. وأمّا جنوب المغرب، فقد ذُكر أنّ السائرين على سمت منابع نيل مصر انتهوا إلى مواضع زاد**

عرضها الجنوبي على بضع عشرة درجة، وشاهدوا الجبال البيض من الثلج المنسوبة إلى القمر التي منها منابع النيل في جنوبهم من بعيد، ولم يصلوا إلى بحر. وكذلك **ليس لنا على البحر الذي في شمال المشرق وقوف يقيني،** لكنّهم حدسوا أنّ في جنوب المغرب وشمال المشرق بحراً أيضاً. /ولهذا سمّوا هذا البحر بالبحر المحيط./† [iv]

[٥أ] واعلم أنّ **في القدر المكشوف للعمارة بحاراً كثيرة بعضها متّصل بالمحيط** وبعضها غير متّصل به. فمن المتّصل بحر عمان، ويقال له بحر الفارس والهند والصين، وهو أعظم الجميع، يبتدئ من أقصى أرض الصين والهند إلى أقصى أرض /الحبشة والبربر لا/‡ [v] حيث يكون هناك سودان المغرب، /على ما هو المشهور. فإنّه لا يصحّ، لأنّ هذا البربر هو غير البربر الذي في المغرب من أرض إفريقية. وإن كان المراد ذلك، لكان طوله أكثر ممّا اتّفق عليه، وهو/‡ [vi] ألفا فرسخ وستّمائة وستّون فرسخاً. وعرضه تسعمائة فرسخ، منها ثلاثمائة وستّون فرسخاً أو ثلاثون فرسخاً، على اختلاف القولين، شمالي عن خطّ الاستواء والباقي جنوبي عنه. وخطّ الاستواء يمرّ بأكثره. وهذا هو البحر الجنوبي المتّصل بالجانب الشرقي من المحيط ويخرج منه أربع خليجات إلى وسط العمارة. الأوّل هو الخليج البربري لكونه في حدود بربر، وهو أقربها إلى المغرب. طوله في جانب الشمال مائة وستّون فرسخاً، وعرضه /عند أصله وقيل عند طرفه/‡ [vii] خمسة وثلاثون فرسخاً. والثاني الخليج الأحمر،* [viii] طوله في الشمال أربعمائة وستّون فرسخاً. وعرضه عند أصله مائتا فرسخ، وحيث يستدقّ، وهو منتهاه، ستّون فرسخاً. وهناك

[iv] ولهذا سمّوا هذا البحر بالبحر المحيط] هاب، هاك، هال

[v] الحبشة والبربر لا] مضاف في المتن: ك، ل = المغرب والبربر: ب («المغرب»: طاك، طال)

[vi] على ما هو المشهور... ممّا اتّفق عليه وهو] هاك، هال = طوله: ب

[vii] عند أصله وقيل عند طرفه] - ب، هاك، هال

[viii] الخليج الأحمر] + وهو قريب من أرض أبلّة: شاب، شاك

يُقال له بحر قلزم لأنّه بلد على طرفه المستدقّ، ويسمّى لسان البحر أيضاً. وعلى جانبه الشرقي أراضي عدن ويمن، وعلى الغربي أرض حبشة، /ولهذا يسمّون هذا الخليج ببحر اليمن وبحر الحبشة أيضاً./‡ [ix] والثالث خليج فارس الذي على طرفه بصرة، ويتّصل به فارس وكرمان. طوله في الشمال أربعمائة وستّون فرسخاً، وعرضه في الأصل مائة وثمانون فرسخاً، وعرض طرفه أربعة وخمسون فرسخاً. وعلى ساحله الشرقي نواحي تيز ومكران، وعلى الغربي في مقابلته فرضة عمان، /ولهذا يسمّى ببحر عمان أيضاً./‡ [x] وبين[١٨] هذا الخليج والخليج الأحمر، وهو قريب من خمسمائة فرسخ، كلّه ولاية العرب وأرض الحجاز واليمن. وفرات الذي أصله من جبال أرزن الروم،[١٩] يتّصل عند بصرة بالدجلة التي أصلها من جباله أيضاً، أو من جبال الروم والشام، على ما قيل، ثمّ يدخل في هذا الخليج عند عبادان. وحدّ هذا الخليج إلى أرض السند، وهناك يدخل فيه أنهار كثيرة مثل نهر منصور الذي يتوجّه من هند إلى سند. وفيه جزائر كثيرة. والخليج الرابع الخليج الأخضر[٢٠] ويسمّى خليج الهند لأنّه في بلاد الهند. وقيل في أقصاها طوله في الشمال خمسمائة فرسخ. وفيه، /أي بحر الصين والهند،/‡ [xi] من الجزائر العامرة وغير العامرة ألف وثلاثمائة وسبعون جزيرة. منها جزيرة ضخمة في أقصى هذا الخليج مقابل أرض الهند من ناحية المشرق عند بلد الصين. /وليست هي سرنديب، على ما قيل، ويحيط/‡ [xii] بها ألف فرسخ. فيها جبال عظام وأنهار كثيرة، ومنها يخرج الياقوت الأحمر ولون السماء. وحول هذه الجزيرة تسع عشرة جزيرة عامرة فيها مدائن وقرىً كثيرة. ومنها جزيرة يجلب منها الرصاص القلعي، وأخرى يجلب منها الكافور.

[ix] ولهذا يسمّون هذا الخليج ببحر اليمن وبحر الحبشة أيضاً] - ب، هاك، هال

[x] ولهذا يسمى ببحر عمان أيضاً] - ب، هاك، هال

[xi] أي بحر الصين والهند] - ب، هاك، هال

[xii] وليست هي سرنديب على ما قيل ويحيط] مضاف في المتن والهامش: ك، ل = وهي سَرنديب يحيط: ب

[٥ب] ومن المتّصل بالمحيط من جانب الغرب بحر يسمّى بحر الروم والشام ومصر وإفريقية. طوله من أندلس نحو المشرق ألف وستّمائة فرسخ، وبين طرفه وبحر القلزم، على البرّ، ثلاثة منازل. وعرضه حيث هو متّصل بالمحيط ثلاثة فراسخ، وإذا بعد عنه إلى نصف الطول كان مائتي فرسخ، وإذا وصل إلى حدّ الشام كان مائتين وستّين فرسخاً. وتجري إليه أنهار كثيرة مثل نهر جيحان ونهر /سيحان/‡ [xiii] ونهر يزدان، وهذه أسماء جبال في حدود الروم. ويخرج من هذا البحر خليجان إلى الشمال. أحدهما، وهو أقرب إلى المشرق، خليج قسطنطينية، طوله مائة وستّون فرسخاً. وهو لا يتّصل بالمحيط، هكذا ذكره الأستاذ أبو ريحان في كتابه، وقال يمكن المسير على البرّ من صقلاب وروس إلى قسطنطينية. وقال المسعودي أنا سمعت ممّن يُعتمد على قولهم من التجار أنّا سافرنا من روس إلى قسطنطينية على البرّ. وثانيهما، وهو أقرب إلى المغرب، /غير/‡ [xiv] متّصل بالمحيط /أيضاً على الصحيح،/‡ [xv] طوله /إلى شمال المغرب/‡ [xvi] سبعون فرسخاً. وجزائر اليونانيّين في هذا البحر. ويدخل فيه من جانبه الجنوبي نيل مصر. وقسطنطينية بين هذين الخليجين قريب من الخليج الشرقي.

[٥ج] ومنه أيضاً بحر المغرب، وهو معروف بأوقيانوس، ويتّصل به بحر الهند. ولا يُعرف منه إلّا في ناحية المغرب والشمال عند محاذاة أرض الروس والصقالبة. فيأخذ من أقصى الجنوب محاذياً لأرض السودان مارّاً على حدود السوس الأقصى وبلاد طنجة[٢١] وأندلس، ثمّ يبتدئ من هناك وراء الجبال غير المسلوكة والأراضي الغير المسكونة نحو المشرق. وهذا البحر، أعني أوقيانوس، لا تجري فيه السفن، وإنّما تسلك السفن بالقرب من ساحله. وفيه ستّ جزائر مقابل أرض الحبشة

[xiii] سيحان] سنجار: ب، متغير من« سنجار»: ك، ل

[xiv] غير] و: ب = متغير من«و»

[xv] أيضاً على الصحيح] - ب، هاك، هال

[xvi] إلى شمال المغرب] مضاف في: هاك، متن ل = إليه: ب، طال

تسمّى جزائر الخالدات وجزائر السُعَداء، وجزيرة أخرى تسمّى غديرة مقابل أندلس عند خليج يخرج من هذا البحر وعرضه حيث يخرج فرسخان وميل. وهو بين الأندلس وطنجة وكان يُعرف في القديم بمَعَبَرة هرقْلِسْ والآن يُعرف بالزقاق. وهذا الخليج ينصبّ في بحر الروم والشام، /هكذا قيل، لكن الصحيح أنّ ماء بحر الروم والشام ينصبّ في الزقاق إلى البحر كما أنّ ماء خليج قسطنطينية ينصبّ إلى هذا البحر، أعني بحر الروم والشام، وكذا ماء بحر طرابزندة ينصبّ إلى خليج قسطنطينية على ما يشهد به الحسّ./‡ [xvii] وفي هذا البحر من ناحية الشمال جزائر برطانية، وهي اثنتا عشرة جزيرة. ويخرج منه خليج آخر في شمال أرض أندلس، ويتّصل أيضاً ببحر الشام، /هكذا قيل، لكن اتّصاله ببحر الشام لا يصحّ./‡ [xviii] فيكون طول بحر الشام من هذا الموضع، المسمّى بالزقاق، ويمتدّ في جهة الشرق إلى الشام، وهذا الطول هو ألف وثلاثمائة فرسخ.

[٥د] ومن المتّصل بالمحيط في جانب الشمال بحر وَرَنْك، وهم أمّة على ساحله. ويمتدّ هذا البحر في شمال أرض الصقالبة إلى أرض بلغار. طوله من المشرق إلى المغرب مائة فرسخ وعرضه ثلاثة وثلاثون فرسخاً. ومن المتّصل بالمحيط بحر نيطُس، ويسمّى بحر طرابزون، لأنّه فرضة عليه. ويمتدّ خلف قسطنطينية في أرض الروس والصقالبة. طوله أربعة آلاف وثلاثة وثلاثون فرسخاً. وينفجر من بحر نيطس عند سور قسطنطينية خليج يجري فيه مائة نهر وينصبّ في بحر مصر. وعرضه عند قسطنطينية فرسخ، ولا يزال يتضايق حتّى يقع في بحر مصر[٢٢] والشام الذي على جنوبيّه بلاد المغرب وإفريقية

[xvii] هكذا قيل... على ما يشهد به الحسّ] - ب، هاك، هال

[xviii] هكذا قيل لكن اتّصاله ببحر الشام لا يصحّ] - ب، هاك، هال

إلى الإسكندرية ومصر وبحذائه في الشمال أرض الأندلس والروم وفرنجة إلى أنطاكية. ويليها بلاد الشام /لأنّها فيما بين جانبَيْهِ الجنوبي والشمالي عند انتهائه في الشام وفلسطين./‡ xix

[٥هـ] ومن البحار التي لم يتّصل بالمحيط، أعظمها بحر الخزر المسمّى ببحر آبسكون الآن، لأنّه على فرضته، وبحر جرجان وبحر الباب في القديم. طوله من المشرق إلى المغرب مائتان وستّون فرسخاً، وعرضه مائتا فرسخ. ولا يتّصل ببحر آخر بل يمتدّ من آبسكون إلى طبرستان والديلم وشروان وباب الأبواب ثمّ الخزر على مصبّ نهر آتِل ثمّ ديار الغُزية[٢٣] إلى أن يعود إلى آبسكون. ويسمّى باسم كلّ بقعة حاذاها. ويدخل فيه أنهار عظيمة مثل نهر أَرَسْ الذي هو من أرض أرمينية؛ ونهر آتل الذي هو من بلغار، وهو أعظم من جيحون؛ ونهر آخر يُعرف بسپِيذروذ؛ وغيرها من الأنهار التي أصولها من جبال الشام والتي من جنوب هذا البحر كالتي أصولها من جبال كيلان وديلمان وطبرستان.

[٥و] فهذه الخمس هي البحور العظام، وأمّا غيرها فبحيرات وبطائح ومغايض، كبحيرة طبرية بأرض الشام وكبحيرة خوارزم التي دورها مائة[٢٤] فرسخ، وبينها وبين بحر آبسكون مسافة عشرين يوماً، وجيحون وسيحون يدخلان فيها. أمّا جيحون، فيمتدّ من شرقي بلخ من اجتماع خمسة أنهار عظيمة، أعظمها من شرقي أرض تُبُتْ؛[٢٥] وشعبة أخرى من أرض خرخيز؛ والبواقي من جبال طخرستان. وأمّا سيحون، وهو نهر فرغانة، فأصله من أقصى المشرق وبلاد الترك. وهذه البحيرة كبحيرة طبرية أو أعظم منها. وفي الأرمينية بحيرة في حدود ملازجِرْد.

[٥ز] وقد حكي عن أرسطوطاليس أنّ بحر أوقيانوس محيط بالأرض بمنزلة إكليل لها. وإنّه ينفتح منه خليج في ناحية المغرب في الموضع المسمّى بمعبَرة هرقلِس، فيدخل إلى المعمورة مارّاً نحو المشرق، وهو بحر مصر والروم وإفريقية والشام.

---

xix لأنّها فيما بين جانبَيْهِ الجنوبي والشمالي عند انتهائه في الشام وفلسطين] وفلسطين: ب = هاك، هال

وينفتح منه أيضاً في ناحية المشرق خليج فيدخل إلى المعمورة مارّاً نحو المغرب، وهو بحر الصين والهند وفارس والقلزم وبَربَر. فهذا أنموذج في أحوال البحار على ما حكاها الجيهاني وغيره من العلماء بمواقع البحور وامتداداتها. وأمّا تفاصيلها فكثيرة تذكر أكثرها في كتب المسالك والممالك، فمن أراد الاستقصاء فيه فليراجع تلك الكتب. **و**أيضاً **غير البحار من موانع العمارة** كثيرة **كالبراري والجبال والتلال والرمال والآجام وغيرها** من البوادي كبادية العرب ومعبد[٢٦] وخوارزم، **يعرفها أهل العلم بالمسالك والسيّاح وغيرهم.** وهذه الجملة في[٢٧] حساب الربع المسكون.

[٦أ] واعلم أنّ سبب انكشاف الناحية الشمالية، بعد العناية الالهية والأسباب السماوية، كالاتّصالات الكوكبية ونحوها من الأمور الأحكامية، هو انجذاب أكثر المياه إلى الناحية الجنوبية لكونها أحرّ من الناحية الشمالية، مع أنّ من شأن الحرارة جذب الرطوبات، كما يُشاهد في السراج، وأنّها كلّما كانت أشدّ كانت أجذب. وإنّما كانت الجنوبية أحرّ لقرب الشمس منها وبعدها من الشمالية لكون حضيض الشمس في البروج الجنوبية وأوجها في الشمالية وكونها في القرب أشدّ شعاعاً من كونها في البعد وكون الحرارة اللازمة من الشعاع الأشدّ أقوى وأحدّ من اللازمة من الأضعف. **و**على هذا **تنتقل العمارة** من الشمال إلى الجنوب وبالعكس **بسبب انتقال الأوج** من أحدهما إلى الآخر.§ [xx] وقول من قال **وجود البحار في شمال العمارة ينافي هذا**

[xx] الآخر] + وتكون العمارة دائماً حيث أوج الشمس لئلا يجتمع القربان في الصيف، قرب الشمس من سمت الرأس، ومن الأرض، فيبلغ الحرّ إلى حدّ النكاية والإحراق، ولا البعدان في الشتاء، فيبلغ البرد إلى حدّ النكاية والتفجيج. ومن ههنا يُعلم أنّ حرّ صيفنا والأوج في السرطان أقلّ بكثير من حرّ صيف المتقدّمين والأوج في عشر من الجوزاء. ولهذا كان الحذّاق من الأطبّاء المتقدّمين كأبقراط وجالينوس وغيرهما يأمرون الأصحّاء بإدمان تناول الترياقات الحارّة، ويعالجون الأمراض الحارّة بالعسل ويرجّحان نفعه على غيره. ولو اعتمده الناس في هذا الزمان في معالجة الأمراض الحارّة، لزاد فيها. ولا يظنن ظانّ أنّ صيفهم إذا كان أحرّ من صيفنا، كانوا أقلّ احتمالاً للأدوية الحارّة منّا، «فإنّ الشيء إنّما ينفعل عن ضدّه لا عن شبهه». ولهذا فإنّ الهند يواظبون على تناول ما تنبتهم أرضهم من الأفاويه، وهم يرون ذلك أحد أسباب دوام صحتهم، وأهل آذربيجان يغتذون بلحم البقر والبطيخ الأخضر في شتائهم. فإن قيل المسافة التي بين الشمس والأرض إذا كانت في الأوج، لا تخالف المسافة التي بينهما إذا تجاوزت الأوج بنحو عشرين درجة، مخالفة محسوسة تؤثر في كون صيف من قبلنا أحرّ من صيفنا، قلنا هذا

الحكم ممنوع، لأنّ المنافي له كون البحار في شمال العمارة أكثر لا أقلّ، على ما هو الواقع، واعترف هذا القائل به. وليس السبب في كون الجنوبية أحرّ كون الشمس **أعظم جرماً** في الرؤية هناك، لقربها من مدار حضيضها، وكون الأعظم **أشدّ شعاعاً** وإشراقاً،[٢٨] على ما قيل، فإنّه باطل، لا لما قيل من **أنّ التفاوت بين صغر الشمس من جهة كونها في الأوج وكبرها من جهة كونها في الحضيض ليس ببيّن** في **الحسّ، فمن البعيد أن يبلغ تأثيرها إلى حدّ يصير أحد موضعين متساويين في الوضع بالقياس إلى السماويات،** أعني الجنوبي والشمالي من نصفي الأرض، **مسكوناً والآخر غير مسكون.** سلّمناه لكن هذا التعليل وإن كان مقنعاً في اختصاص العمارة بالنصف الشمالي دون الجنوبي، فلا يكون مقنعاً في اختصاصها بأحد الربعين الشماليين دون الآخر، لأنّا لا نُسلّم تساوي وضع نصفي الأرض الجنوبي والشمالي بالقياس إلى السماويات، /لما مرّ،/* [xxi] ولا اختصاص العمارة بأحد الربعين الشماليين دون الآخر لجواز أن يكون الآخر مسكوناً، ولا يصل إلينا خبرهم لما تقدّم. ولا أنّ التفاوت بين صغر جرمها وكبره، لو كان بيّناً في الحسّ، أمكن أن يبلغ تأثيرها إلى الحدّ المطلوب، على ما دلّ عليه سياق الكلام إذ المؤثّر هو العظم في نفس الأمر، لا بحسب الحسّ. ولهذا فإنّ النار، وإن كانت تُرى في الليل من بعيد أعظم ممّا هي عليه، لا تكون تسخينها أشدّ، بل لأنّ المعتبر هو العظم في نفس الأمر، كما[٢٩] ذكرنا. والظاهر أن سبب عدم العمارة في الناحية الجنوبية هو أيضاً كونها أحرّ على الوجه الذي ذهبنا إليه.

[٦ب] **وقول من قال لو كان السبب ذلك لكان ما جاوزه في الجنوب من المساكن التي تزيد عروضها على غاية الميل معموراً،** في حيّز المنع، وسنده لا يخفى على الفطن بعد الإحاطة بما ذكرنا /من انجذاب المياه إلى تلك المواضع أو كونها في غاية

القدر من البعد عن الأوج يوجب أن تكون الشمس في صيف المذكورين من المتقدّمين أقرب إلى الأرض منها في صيفنا بثلاثة آلاف ومائة وثمانين فرسخاً، كل فرسخ اثنا عشر ألف ذراع. فهل هذه الزيادة في قرب الشمس على عظمها ممّا ينكر العقلاء أثره في السخونة؟: هاب، هار، هاك، هال

[xxi] لما مرّ] - ب، هاك

السخونة./* [xxii] نعم لو قيل[٣٠] السبب ما ذكره الأحكاميون في خرافاتهم من كونها **تحت المدارات الجنوبية التي تقع بين هبوطي النيّرين،** أعني فيما بين تسعة عشر جزءاً من الميزان إلى ثلاث درج من العقرب، لورد عليه ما ذكره. هذا مع أنّ ما ذكروه من كون **المواضع التي تحت المدارات** المذكورة المسمّاة، هي وما يحاذيها من الفلك، عندهم **بالطريقة المحترقة غير مسكونة،** باطل بما ذكره بطلميوس في *جغرافيا*، ونقلنا عنه. ولا يبطل ما ذكرنا به، لأنّ الحرارة عند كون الشمس في المنقلب أو قريباً منه، أشدّ ممّا لو كانت بعيداً منه[٣١] على ما يجيء[٣٢] تحقيقه ـــ إن شاء الله العزيز.

[٦ج] قال الخرقي «وهذا الموضع من الأرض»، يعني به المواضع التي تحت مدار حضيض الشمس وما يقرب منه، «يسمّى الطريقة المحترقة لأنّا إذا توهّمنا خطّاً يخرج من مركز العالم إلى مركز الشمس، فإنّه يلقى سطح الأرض على نقطة، فإذا دارت الشمس ودار الخطّ بدورانها إلى أن يعود إلى مبدأه تحدث دائرة على سطح الأرض، تلك الدائرة بالحقيقة هي الطريقة المحترقة وهي ليست بدائرة عظيمة، فالخطّ الراسم للدائرة على سطح الأرض يكون مارّاً على سطح مخروط لا يقطع الأرض بنصفين.» هذا لفظه في *منتهى الإدراك*، وفيه نظر. أمّا أوّلاً فلأنّ الطريقة المحترقة عند الجمهور هو المشهور المذكور من قبل لا ما ذكره. وأمّا ثانياً فلأنّ ما ذكره لا يصلح تعليلاً لتسميتها بالطريقة المحترقة، مع أنّ لفظه صريح في ذلك. وكأنّه أراد أن يقول وإنّما سمّيت تلك المواضع من الأرض الطريقة المحترقة لأنّها مواضع منها تحاذي ما بين هُبوطي النيّرين من الفلك. وليس المراد من محاذاتها[٣٣] ما يسبق إلى الفهم من كون تلك المواضع بين دائرتين حادثتين على بسيط الأرض من توهّم قطع مداري هبوطي النيّرين الأرض، إذ ليس كلّ مدار يومي يقطع الأرض ولو بالتوهّم. بل المراد من المحاذاة كون تلك المواضع بين دائرتين صغيرتين حادثتين على بسيط الأرض من توهّم خطّين يخرجان من مركز العالم إلى مركز الشمس، أحدهما عند كونها في

[xxii] من انجذاب المياه إلى تلك المواضع أو كونها في غاية السخونة] - ب، هاك

هبوطها، وهو التاسعة عشر[٣٤] من الميزان، والآخر عند كونها في هبوط القمر، وهو الثالثة من العقرب. ويدوران معها إلى أن عادا إلى موضعها. فيرسمان كما ذكر مخروطين، وعلى بسيط الأرض دائرتين ما بينهما هو الطريقة المحترقة بالحقيقة. وهذا هو الذي ذهب إليه المحقّقون من أهل الصناعة. والظاهر أنّه أراد تقرير ذلك أيضاً، لكن حدث له عيّ في الكلام، فوقع فيما وقع. واعتبر ما ذكرناه في كون الأقاليم والمساكن تحت المدارات اليومية، ولا تلتفت إلى ما يسبق إلى الفهم، فإنّه لا طائل تحته.

[٧أ] واعلم أنّ اليونانيّين جعلوا مبدأ العمارة في الطول الجانب الغربي لأنّه أقرب نهايتي العمارة إليهم، وهو عند بطلميوس **جزائر منسوبة إلى الخالدات،** كانت معمورة في قديم الدهر، في البحر الغربي المسمّى أوقيانوس، والآن غير معمورة؛ وعند بعضهم ساحل البحر الغربي، **وبينهما عشر درجات،** وهي قريبة من مائتي وعشرين فرسخاً. وبعض الهند جعلوا مبدأ العمارة الجانب الشرقي، لأنّه أشرف لكونه يمين الفلك ــــ لأنّهم توهّموا الفلك على صورة انسان مستلقي، رأسه القطب الجنوبي، والباقي واضح على ما هو المشهورــــ وهو عند علمائهم موضع يسمّى كَنك دز، وهو مستقرّ الشياطين على زعمهم. وطوله من ساحل بحر المغرب مائة وسبعون جزءاً. وحُكي أنّ رصد علماء الهند كان هناك. و**مبدأ** العمارة في العرض، **خطّ الاستواء، لأنّه متعيّن بالطبع دون ما عداه.** ثمّ ما كان منها في الجنوب يقال عرضه جنوبي، وما كان في الشمال عرضه شمالي.

[٧ب] واعلم أنّ تعريف مواضع البلاد إنّما هو بالطول والعرض. فطول البلد قوس من معدّل النهار بين نصف نهار مبدأ العمارة وبين نصف نهار ذلك البلد. ولمّا كان الواصلون إلى الإسكندرية من جهة المغرب أكثر من الواصلين إليها من جهة المشرق كان بُعَد الطرف الغربي عند بطلميوس أكثر تحقيقاً من بعد الطرف الشرقي، فجعل بدء الطول من جانب الغرب لذلك، وتابعه الجمهور في ذلك تأسّياً به، **وليكون ازدياد عدد الطول في جهة توالي البروج،** إلّا أنّ بطلميوس وبعض أهل العلم يأخذون الابتداء من الجزائر والباقون من الساحل ــــ ولهذا يوجد في الأطوال اختلاف في الكتب ــــ بينهما عشر

درجات. ومنهم من جعل بدء الطول من جهة الشرق، ليكون البعد في جهة الحركة الأولى. وقد عرفت أنّ **ما بين النهايتين على خطّ الاستواء، وهو على بعد ربع دور من المبدأ الغربي،** يسمّى **قبّة الأرض، فيلزمها الاختلاف بسبب الاختلاف فيه.** وذهب بعضهم إلى أنّ قبّة الأرض هي وسط عمارة العالم في الطول والعرض، وهو موضع طوله ربع الدور، وعرضه ثلاث[٣٥] وثلاثون درجة وكسر[٣٦] ـــ نصف تمام عرض المعمور ولا مشاحّة في الأسامي. ولمّا كان هذا الموضع وسط العمارة جُعل أصلاً، وقيل كلّ بلد طوله أقلّ من طوله، أعني من الربع، فهو غربي؛ وما زاد عليه فهو شرقي؛ وكلّ بلد عرضه أقلّ من عرضه فهو جنوبي؛ وما زاد عليه، فهو شمالي. وذهب آخرون إلى أنّ كلّ بلد يكون تحت نصف نهار القبّة فهو على القبّة، لأنّها ليست موضعاً معيّناً، بل كلّ موضع[٣٧] طوله تسعون فهو القبّة؛ وآخرون إلى أنّ معنى كون البلد على القبّة، هو أن يكون سكّانه ساكني القبّة، أعني ما بين نهايتي العمارة على خطّ الاستواء، وهو الصحيح، إذ على هذا لا يختلف طالع العالم، وعلى الأوّل يكون لكلّ بلد تحت نصف نهار القبّة طالع آخر للعالم. وأمّا عرض البلد، فهو قوس من دائرة نصف النهار المارّة بسمت ذلك البلد فيما بين معدّل النهار والسمت. وتسامتها[٣٨] قوس من دائرة عظيمة على الأرض فيما بين خطّ الاستواء ووسط البلد، وهو مثل ارتفاع القطب الظاهر، ومثل ميل المعدّل إلى جهة القطب الخفي. ولهذا إذا عُرف ارتفاع معدّل النهار في البلد بآلة تصلح لها،[٣٩] ونُقص ذلك من تسعين، حُصل عرض البلد. وهذه طريقة ثالثة[§] [xxiii] في معرفة عرض البلد.

[٧ج] وإذا عرفت الطول والعرض، فاعلم أنّ ما بين الطولين قوس من معدّل النهار بين دائرتي نصف نهار البلدين. /وبذلك القدر يكون البعد بين أفقها حتّى إذا علم الطالع في أحدهما علم في الآخر./[‡] [xxiv] وما بين العرضين قوس من نصف

[xxiii] ثالثة] ذكرت (متغير من «ثالثة»): ر، ك، ل

[xxiv] وبذلك القدر يكون البعد بين أفقها حتّى إذا علم الطالع في أحدهما علم في الآخر] هاب، هاك، هال

النهار ما بين سمت رأس أحد البلدين وبين تقاطع نصف نهاره مع الدائرة المخطوطة على القطب الظاهر من قطبي المعدّل ببعد وتر تمام عرض البلد الآخر. والبعد بين البلدين قوس من دائرة الارتفاع بين سمتي رؤوسهما. وتعديل الطول قوس من دائرة تمرّ بمطلع اعتدالنا وسمت رؤوس أولئك. وتعديل العرض قوس من دائرة نصف النهار ما بين دائرة تعديل الطول وبين معدّل النهار. وعرض[٤٠] البلد المعدّل قوس من دائرة نصف النهار[٤١] بين سمت رؤوسنا وبين دائرة تعديل الطول.

[٧د] ولنشر ههنا إلى أحكام للثوابت، لم يحسُن ذكرها في خلال ما تقدّم، لتوقّفها على معرفة الطول والعرض. فنقول إذا اختلفت الأطوال دون العروض، أي يكون الجميع تحت مدار يومي بعينه، فالثوابت لا تطلع عليهم معاً ولا يغرب كذلك، ويكون مقدار تقدّم طلوعها على المشرقيين كمقدار تقدّم غروبها عنهم. وإذا اختلفت العروض دون الأطوال، أيّ يكون الجميع تحت نصف نهار بعينه، فالثوابت التي مداراتها بين أعظم الأبدية الظهور وبين المعدّل تقيم فوق الشماليين منهم أكثر ممّا تقيم فوق الجنوبيين، وبقدر ما يتقدّم طلوعها على الشماليين يتأخّر غروبها عنهم؛ والتي مداراتها بين أعظم الأبدية الخفاء وبين المعدّل، بالعكس من ذلك، أعني أنّها تقيم فوق الجنوبيين أكثر ممّا تقيم فوق الشماليين، وبقدر ما يتقدّم طلوعها على الجنوبيين يتأخّر غروبها عنهم؛ والكواكب التي على المعدّل تطلع عليهم معاً وتغرب معاً. والمختلفة الأطوال والعروض، تقيم الثوابت التي مداراتها بين أعظم الأبدية الظهور وبين المعدّل فوق الشماليين منهم أكثر، والتي مداراتها بين المعدّل وبين أعظم الأبدية الخفاء، بالعكس من ذلك، أعني أنّها تقيم فوق الجنوبيين أكثر.

[٧هـ] واعلم أنّ **معظم العمارة في طرف الشمال يقع بين ما يجاوز عشر درجات في العرض إلى حدود الخمسين.** وأ**هل الصناعة** قسّموا معظم المعمور من الربع المسكون سبعة أقسام **طولاً ليكون كلّ**§ [xxv] **إقليم تحت مدار، فتتشابه أحوال البقاع التي فيه.** ومنهم من قسّم المعمور كذلك، وسمّوا كلّ قسم منها إقليماً، وهو قطعة من الأرض حاصرة لبعض البلاد، محصورة[٤٢] فيما بين نصفي دائرتين متوازيتين، /بينهما بُعد سنذكره،/* [xxvi] وموازيتين لخطّ الاستواء، /إن لم تكن إحداهما هو./* [xxvii] **فإذن كلّ إقليم يمتدّ بين الخافقين طولاً،** على شكل نصف دُفّ، أحد طرفيه أضيق من الطرف الآخر، لأنّ الأقاليم متفاوتة الأطوال. فالذي على خطّ الاستواء أطول من الذي بعده. فيكون طول الإقليم الواحد من جهته الجنوبية أكثر من طوله من جهته الشمالية. وأقلّها طولاً الجانب الذي يلي الشكل الطبلي الذي لا عمارة فيه، /لأنّ الدوائر الموازية للمعدّل بل لخطّ الاستواء كلّما أزداد عنه بعداً أزدادت صغراً./* [xxviii] ويظهر من هذا أنّ مقادير درجات الطول تقلّ بالبعد عن خطّ الاستواء. ولهذا فإن طول ما يلي خطّ الاستواء بالأميال عشرة آلاف ومائتا ميل، وما يلي الطبلي بها أربعة آلاف وثمانون ميلاً تقريباً. وأمّا مقادير درجات العرض، فيتّفق في جميع المواضع، لأنّ دوائر أنصاف النهار بمنزلة دائرة واحدة. وأمّا عرض كلّ إقليم، فهو قدر قليل، **وهو ما يوجب تفاضل نصف ساعة في مقدار النهار الأطول** في أوساط الأقاليم، وربع ساعة فيما بين الأوّل والأوسط، وبين الأوسط والآخر، إلّا أوّل الإقليم الأوّل وآخر الإقليم الآخر، فإنّه يكون أكثر من هذا القدر لتفرّق العمارة فيهما.

[xxv] كلّ] + قسم اى: هار، هاك، هال

[xxvi] بينهما بُعد سنذكره] هاب، هاك

[xxvii] إن لم تكن إحداهما هو] هاب، هاك

[xxviii] لأنّ الدوائر الموازية للمعدّل بل لخطّ الاستواء كلّما أزداد عنه بعداً أزدادت صغراً] هاب، هاك

[٨أ] فـمبادئ **الأقاليم وأوساطها بحسب العرض وساعات النهار الأطول هي هذه: أمّا** الإقليم **الأوّل، فمبدؤه**[٤٣] **حيث النهار الأطول اثنتا عشرة ساعة ونصف وربع، وعرضه اثنتا عشرة درجة وثلثا درجة، ووسطه حيث النهار ثلاث عشرة والـعرض ستّ عشرة درجة ونصف وثمن.** /فيأخذ في الطول من المشرق وأرض الصين ويمرّ على بحار الصين، وهي أنهار عظيمة يصعد منها السفن من البحر إلى الفرضة، ثمّ على سواحل البحر الجنوبي، وبعض البلاد الجنوبية في الهند والسند، ثمّ في البحر على جزيرة كرك ـــ التي واليها من قبل ملك اليمن ويأخذ العشر من المراكب التي تمرّ عليها ـــ ثمّ على خليج فارس وجزيرة العرب، ثمّ على الطرف الجنوبي في أرض الحجاز وعلى أكثر بلاد اليمن، مثل الميد ومدينة الطيب ومُعَلّا وحضرموت وصنعا ومارا وزَبيد وقَلْهات وظفار وشِهْر [كذا] وعدن، ثمّ على الخليج الأحمر وبلاد حبشة والسودان والنوبة مثل جَرْمى دار ملك الحبشة ودُنقُلة ومدينة النوبة، وغانة، معدن الذهب من بلاد سودان المغرب، ثمّ على بلاد البربر إلى المحيط المغربي./† [xxix]

[٨ب] **وأمّا الثاني، فمبدؤه**[٤٤] **حيث النهار ثلاث عشرة وربع، والعرض عشرون وربع وخمس، ووسطه حيث النهار ثلاث عشرة ونصف والعرض أربع وعشرون ونصف وسدس.** فيأخذ في الطول من بلاد الصين، ثمّ يمرّ بمعظم بلاد الهند ثمّ بشمال جبال معروفة في ديارهم، ثمّ ببلاد السند، ويصل إلى عمان ويقطع جزيرة العرب من أرض نجد وتهامةَ ويمرّ بالطائف ومكّة ومدينة ويثرب، ويقطع القلزم ويصل إلى صعيد مصر ويقطع النيل، ويأخذ في أرض المغرب ويمرّ بأوساط بلاد إفريقية ثمّ ببلاد البربر ويصل إلى المحيط.

[xxix] فيأخذ في الطول من المشرق ... ثمّ على بلاد البربر إلى المحيط المغربي] مضاف في: هامش ك، متن وهامش ل = ومن بلاده سودان المغرب وبعض من ولايات البربر واليمن وبلاد حبشة والزنج وجزائر الهنود إلى حد الصين: ب، شاك، طال

[٨ج] **وأمّا الثالث، فمبدؤه**[٤٥] **حيث النهار ثلاث عشرة ونصف وربع، والعرض سبعة وعشرون ونصف، ووسطه حيث النهار أربع عشرة والعرض ثلاثون وثُلثان.** فيأخذ من شرقي أرض الصين، وفيه دارُ ملكهم، ووسطُ مملكة الهند، وقَنْدهار الذي هو من عظام بلاد الهند، ومولتان من أرض السند، وزابل وبست وسيستان وكرمان وفارس وإصفهان وأهواز وعسكر والكوفة وبصرة وواسط وبغداذ والأنبار وهيت كلّها فيه. وإذا جاوز هذه البلاد، مرّ ببلاد جزيرة والشام وديار ربيعة ومُضَر ودمشق وحمص والصورية وطبرية وقيسارية وبيت المقدس وعَسقلان والمدين. ويقطع طرفاً من أرض مصر فيه دمياط وفُسطاط وإسكندرية، ثمّ يمرّ ببلاد إفريقية، وفيه بلد قيروان والسوس، ثمّ بقبائل[٤٦] البربر في أرض المغرب وببلاد طنجة وينتهي إلى المحيط.

[٨د] **وأمّا الرابع، فمبدؤه**[٤٧] **حيث النهار أربع عشرة وربع، والعرض ثلاث وثلاثون ونصف وثمن. ووسطه** — وهو وسط الأقاليم ووسط معظم عمارة العالم إذ الإقليم الثالث والرابع والخامس أكثر عمارة من غيرها، **حيث النهار أربع عشرة ونصف — والعرض ستّ وثلاثون وخمس وسدس.** فيبتدئ من شمال بلاد الصين ويمرّ ببلاد تُبت وخرخيز[٤٨] وخطا وختن وبجبال كشمير وبلور وبذخشان وكابل وغور، ثمّ بطخارستان وبلخ وهراة ومروشاهجان ومرروذ وسرخس وباورد ونسا وطوس ونيسابور وإسفرايين وقهستان وقومس والديلم وجرجان وطبرستان وقم وهمذان[٤٩] وآذربيجان وقزوين ونهاوند ودينور وحلوان وشهرزور والموصل وسامرة ونصيبين ورأس العين وقاليقلا[٥٠] وسُميساط وملطية وحلب وقنّسرين وأنطاكية وطرابلس وطرسوس، وببحر الشام على جزيرة قبرس وروذس، وبأرض المغرب على بلاد إفرنجة، وطنجة وينتهي إلى المحيط على الزقاق بين الأندلس وبلاد المغرب.

[٨هـ] **وأمّا الخامس، فمبدؤه**[٥١] **حيث النهار أربع عشرة ونصف وربع، والعرض تسع وثلاثون إلّا عُشر، ووسطه حيث النهار خمس عشرة، والعرض إحدى**[٥٢] **وأربعون وربع.** فيبتدئ من أقصى بلاد الترك ويمرّ على أجناس الترك المعروفين بقبائلهم إلى حدّ كاشغر وبلاساغون وفرغانة وطراز وإسپيجاب[٥٣] وچاچ وأسروشنة وسمرقند وسغد وبخارا وخوارزم وبحر خزر وديار أرمينية وبردعة وميّافارقين[٥٤] ودروب الروم، ثمّ بساحل بحر الشام وبلاد الروم وبلاد أندلس إلى أن ينتهي إلى المحيط.

[٨و] **وأمّا السادس، فمبدؤه**[٥٥] **حيث النهار خمس عشرة وربع، والعرض ثلاث وأربعون وربع وثمن، ووسطه حيث النهار**[٥٦] **خمس عشرة ونصف، والعرض خمس وأربعون وربع وعُشر.** ومن بلاده معظم الروم، والخزر والتركستان وولاية أصناف طوائفهم. فيبتدئ من المشرق ويمرّ بمساكن أتراك المشرق وقبائلهم، ويقطع وسط بحر جرجان ويمرّ على خزر وموقان وعلى الصقالبة وألّان وباب الأبواب والروس ثمّ ببلاد الروم مثل قسطنطينية وشمال الأندلس وينتهي إلى المحيط.

[٨ز] **وأمّا السابع، فمبدؤه**[٥٧] **حيث النهار خمس عشرة ونصف وربع،**[٥٨] **والعرض سبع وأربعون وخمس، ووسطه حيث النهار ستّ عشرة، والعرض ثماني** [كذا] **وأربعون ونصف وربع وثمن. وآخره حيث النهار ستّ عشرة وربع، والعرض خمسون وثُلث. وآخر كلّ إقليم ما عداه أوّل الذي يليه.** وهو يبتدئ أيضاً من المشرق، ويمرّ بنهايات أتراك الشرق وقبائلهم وبشمال بلاد يأجوج ومأجوج ثمّ على غياض وجبال يأوي إليها أتراك كالوحوش، ثمّ على بلغار والروس والصقالبة، ويقطع بحر اَلَمان[٥٩] والصقالبة، وينتهي إلى المحيط. وأهل بعض هذه البلاد يسكنون مدة ستّة أشهر في الحمّامات لشدّة البرد.

[٨ح] وما وراء هذه المواضع وما دونها لا يُعدّ أقاليم، إلّا عند **قوم جعلوا مبدأ الإقليم الأوّل خطّ الاستواء** ـــ حيث النهار الأطول اثنتا عشرة ساعة، ووسطه، على ما كان، أعني حيث النهار الأطول ثلاث عشرة ساعة، والعرض ستّ عشرة

درجة ونصف[٦٠] وثمن ـــ **وجعلوا آخر السابع منتهى العمارة.** وإنّما جُوّز كون ما بين أوّل الأوّل ووسطه أكثر من وسطه إلى آخره لتفرّق العمارة، كما مرّ، ولذلك أيضاً جُوّز كون ما بين أوّل الآخر ووسطه أقلّ من وسطه إلى آخره.

[٨ط] ويبتدئ خطّ الاستواء من شرقي أرض الصين فيمرّ على جزيرة يسمّيها الهنود جمكوت، ثمّ ببلاد الصين ممّا يلي الجنوب وعلى دزكنك، الذي هو من /حساب الصين، ثمّ على جزائر زاوة، التي تسمّى أرض الذهب، وعلى جنوب جزيرة سرنديب، بين جزيرتي كلّة وسربزة، وفي وسط جزائر ديوة، وعلى شمال جزائر الزنج وشمال معظم بلادهم. وإذا جاوز حدود الزنج، مرّ بصحاري السودان وبواديهم ثمّ على شمال جبال القمر وجنوب سودان المغرب إلى أن يصل إلى البحر المحيط المسمّى أوقيانوس./[†] [xxx]

[٨ى] فهذا تلويح إلى بعض بلدان الأقاليم تشويقاً للمتعلّمين.

[٩] واعلم أنّ **النهار الأطول يبلغ سبع عشرة ساعة حيث العرض أربع وخمسون درجة وكسر؛ ويبلغ ثماني عشرة حيث العرض ثمان وخمسون؛ ويبلغ تسع عشرة حيث العرض إحدى وستّون؛ ويبلغ عشرين حيث العرض ثلاث وستّون ـــ** وهناك جزيرة تسمّى تولي يقال أنّ أهلها يسكنون الحمّامات لشدّة بردها ـــ **ويبلغ إحدى وعشرين حيث العرض أربع وستّون ونصف؛ ويبلغ اثنتين وعشرين حيث العرض خمس وستّون وكسر؛ ويبلغ ثلاثاً وعشرين حيث العرض ستّ وستّون؛ ويبلغ**

[xxx] حساب الصين ثمّ على جزائر زاوة... وجنوب سودان المغرب إلى أن يصل إلى البحر المحيط المسمّى أوقيانوس] هاك، مضاف في المتن: ل = حسابه وعلى سواحل بحر الجنوب وعلى الأنهار التي منها يصعد السفن من البحر ثم على بلاد الهند وجزيرة سرنديب ثم بلاد السند ثم في البحر على جزيرة كرك التي واليها من قبل ملك اليمن ويأخذ العشر من المراكب التي تمر عليها ثم يقطع البحر إلى جزيرة العرب وإلى اليمن فيقع فيه من بلاد اليمن ما كان جنوبياً مثل صنعا وظفار وحضرموت والعدن ثم يقطع خليج البحر الأخضر فيمر ببلاد الحبشة والسودان وفيه مدينة النوبة واسقوطرة ثم يمر في المغرب على بلاد البربر إلى أن ينتهي إلى البحر المحيط: ب، ك («حسابه»: شاك)، طال

أربعاً وعشرين حيث العرض مثل تمام الميل كلّه. ويبلغ شهراً حيث العرض سبع وستّون وربع، وشهرين حيث العرض سبعون إلّا ربع، وثلاثة أشهر حيث العرض ثلاث وسبعون ونصف، وأربعة أشهر حيث العرض ثماني [كذا] **وسبعون ونصف، وخمسة أشهر حيث العرض أربع وثمانون، ونصف السنة** تقريباً **حيث العرض ربع الدور.**

[١٠] ولنشرع الآن في خواصّ البقاع التي تحت **المدارات** اليومية وما يجري مجراها كالمعدّل والقطبين ـــ بعون الله وحسن توفيقه.

الباب **الثاني**

في خواصّ خطّ الاستواء

[١] **البقاع التي تكون على خطّ الاستواء** يمرّ معدّل النهار بسمت رؤوسهم فيقطع آفاقهم على قوائم، لما تقدّم في هـَ.[٦١] ويكون أوّل السموت هو المعدّل، وقطباه على نقطتي الشمال والجنوب من الأفق، لما تقدّم في دَ.[٦٢] فلا يكون هناك كوكب أبدي الظهور ولا أبدي الخفاء، بل يكون لجميع الكواكب طلوع وغروب إلّا ما كان على نفس القطبين فإنّه يكون أبداً نصف منه لا بعينه ظاهراً ونصفه الآخر خفياً. ولأنّ السطح المارّ بمركز الدائرة ينصّفها، وآفاقهم **مارّة بقطبي معدّل النهار،** بل على المحور الذي عليه مراكز المدارات اليومية، فـ**آفاقهم تنصف جميع المدارات اليومية،** حتّى يكون الظاهر منها[٦٣] أبداً نصفها، وهو قوس النهار، وكذا الخفي وهو قوس الليل. **فلذلك يكون النهار والليل في جميع السنة متساويين.** وكذا **زمان ظهور كلّ نقطة على الفلك مساوياً لزمان خفائه؛ فإن كان تفاوت كان بسبب اختلاف السير بالحركة الثانية في النصفين،** مثل سرعة حركة الشمس فيما بين مكثها فوق الأرض ومكثها تحت الأرض: فإذا كانت فوق الأرض أسرع كان مكثها هناك أعظم والنهار أطول من الليل؛ وإن كانت تحتها أسرع كان المكث هناك أعظم والليل أطول من النهار، لكن **ذلك لا يكون محسوساً. وتمرّ الشمس في السنة مرّتين بسمت رؤوسهم، وذلك عند كونها في نقطتي الاعتدالين.** ولا يكون لها ظلّ، أعني الظلّ المنبسط على سطح الأفق، وقت انتصاف النهار،[٦٤] واعتبر هذا حيث أطلقنا الظلّ فإنّه المراد. ويكون ارتفاع الشمس في اليومين الارتفاع الذي لا سمتَ له. **ولا تبعد** الشمس **عن سمت رؤوسهم إلّا بقدر غاية ميل فلك البروج عن معدّل النهار، فلا تنقص غاية ارتفاعها عن تمام الميل كلّه. وتكون الشمس نصف السنة** /تقريباً/[i] **في كلّ جهة وظل نصف النهار إلى خلاف تلك**

---

[i] تقريباً] هاب، هاك، هال

الجهة. ويكون ظلّا أوّل الصيف والشتاء متساويين، وغايته ستّ وعشرون جزءاً ونصف على أنّ المقياس ستّون جزءاً. **وقطبا البروج يكونان على الأفق عند كون إحدى نقطتي الاعتدالين على** السمت، **وهناك يكون قطع** فلك **البروج** الـ**أفق على قوائم،** لما تقدّم في دَ،[٦٥] وينصّف حينئذ نصف النهار النصف الظاهر من فلك البروج، لما تقدّم في حَ.[٦٦] فإن كان[٦٧] ما على السمت الاعتدال الربيعي، كان القطب الشمالي من قطبي البروج على أفق الغرب يُريد الغروب، والآخر على أفق الشرق يريد الطلوع؛ وإن كان[٦٨] الخريفي، كان بالعكس. فـ**في مدّة مرور النصف الشمالي من المنطقة على نصف النهار يكون الظاهر من قطبي البروج جنوبيهما، وفي مدّة مرور النصف الجنوبي يكون الظاهر شماليهما؛ ولا يزيد ارتفاعهما** ولا انحطاطهما **على قدر الميل الكلّي.** فيستوي غايتا ارتفاعهما وانحطاطهما عن الأفق. ويكون غاية ارتفاع القطب الشمالي وغاية انحطاط الجنوبي إذا كان المنقلب الجنوبي على نصف النهار؛ فإن كان على نصف النهار المنقلب الشمالي كان غاية انحطاط الشمالي وغاية ارتفاع الجنوبي. **ولكون مبدأ الصيف الوقت الذي تكون فيه الشمس إلى سمت الرأس أقرب ومبدأ الشتاء الوقت الذي تكون فيه منه أبعد، يكون وقت كونها في نقطتي الاعتدال مبدأ صيفهم ووقت كونها في نقطتي الانقلاب مبدأ شتائهم. وتكون مبادئ الفصلين الآخرين** أواسط **الأرباع؛** فمبدأ الربيع أواسط الأسد والدلو، ومبدأ الخريف أواسط الثور والعقرب. **فيلزم على ذلك أن يكون لهم في سنة ثمانية فصول. ويكون دور الفلك هناك دولابياً لأنّ سطوح جميع المدارات** اليومية **تقطع سطح الأفق على قوائم،** لما تقدّم في دَ،[٦٩] **ولذلك** سميّت **آفاقها بآفاق الفلك المستقيم** وآفاق الكرة المنتصبة. **ولكون دائرة الأفق** هناك **إحدى دوائر الميول،** لمرورها بقطبي المعدّل، **تكون سعة مشرق كلّ نقطة، وهي القوس التي تكون من الأفق بين مطلعها ومطلع معدل النهار، بقدر ميلها؛ وكذلك سعة المغرب.**

[٢أ] وههنا بحث، وهو أن الكلّ اتّفقوا على **أنّ أحرّ البقاع صيفاً هي التي** تحت مداري المنقلبين، أعني التي **عروضها مساوية للميل الكلّي،** إذا لم تعارضها أسباب أرضية تنقص من حرارتها، واختلفوا في أنّ أعدل البقاع ما هي. فذهب **الشيخ الرئيس أبو علي بن سينا** إلى أنّه خطّ الاستواء؛ **والإمام** العلّامة أفضل المتأخرين **فخر الدين الرازي** إلى أنّه الإقليم الرابع. ولنقدّم قبل الخوض فيه مقدّمة هي أنّ شدّة السخونة قد تكون لقوّة المسخن وقد تكون لدوام إسخانه وإن كان ضعيفاً، والمؤثّر الضعيف قد يصير أثره أقوى إذا كان زمانه أكثر من زمان المؤثّر القوي؛ بحجّة لمّية هي أنّ المؤثّر في الزمان الأوّل يُفيد أثراً وينضمّ إليه في الزمان الثاني أثر آخر ولا شكّ أنّ مجموع الأثرين أقوى من أثر واحد، أو لأنّ المؤثّر يفيد في الوقت الأوّل أثراً فإذا بقي إلى الوقت الثاني اشتدّ الاستعداد، فكان الأثر أقوى؛ وخمس إنّيات: الأوّل زيادة حرّ الشمس عند كونها في الأسد مع بعدها عنّا عليه وهي في المنقلب مع قربها منّا؛ الثاني زيادته عند كونها في الأسد والسنبلة عليه وهي في الثور والحمل؛ الثالث زيادته بعد الزوال بساعتين عليه قبله بساعتين مع تساوي بعدها عنّا في هاتين الصورتين؛ الرابع زيادة حرّ الجسم في نار ضعيفة ساعة عليه وهو في نار قوية لحظة؛ الخامس زيادة البرد في الأسحار عليه في نصف الليل مع أنّ الشمس حينئذ أبعد. /هذا هو المشهور لكن لا يخفى أنّ اللمّية إنّما تدلّ على أنّ شدّة السخونة قد تكون لدوام إسخان المسخن وإن كان ضعيفاً؛ والأوّل والرابع والخامس على أنّ المؤثّر الضعيف قد يصير أثره أقوى إذا كان زمانه أكثر من زمان المؤثّر القوي؛ وأمّا الثاني والثالث فلا يدلّان على شيء منها وإن كان في المشهور يُذكر الستّة لبيان القضية الثانية فاعرفه./[ii †]

[٢ب] وإذا عرفتَ ذلك، فاعلم أنّ الكلّ استدلّوا على كون البقاع التي تحت مداري المنقلبين أحرّ البقاع، **بـأنّ الشمس تسامتها وتلبث في قرب مسامتتها قريباً من شهرين،** لتناقص تفاضل ازدياد الميول لما تقدّم في يب،[٧٠] ولهذا لا يظهر

[ii] هذا هو المشهور... لبيان القضية الثانية فاعرفه] هاب، هاك، هال

لها حركة في الميل أيّاماً عند المنقلبين فتكون الشمس كالواقف على سمت رؤوسهم المدّة المذكورة، وبأنّ **نهارها** الصيفية **يطول وليلها يقصر؛** وعلى التقديرين يشتدّ التسخين فيها أكثر ممّا في غيرها من البقاع لأنّ هاتين العلّتين لا تجتمعان في غيرها.[٧١] وقول من قال الأوّل، معارض بحصول أسباب البرد فيما قبل ذلك من السنة لبعد الشمس عن سمت رؤوسهم، مع أنّ من المعلوم أنّ تسخّن البارد أضعف بكثير من تسخّن غيره؛ والثاني بأنّ طول لياليهم الشتوية يوجب زيادة البرد فالمقابلة حاصلة بينهما مدفوع، لما سيظهر في خلال ما نذكره.

[٢ج] واحتجّ الشيخ على مدّعاه بـ**أنّ الشمس لا تلبث على سمت الرؤوس هناك كثيراً بل إنّما تمرّ به وقتي اجتيازها عن إحدى الجهتين إلى الأخرى وتكون هناك حركتها في الميل أسرع ما تكون،** لما تقدّم في يب، فإنّها هناك تبعد عن المعدّل في كلّ يوم خمساً وعشرين دقيقة، **فلا تكون لذلك حرارة صيفهم شديدة،** لأنّ دوام /ما هو في حكم/[†] [iii] المسامتة أبلغ في التسخين من نفس المسامتة، لما تقرّر في المقدّمة. ولقائل أن يقول هذا يدلّ على أنّ خطّ الاستواء ليس أحرّ من البقاع التي تحت مداري المنقلبين، لا على أنّه ليس أحرّ من الإقليم الرابع وغيره الذي هو المطلوب؛ و**أيضاً** بأنّ **تساوي نهارهم وليلهم** يوجب اعتدال الزمان لانكسار **سَورة كلّ واحدة من الكيفيتين الحادثتين منهما بالآخر سريعاً** ـــ بخلاف غيرهم لطول نهرهم[٧٢] وقصر لياليهم ـــ ولأنّ الهواء لا يتضادّ عليهم تضادّاً محسوساً لأنّ الشمس حين تسامتهم لا تسامتهم،[٧٣] وقد بعدت عنهم كثيراً بل بعد أن كانت على قرب مسامتتهم، فكأنّهم منتقلون دائماً من حال إلى ما يُشبهها، بخلاف غيرهم فإنّهم كالمنتقلين من ضدّ إلى ضدّ لغاية تباعد الشمس عنهم؛ ومن قال طول النهار لا يؤثّر في زيادة الحرّ وإلّا كان الحرّ حيث النهار ستّة أشهر كثيراً والوجود بخلافه، ولأنّ البرد يستحكم فيهم بسبب طول الليل شتاءً فلا يتأثّرون بحرّ طول النهار صيفاً، إخطاء. أمّا الأوّل،

[iii] ما هو في حكم] هاب، هاك، هال

فلأنّا لا نُسلّم أنّ الوجود بخلافه إذ المعلوم عدم العمارة ثمّة، إمّا إنّه لشدّة البرد أو لشدّة الحرّ فغير معلوم، سلّمناه؛ لكن لا نُسلّم لزوم كون الحرّ هناك كثيراً. فإنّ العلّة ليست هي طول النهار فقط، بل هو مع قرب الشمس من السمت، لتكاثف[٧٤] الأشعّة[§] [iv] لانعكاسها على زوايا حادّة جدّاً فيقوى التسخين، على ما بُيّن في الجزء الطبيعي من الفلسفة، وفي عرض تسعين، لغاية بعد الشمس عن السمت، لا تنعكس أشعّتها على زوايا حادّة جدّاً، بل على زوايا منفرجة، فلا تتكاثف الأشعّة بل تتخلخل وتسخف فيضعف التسخين. /والوضع الطبيعي والنظم المألوف أن يُقدَّم هذا المنع لكونه منع الملازمة على الأوّل لكونه منع نفي التالي، لكن كذا وقع ولا تفاوت بعد اتّضاح المعنى./[‡] [v] وأمّا الثاني، فلأنّ المزاج الذي استحكم البرد فيه هو أشدّ تأثراً من الحرّ من الذي لم يستحكم فيه، فضلاً من الذي اعتاد الحرّ. ولهذا فإنّ المغافص من خارج شتاءً في البيت المعتدل من الحمّام يستسخن هواؤه، والمغافص من البيت الحارّ إليه يستبردها، مع أنّ ألف كلّ منها ساعة، فكيف إذ ألفوه مدة أكثر.[٧٥]

[٣] وردّ الإمام العلّامة على الشيخ قائلاً أنّ تسخين الشمس في البلدة التي عرضها ضعف الميل الكلّي كتسخينها في خطّ الاستواء إذا كانت في غاية الميل، لكن تسخينها في البلدة المفروضة شديد جدّاً فكذا في خطّ الاستواء بل أشدّ؛ لأنّ **لبث الشمس في خطّ الاستواء ـــ وإن كان قليلاًــــ لكنّها لا تبعد كثيراً عن المسامتة، فهي طول السنة في حكم المسامتة،** بخلاف البلدة المفروضة فإنّها تبعد عنها كثيراً، وإذا كان حال حرّ شتاء[٧٦] خطّ الاستواء ذلك فما ظنّك بحرّ صيفهم، فثبت أنّ الحرّ هناك عظيم جدّاً. ثمّ **حكم بأنّ أعدل البقاع الإقليم الرابع.** واستُدلّ له بأنّ **توفّر العمارات وكثرة التوالد والتناسل في**

[iv] الأشعّة] + حينئذ: هار، هاك، هال

[v] والوضع الطبيعي... بعد اتّضاح المعنى] - ب، هاك، هال

الأقاليم السبعة دون سائر المواضع المنكشفة من الأرض يدلّ على كونها أعدل من غيرها. وما يقرب من وسطها يكون لا محالة أقرب إلى الاعتدال **ممّا على أطرافها، فإنّ الاحتراق والفَجاجة اللازمين من الكيفيتين ظاهران في الطرفين.** ورُدّ على الإمام المذكور بأنّا[٧٧] لا نسلّم أن الحرّ في البلدة المفروضة وقت كون الشمس في المنقلب كحرّ خطّ الاستواء بل الحرّ في البلدة المفروضة أكثر لطول نهارهم وقصر ليلهم، بخلاف من على خطّ الاستواء، ولأنّ المألوف لا يُؤثِر، فلعلّهم لإلف مزاجهم بالحرارة، يستبردون الهواء والشمس في المنقلب، بخلاف البلدة المفروضة لعدم إلف مزاجهم بالحرارة؛ ولا يستحرّون الهواء وهي في سمت رؤوسهم للإلف، بخلاف البلدة المذكورة لعدمه.

[٤] **والحقّ في ذلك أنّه إن عُني بالاعتدال تشابه الأحوال فلا شكّ أنّه في خطّ الاستواء أبلغ** بخلاف الإقليم الرابع. **وإن عُني به تكافؤ الكيفيتين فلا شكّ أنّـ**ـه في الإقليم الرابع أبلغ بخلاف خطّ الاستواء ـــ **يدلّ عليه شدّة سواد لون سكّانه من أهل الزنج والحبشة وشدّة جُعودة شعورهم وغير ذلك ممّا تقتضيه حرارة الهواء. وأضداد ذلك في أهل**[٧٨] **الإقليم الرابع تدلّ على كون هوائه أعدل.**

الباب **الثالث**

في خواصّ المواضع التي لها عرض على وجه كلّي **وتُسمّى بالآفاق المائلة**

وفي سعة المشرق والمغرب وتعديل النهار

[١] **كلّ موضع** لا يكون تحت معدّل النهار ولا تحت أحد قطبيه، بل **يكون تحت أحد المدارات اليومية بين خطّ الاستواء وأحد قطبي الحركة، يكون دور الفلك هناك حمائلياً،** لميل المعدّل على الأفق في جهة القطب الخفي وميل الأفق عنه في جهة القطب الظاهر، ولهذا سُمّيت بالآفاق المائلة، لا لميل المعدّل عن السمت، على ما قيل، فإنّه لا يناسبه ظاهراً. وهي خمسة أقسام، لأنّ العرض إمّا أقلّ من الميل الكلّي؛ أو مساوٍ له؛ أو أكثر منه وأقلّ من تمام الميل؛ أو مساوٍ لتمامه؛ أو أكثر منه وأقلّ من الربع. وعلى الأقسام **يكون ارتفاع القطب الذي يكون في الجهة التي مال الموضع إليها بقدر عرض البلد، و**يكون **بُعد المدارات الأبدية الظهور والأبدية الخفاء عن معدّل النهار أكثر من تمام عرض البلد،** /إلّا **بُعد أعظمها** وهو **الذي يماسّ الأفق** فإنّه مساوٍ لتمام العرض، وتكون/* [i] غاية ارتفاع الكوكب الأبدي الظهور أن يصل إلى التقاطع الفوقاني بين مداره ونصف النهار، وغاية انحطاطه أن يصل إلى التقاطع الآخر.* [ii] **وسائر المدارات،** /وهي التي بعدها أقلّ من تمام عرض البلد،/* [iii] **ينقسم بالأفق إلى مختلفين، أعظمها الظاهر فيما هو إلى القطب الظاهر أقرب** /وفي جهته،/* [iv] **والخفي** فيما هو إلى القطب الخفي أقرب /وفي جهته،/* [v] لا الخفي **فيما هو أبعد** من القطب الظاهر، على ما قيل، فإنّه لا يصحّ /إلّا أن يُقيّد بما

[i] إلّا بُعد أعظمها وهو الذي يماسّ الأفق فإنّه مساوٍ لتمام العرض وتكون] هاب، هاك

[ii] الآخر] + ويكون بعد أعظمها وهو الذي يماسّ الأفق مساوياً لتمام العرض: شاب، شاك

[iii] وهي التي بعدها أقلّ من تمام عرض البلد] هاب، هاك

[iv] وفي جهته] هاب، هاك

[v] وفي جهته] هاب، هاك

قلنا./* [vi] **ويتساوي القسمان على التبادل في كلّ مدارين متساويي**[٧٩] **البعد عن معدّل النهار** في جهتيه. وكلّ مدارين في جهة يكون الظاهر من الأقرب إلى المعدّل أصغر من /ظاهر/* [vii] الأبعد منه إن كان في جهة القطب الظاهر، وبالعكس إن كان في جهة القطب الخفي؛ والخفي فيهما بالضدّ. ولهذا كلّما بعدت الشمس عن المعدّل في جهة القطب الظاهر كانت زيادة النهار على الليل أكثر وبالعكس في جهة القطب الخفي،[٨٠] لكون نقصان النهار عن الليل أكثر. وكان أقصر أيام النصف الذي يتوسّطه[٨١] المنقلب الذي يلي القطب الظاهر أطول من أطول لياليها؛ وأطول أيام النصف الآخر أقصر من أقصر لياليها. وكلّما كان عرض البلد أكثر، كان مقدار التفاوت بين الليل والنهار أكثر، لازدياد ارتفاع القطب الظاهر والمدارات التي تليه وازدياد فضل قسيها الظاهرة على الخفية وازدياد انحطاط القطب الخفي والمدارات التي عنده، فيزداد فضل قسيها الخفية على الظاهرة. **و**يكون **تزايد النهار** وتناقص الليل **إلى رأس المنقلب الذي يلي القطب الظاهر وتناقص** النهار وتزايد الليل **إلى رأس المنقلب الآخر.** ويكون نهار كلّ جزء مساوياً لليل نظيره وبالعكس، كنهار أوّل السرطان لليل أوّل الجدي/وبالعكس./‡ [viii] وكلّ جزئين يتساوي بعدهما عن المعدّل في جهة كأوّل الثور والسنبلة يتساوي نهارهما وليلهما. **ولا يكون النهار مساوياً لليل إلّا عند كون الشمس في نقطتي الاعتدالين** عند طلوعها أو غروبها. فإنّها إذا طلعت، /وهي/* [ix] على المعدّل سائرة من المنقلب الصيفي مثلاً، فليلة ذلك الطلوع مساوية لنهاره؛ وإن[٨٢] غربت، /وهي/* [x] على المعدّل، كان يوم الغروب مساوياً لليلته؛ وإذا

[vi] إلّا أن يُقيّد بما قلنا] هاب، هاك

[vii] ظاهر] هاب، هاك

[viii] وبالعكس] - ب، - ك، هال

[ix] وهي] هاب، فاك

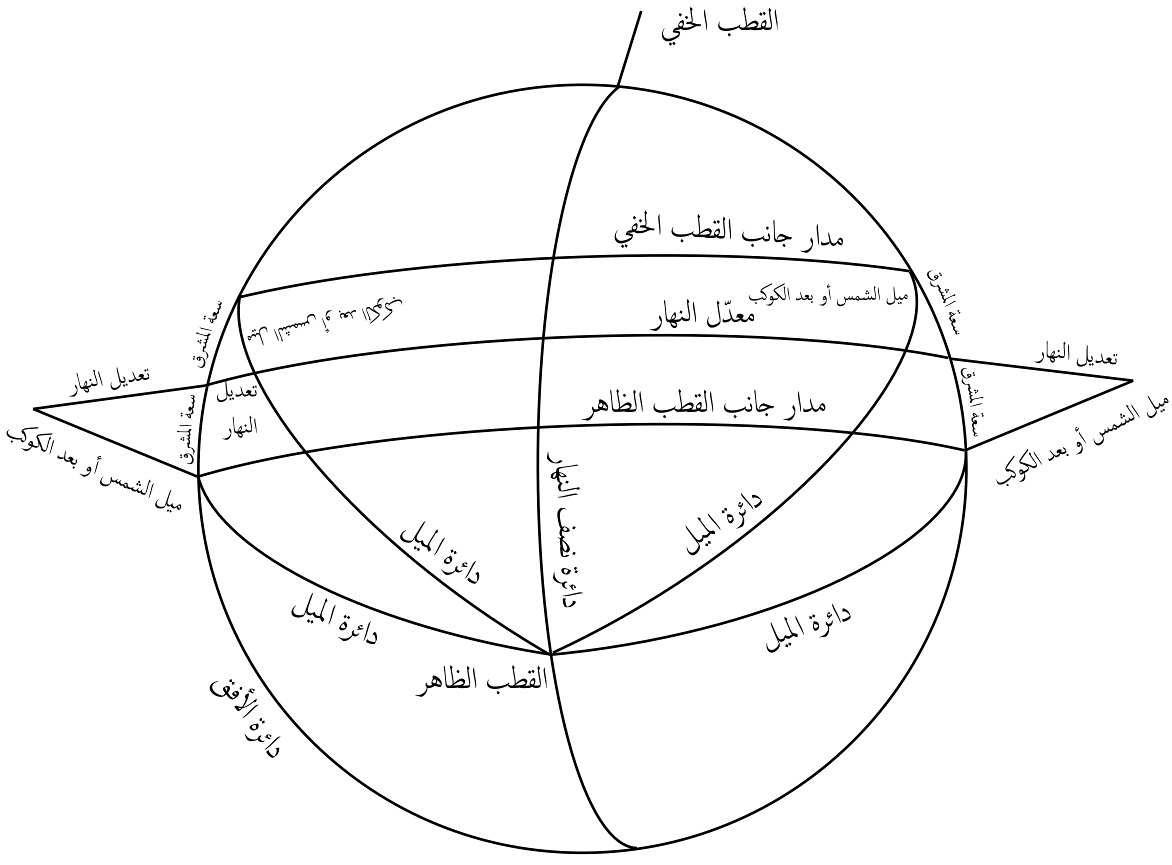
[x] وهي] هاب، فاك

طلعت وغربت في يوم وكان بعدها في الوقتين من أحد المنقلبين متساوياً،[٨٣] كانت[٨٤] في المنقلب عند انتصاف النهار؛ وإن لم يتساوَ بعدُها في الوقتين لم تنزل الانقلاب عند انتصاف النهار. وتقوم الدوائر المارّة بقطبي[٨٥] الكلّ على الأفق على قوائم في كلّ دورة مرّتين، وكذا منطقة البروج على نصف النهار. ولا تقوم على الأفق إذا كان قطب الأفق بين القطب الظاهر ومدار المنقلب الذي يليه؛ وقامت عليه في كلّ دورة مرّة إذا كان قطبه على أحد مداري المنقلبين؛ ومرّتين إن كان القطب بينهما. ومن خطّ الاستواء إلى عرض يساوي الميل الكلّي يكون ذا ظلّين، أي يقع ظلّ نصف النهار تارة إلى الشمال وتارة إلى الجنوب؛ /وفي هذا العرض قد لا يكون في نصف النهار ظلّ؛/‡ [xi] ومن هذا العرض إلى عرض تسعين يكون ذا ظلّ واحد، وهو إلى جهة القطب الظاهر.

[٢] **وكلّ مدار يكون بعده**[٨٦] **عن معدّل النهار** مثل عرض البلد، فإن كان **في جهة القطب الظاهر،** مرّ **بسمت الرأس** وماسّ **دائرة أوّل السموت فوق الأرض؛** وإن كان في جهة القطب الخفي، مرّ بسمت الرجل وماسّها أيضاً. **وكلّ ما يكون بُعده أكثر من ذلك فهو لا يلاقي دائرة أوّل السموت** بل **يمرّ عن سمت الرأس في جهة القطب الظاهر،** أو[٨٧] عن سمت الرجل في جهة القطب الخفي؛ **وكلّ ما يكون بُعده أقلّ من ذلك فهو يقطع أوّل السموت على نقطتين إحداهما شرقية والأخرى غربية. ويكون الكوكب ما دام** في القوس من مداره التي تقع بين **أوّل السموت** والمعدّل، **في جهة القطب الخفي** عن أوّل السموت، إن كان المدار في جهة القطب الظاهر؛ وفي جهة القطب الظاهر عن أوّل السموت، إن كان المدار في جهة القطب الخفي. ومن هذا يظهر أنّه لا يصحّ قول من قال **ويكون الكوكب ما دام بين النقطتين عن دائرة أوّل السموت في جهة القطب الخفي.**

[xi] وفي هذا العرض قد لا يكون في نصف النهار ظل] - ب، - ك، هال

[٣] وإذا فُرضت دائرتا ميل تمرّان بالنقطتين اللتين عليهما يتقاطع مدار الشمس أو كوكب من الكواكب والأفق، حدث مثلّثان بين الدائرتين والأفق ومعدّل النهار، أحدهما شرقي والآخر غربي. أحد أضلاع كلّ واحد منهما ميل الشمس أو بُعد[٨٨] **الكوكب عن معدّل النهار وهو الذي يكون من دائرة الميل، وثانيها سعة مشرق الشمس أو الكوكب وهو الذي يكون من دائرة الأفق، وثالثها تعديل نهار الشمس أو الكوكب وهو الذي يكون من معدّل النهار. ويكون المثلّثـ**ان **في جانب القطب الظاهر تحت الأرض وفي جانب القطب الخفي فوقها.** وهذه صورته:

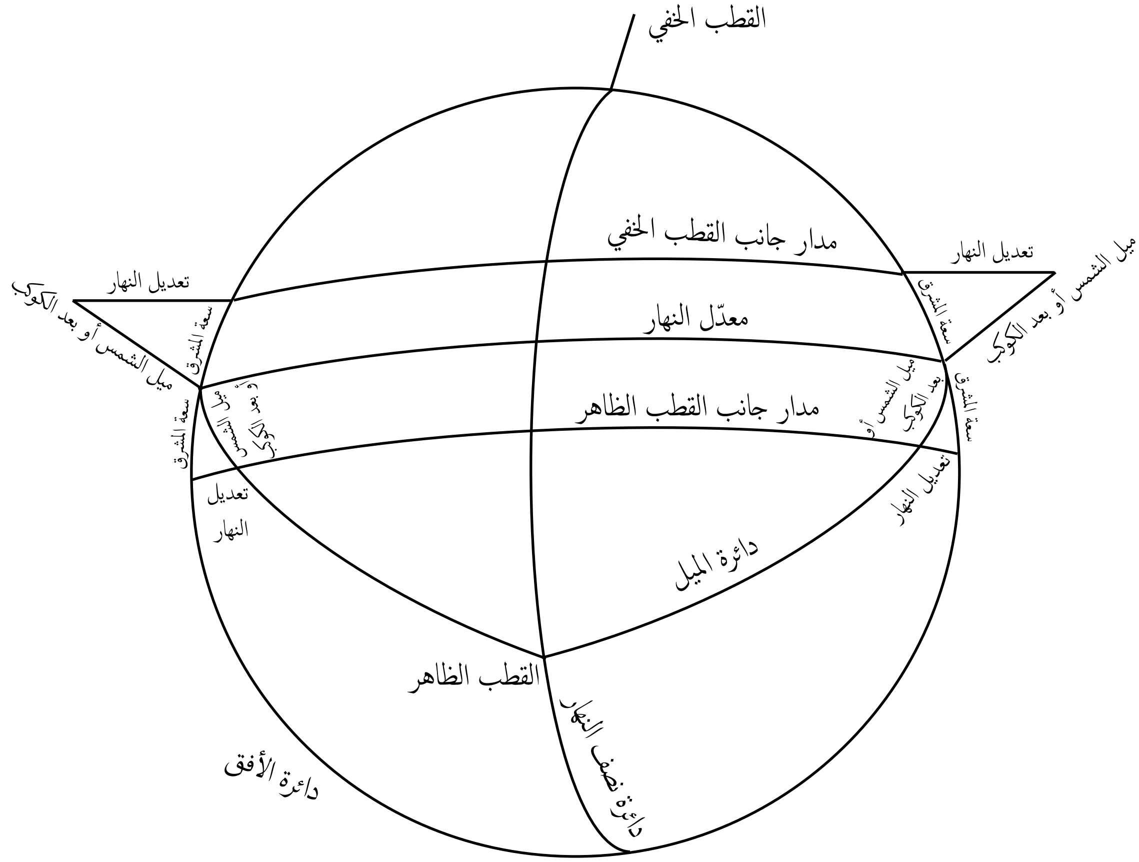


[شكل ١]

[۴] ومنهم من يفرض دائرة ميل واحدة تمرّ بمطلع الاعتدال ومغيبه. فيحدث منها ومن الأفق ومن كلّ مدار مثلّثان، أحدهما شرقي والآخر غربي. ويكونان فوق الأفق في جانب القطب الظاهر وتحته في الجانب الآخر. وسعة المشرق والميل بحالهما إلّا أنّ تعديل النهار، /على هذا الفرض،/† [xii] يكون من المدار؛ وفي الفرض الأوّل /كان/† [xiii] من المعدّل. وأضلاع المثلّث كلّها من الدوائر العظام على الفرض الأول، وعلى الثاني تعديل النهار من دائرة صغيرة والباقيان من العظام. ولا يختلف الحكم لأنّ هذه القوس من الصغيرة شبيهة بتلك القوس من المعدّل لكونهما بين دائرتي ميل تمرّ إحداهما[٨٩] بمطلع الاعتدال ومغيبه والأخرى بمطلع المدار أو مغيبه. وهذه صورته:

[xii] على هذا الفرض] هاب، هاك، هال

[xiii] كان] - ب، - ك، فال



[شكل ٢]

[٥] فقد ظهر بما[٩٠] ذكرنا أنّ سعة مشرق الكوكب أو الجزء من فلك البروج هي قوس من الأفق بين مدار الكوكب أو الجزء وبين مطلع الاعتدال؛ وسعة المغرب هي قوس من الأفق بين المدار ومغيب الاعتدال؛ وهي شمالية إن كان الكوكب أو الجزء شمالياً، وجنوبية إن كان جنوبياً. ولمّا كانت المدارات موازية لمعدّل النهار كانت سعة مشرق كلّ كوكب تساوي سعة مغربه، لا تحقيقاً على ما أُطلق القول فيه، بل تقريباً لحركة الكواكب.[٩١] فكلّ ما كانت حركته أسرع كان التفاوت بين سعة مشرقه ومغربه أكثر كما في القمر؛ وإن كانت أبطأ كان أقلّ كما في الشمس؛ وقس عليهما باقي الكواكب. وقد علمت ممّا[٩٢] سبق أنّ سعة مشرق كلّ جزء في خطّ الاستواء تساوي ميله، فتكون غاية سعة مشرق الشمس فيه تساوي الميل الكلّي.

وأمّا في غيره من الآفاق فتزيد بازدياد عرض البلد حتّى إذا ساوى العرض تمام الميل الكلّي كانت سعة مشرق أوّل الصيف ربعاً من الدور، كما سيجيء تحقيقه ــ إن شاء الله العزيز. وغاية سعة مشرق الشمس في الشمال هي سعة مشرق رأس السرطان، وفي الجنوب سعة مشرق رأس الجدي؛ وكذا سعة مغربها. وسعة مشرق كلّ ربع من الفلك تساوي سعة مشرق الربع الآخر أحدهما على الولاء والآخر لا على الولاء؛ وسعة مشرق الربعين الشماليين مثل سعة مشرق الربعين الآخرين؛ وسعة مشرق كلّ جزء مثل سعة مغرب نظيره. فالحاصل أنّ كلّ جزئين يتساوي بعدهما عن المعدّل، إمّا من جهة واحدة أو من جهتين، فإنّ سعة مشرقهما ومغربهما واحدة.

[٦] وقد ظهر أيضاً أنّ تعديل نهار الكوكب أو الجزء قوس من معدّل النهار بين مطلعه أو مغيبه وبين دائرة الميل المارّة بمقطع الأفق ومدار الكوكب أو الجزء؛ أو قوس من مدار الكوكب أو الجزء بين دائرة الأفق ودائرة الميل المارّة بمطلع الاعتدال ومغيبه. وبالاعتبار الأوّل يُعرف أيضاً بأنّها قوس من معدّل النهار بين دائرتين تمرّان بالكوكب أو الجزء إحداهما من قطب أوّل السموت والأخرى من قطب المعدّل يعنون بهما دائرة الأفق والميل، وقد يُعرف تعديل نهار الجزء بأنّه الفضل بين مطالعه بخطّ الاستواء وبين مطالعه بالبلد. والمراد من مطالع الجزء قوس من معدّل النهار بين رأس الحمل والجزء الذي يطلع منه مع ذلك الجزء. ولنمثّل لذلك مثالاً، فنقول: إذا كان رأس الجوزاء ممّا يلي المشرق في أفق غير خطّ الاستواء، وفرضنا دائرة من دوائر الميول تمرّ به وتقاطع معدّل النهار، حدث مثلّث. أحد أضلاعه ميل رأس الجوزاء. والضلعان الآخران قوسان بين دائرة الميل وبين نقطة الاعتدال الربيعية، إحداهما من فلك البروج وتسمّى بدرج السواء والأخرى من معدّل النهار وهو مطالع رأس الجوزاء بأفق خطّ الاستواء. وأفق البلد يقسّم هذا المثلّث إلى مثلثين. أحدهما تحت الأرض وتحيط به سعة

المشرق وميل رأس الجوزاء وقوس من معدّل النهار، هو تعديل نهار رأس الجوزاء في ذلك البلد، وهو الفضل بين مطالعه بخطّ الاستواء ومطالعه بالبلد، وهو القوس التي فوق الأرض من المعدّل إلى نقطة الاعتدال. ولمّا كانت الآفاق تختلف قطعها لمثل هذا المثلّث باختلاف عروض البلدان وجب أن تختلف المطالع باختلاف العروض. وسيجيء تفصيله ـــ إن شاء الله العزيز.

[٧] ولا يخفى بعد الإحاطة بما ذكرنا أنّ تعديل النهار هو نصف الفضل بين نهار الشمس أو الكوكب في البلد وبين نهار خطّ الاستواء أو نهار نقطة الاعتدال، أعني النهار المعتدل، لأنّ قوس نهار كلّ جزء في خطّ الاستواء مثل قوس نهار نقطة الاعتدال.[٩٣] /فإذن/†[xiv] في الآفاق المائلة[٩٤] /تزيد/†[xv] قوس نهار الجزء على قوس نهار نقطة الاعتدال بضعف تعديل النهار إن كان الجزء في جهة القطب الظاهر؛ وتنقص منه [كذا] بالضعف أيضاً إن كان في جهة القطب الخفي. ولهذا يُزاد تعديل النهار على ربع الدور لتحصيل نصف قوس النهار في جهة القطب الظاهر، وينقص منه لتحصيله في جهة القطب الخفي. ومن هذا يظهر أنّ تسمية هذه القوس بتعديل النهار مجاز لأنّه تعديل لنصف قوس النهار لا لكلّها. ونصف قوس نهار الكوكب أو الجزء قوس من المعدّل يطلع في نصف زمان ظهور ذلك الكوكب أو الجزء أو نصف القطعة الظاهرة من مداره، ونصف قوس الليل تمام هذه القوس إلى نصف الدور. ولا يخفى معرفة قوسي النهار والليل بعد معرفة أنصافها. هذا هو المشهور وفيه تحقيق سيجيء في موضعه ـــ إن شاء الله العزيز.

[xiv] فإذن] واما: ب = متغير من «واما»: ك، ل

[xv] تزيد] فيزيد: ب، ك = يزيد، متغير من «فيزيد»: ل

الباب **الرابع**

في خواصّ المواضع التي عروضها لا تـجاوز تمام الميل الكلّي

[١] وهي تنقسم أربعة أقسام، لما[٩٥] عرفت:

[٢] الأوّل ما يكون عرضها أقلّ من الميل الكلّي. في تلك المواضع تمرّ الشمس بسمت الرأس في نقطتين ميلهما يساوي عرض البلد في جهة القطب الظاهر؛ /ولا يكون للأشخاص في انتصاف النهار حينئذ **ظلّ**. وعند مرور إحدى النقطتين بالسمت/* [i] **تقوم منطقة البروج على الأفق على قوائم ويكون قطباها على الأفق** فتكون حينئذ دائرة ارتفاع الشمس، والكواكب التي عليها فوق الأرض /إن لم تكن الشمس والكوكب على إحدى النقطتين./* [ii] وكلّما زاد عرض البلد قربت إحدى النقطتين من الأخرى، وصغرت القوس التي بينهما. ويكون لقطبي البروج طلوع وغروب. **وما دامت** الشمس **في القوس التي بين النقطتين في جهة القطب الظاهر يقع الظلّ إلى جهة القطب الخفي ويكون** /حينئذ/† [iii] **القطب الظاهر**[٩٦] **من قطبي فلك البروج هو الذي يلي القطب الخفي من معدّل النهار، والخفي هو الذي يلي القطب الظاهر؛ وما دامت الشمس في القوس الأخرى، أعني التي تكون بين النقطتين في جهة القطب الخفي، يقع الظلّ إلى جهة القطب الظاهر ويكون** /حينئذ/† [iv] **القطب الظاهر من قطبي فلك البروج هو الذي يلي القطب الظاهر من معدّل النهار، والخفي هو الذي يلي الخفي.** وتكون للشمس في ارتفاعها غايتان في النقصان، إحداهما في جهة القطب الظاهر، وهي أعظم؛ والأخرى في جهة

---

[i] ولا يكون للأشخاص في انتصاف النهار حينئذ ظلّ وعند مرور إحدى النقطتين بالسمت] هاب، هاك

[ii] إن لم تكن الشمس والكوكب على إحدى النقطتين] هاب، هاك = + ولا يكون للأشخاص في انتصاف النهار ظل: شاب، شاك

[iii] حينئذ] فاب، ـك، هال

[iv] حينئذ] فاب ، ـر، ـك، ـل

القطب الخفي، وهي أصغر. ولا يخفى مقدار الغايتين ولا مقدار غاية ارتفاع قطبي البروج وانحطاطها بعد الإحاطة بما سلف. **ولا تكون فصول السنة في تلك الآفاق متساوية،** لأنّ صيفهم يكون أطول من غيره بسبب وصول الشمس إلى سمت الرأس[٩٧] مرّتين، وفي وسطه يكون فتور للسخونة[٩٨] بسبب بعد الشمس عن[٩٩] سمت الرأس على قدر البعد. **وإن زادت الأربعة لم تكن متشابهة** لعدم انضباطها /لاختلاف غايتي بعد الشمس عن السمت في الجهتين بخلاف خطّ الاستواء وكونها ذات غايتي قرب بخلاف ما ساوى عرضه الميل وما زاد عليه./† [v]

[٣] **القسم الثاني ما يكون عرضها مساوياً للميل الكلّي. وفي تلك المواضع تمرّ الشمس في السنة مرّة واحدة بسمت الرأس.** ويكون ظلّ نقطة الاعتدال فيها /مساوياً/† [vi] /لظلّ/† [vii] نقطتي الانقلاب في خطّ الاستواء قدراً؛ /ولظلّ/† [viii] إحداهما وهي التي في خلاف جهة عرض البلد جهة أيضاً. **ويصير أحد قطبي فلك البروج أبدي الظهور والثاني أبدي الخفاء، ويماسّان الأفق في دورتهما مرّة واحدة وذلك عند انتهاء نقطة المنقلب الذي يكون في جهة القطب الظاهر إلى سمت الرأس، وحينئذ تقطع منطقة البروج الأفق على قوائم فقط،** وتكون دائرة البروج حينئذ دائرة أوّل السموت. وتكون الشمس دائماً في جهة القطب الخفي، **والأظلال في جميع السنة إلى جهة القطب الظاهر،** إلّا في يوم واحد تصل الشمس إلى المنقلب /الذي في جهة القطب الظاهر./‡ [ix] فإنّ في نصف نهار ذلك اليوم لا يكون ظلّ /ولا الشمس في جهة القطب الخفي، بل على

[v] لاختلاف غايتي... وما زاد عليه] هاب، هاك، هال

[vi] مساوياً] تاب، ـك، تال

[vii] لظلّ] متغير من «كظل»: ب = كظل: ك

[viii] ولظلّ] متغير من «وكظل»: ب = وكظل: هاك

[ix] الذي في جهة القطب الظاهر] الظاهر: ب، هال

السمت./* [x] وتكون غاية ارتفاع القطب الظاهر وغاية انحطاط الخفي من قطبي البروج بقدر ضعف الميل الكلّي، ثمّ تتناقصان إلى أن تفنيا. **وارتفاعات الشمس تتزايد من أحد الانقلابين إلى الآخر، ثمّ ترجع وتتناقص إلى أن تعود إليه. وتصير فصول السنة أربعة لا غير.** وهذه الخواصّ وغيرها أيضاً عامّة للمساكن الشمالية والجنوبية. ويكون الصيف والشتاء لهما على التبادل، يعني إذا كان في جانب الشمال الصيف كان في الجنوب الشتاء وبالعكس. وكذلك الفصلان الآخران. والذي عرضه مساوٍ للميل الكلّي في الجنوب يكون أحرّ من الذي عرضه مساو[١٠٠] له في الشمال، لمكان الأوج والحضيض، كما تقدّم. وفي هذا القسم والذي قبله يوجد للشمس الارتفاع الذي لا سمت له وذلك عند وصولها إلى دائرة أوّل السموت فوق الأرض، /وكذا في كلّ موضع تصل الشمس فوق أفقه إلى دائرة أوّل السموت./‡ [xi]

[٤] **والقسم الثالث ما يكون عرضها زائداً على الميل الكلّي وناقصاً من تمامه. وهناك لا تنتهي الشمس إلى سمت الرأس، ويكون لها ارتفاعان: أعلى وهو يكون بقدر مجموع الميل الكلّي وتمام عرض البلد، وأسفل وهو يكون بقدر فضل تمام عرض البلد على الميل الكلّي.** ولا يكون لقطبي البروج طلوع وغروب ولا تماسّ الأفق. ويكون للقطب الظاهر ارتفاعان: أحدهما أعلى وذلك عند وصول منقلب القطب الخفي إلى نصف النهار؛ والآخر أسفل وذلك عند وصول المنقلب الآخر إليه. ويكون للقطب الخفي انحطاطان على هذا القياس. **ويكون** الأظلال في جميع السنة إلى جهة القطب الظاهر. و**سائر الأحوال** من طول النهار وقصره وغير ذلك، **كما بيّنا.** وذهب بعض الأحكاميّين إلى أن كلّ بلدة يكون عرضها أكثر من ثلاثة وثلاثين لا يخرج منها نبيّ إذا لا يمرّ شيء من السيّارات بسمت رؤوسهم. وظنّ أنّ في عرض ثلاثة وثلاثين يمرّ بعضها بسمت رأسهم

[x] ولا الشمس في جهة القطب الخفي بل على السمت] هاب، هاك

[xi] وكذا في كلّ موضع تصل الشمس فوق أفقه إلى دائرة أوّل السموت] - ب، هاك، هال

كالزهرة مصيراً منه إلى أنّ أحد عرضيها جزءان ونصف والآخر قريب من سبعة وهما مع الميل الكلّي يزيد على ثلاثة وثلاثين فتمرّ الزهرة بسمت رأسهم. وذهب عليه أنّ عرضيها متبادلان، فلا يجتمعان ليصحّ ما ظنّه. فالأولى أن يقال كلّ بلد **لا يزيد** /فضل/† [xii] عرضه **على الميل الكلّي** /على/† [xiii] **عروض سائر السيّارة مرّ منها بسمت الرأس مرّتين ما زاد عرضه على فضل عرض البلد على الميل الكلّي، ومرّة ما ساوى عرضه الفضل.** ويُحتاج في هذا الحكم إلى اشتراط كون درجة الكوكب ذي العرض نقطة الانقلاب التي في جهة عرض البلد /لا في الأوّل أيضاً،/* [xiv] كما اشترطه[١٠١] بعضهم /فإنّه ينافي المطلوب./* [xv] **وفي هذه العروض يزداد تعديل النهار وسعة المشرق والمغرب بازدياد العروض،** إذ لازديادها[١٠٢] يزداد عظم المدارات الأبدية الظهور والخفاء وانحطاط مدار الشمس عن سمت الرأس إلى جهة القطب الخفي، وبَعُد مطلعُ السرطان عن مطلع الاعتدال. وزاد فضل نهاره على نهار الاعتدال فتكثر سعة المشرق وتعديل النهار إلى أن يصير أعظم المدارات الأبدية الظهور مدار المنقلب الذي في جهة القطب الظاهر.

[٥] **القسم الرابع ما يكون عرضه مساوياً لتمام الميل الكلّي. وهناك يصير مدار المنقلب الذي يكون في جهة القطب الظاهر** /أعظم الأبدية/‡ [xvi] **الظهور ومدار المنقلب الآخر** /أعظم الأبدية/‡ [xvii] **الخفاء. ويمرّ مدار قطب فلك البروج الظاهر بسمت الرأس ومدار القطب الآخر بمقابله. فإذا وافى المنقلبُ الظاهرُ مماسّةَ الأفق، ماسَّهُ على نقطة قطب أوّل السموت التي**

[xii] فضل] فاب، هال

[xiii] على] متغير من «بقدر»: ب، ل

[xiv] لا في الأوّل أيضاً] هاب، هاك

[xv] فإنّه ينافي المطلوب] هاب، هاك

[xvi] أعظم الأبدية] مضاف في المتن والهامش: ك، ل = ابدى: ب، طاك، طال

[xvii] أعظم الأبدية] مضاف في المتن والهامش: ك، ل = ابدى: ب، طاك، طال

في جهة القطب الظاهر، وماسّ[١٠٣] **المنقلب الخفي على القطب الآخر، وصار القطبان على سمت الرأس ومقابله، وانطبقت منطقة البروج على الأفق.** فإن كان القطب الظاهر شمالياً يكون أوّل الحمل في المشرق وأوّل الميزان في المغرب وأوّل السرطان في نقطة الشمال وأوّل الجدي في نقطة الجنوب ونظيرة الجدي من المعدّل على نصف النهار في جهة الجنوب فوق الأرض ونظيرة السرطان منه عليه في الشمال تحتها. ومنه يُعلم كيفية وضع المنطقتين من الأفق إذا[١٠٤] كان القطب الظاهر جنوبياً. **ثمّ إذا زال القطب عن سمت الرأس** نحو المغرب **وارتفع المنقلب الظاهر عنه، ارتفع النصف الشرقي من المنطقة عن الأفق دفعة،** وانخفض النصف الآخر منها عنه كذلك. وتتقاطع دائرتا البروج والأفق على نقطتين قريبتين من المنقلبين /وقريبتين من/ * [xviii] الشمال والجنوب. لأنّ المماسّة إذا كانت بين هذه الأربع فالتقاطع لا يكون عليها وهو مع وضوحه دقيق. **فيكون الجزء التالي للمنقلب الخفي على** /قريبة/ * [xix] **قطب أوّل السموت يُريد الغروب، والجزء التالي للمنقلب الظاهر على** /قريبة/ * [xx] **قطبه الآخر يريد الطلوع. ويكون النصف الظاهر ما بينهما، أعني النصف الذي يتوسّطه الاعتدال الربيعي إن كان القطب الظاهر شمالياً أو الخريفي إن كان جنوبياً؛ والنصف الخفي هو النصف الآخر. ثم يطلع النصف الخفي جزءاً بعد جزء في جميع أجزاء نصف الأفق الشرقي.** فيطلع السرطان والأسد والسنبلة من الربع الشرقي الشمالي والميزان والعقرب والقوس من الربع الشرقي الجنوبي إن كان القطب الظاهر شمالياً، وقس عليه إن كان جنوبياً. **ويغيب النصف الظاهر جزءاً بعد جزء كذلك،** أي في جميع أجزاء نصف الأفق الغربي. فيغيب الجدي والدلو والحوت في الربع الغربي الجنوبي والحمل والثور والجوزاء في الربع الغربي الشمالي إن كان القطب الظاهر ما ذكرنا، ولا يخفى الحكم إن كان الظاهر الآخر. وهذا إنّما يتمّ **في مدّة اليوم بليلته** وحينئذ

[xviii] وقريبتين من] هاك = و: ب

[xix] قريبة] هاب، فاك

[xx] قريبة] هاب، فاك

يعود وضع الفلك إلى حاله الأولى. ويكون هناك كلّ واحد من سعة المشرق وتعديل النهار /الكلّي/‡ [xxi] **ربعاً من الدور؛** أمّا الأوّل فلأنّ بين مطلع المنقلب الظاهر وبين مطلع الاعتدال ربع من الأفق، وأمّا الثاني فلأنّ نصف فضل نهاره الأطول، وهو أربع وعشرون ساعة، على النهار المعتدل، وهو اثنتا عشرة ساعة، هو ستّ ساعات التي هي مقدار ربع الدور، لأنّ كلّ ساعة خمس عشرة درجة. ويكون للأجزاء التي بعدها عن المعدّل أقلّ من الميل الكلّي طلوع وغروب، وأمّا غيرها من الأجزاء الفلكية فلا يكون لها طلوع و[١٠٥] غروب. **وتكون زيادة النهار إلى أن يصير مقدار يوم بليلته نهاراً كلّه،** وذلك حين وصول الشمس إلى المنقلب الظاهر، هذا إن اعتُبر ابتداء النهار من وصول مركز الشمس إلى الأفق. فإن اعتُبر ابتداؤه من ظهور الضوء واختفاء الثوابت كان نهارهم شهراً واحداً على ما بيّنه ثاوذوسيوس في *مساكنه*. **ثمّ يحدث ليل ويزيد إلى أن يصير مقدار يوم بليلته ليلة كلّه. ويزيد ارتفاع الشمس إلى أن يبلغ ضعف الميل الكلّي؛ ثمّ يأخذ في التناقص ويتناقص إلى أن يفنى، وتماسّ الشمس الأفق.** وتكون أظلال المقاييس دائرة حولها لأنّ الشمس إذا طلعت على قطب أوّل السموت، وهي في المنقلب الظاهر، أخذت في الارتفاع في جهة المشرق إلى أن تصل إلى مسامتة خطّ المشرق والمغرب؛ ثمّ تصير في الجهة الأخرى عنه وتبلغ غاية ارتفاعها عند وصولها إلى نصف النهار؛ ثمّ يتناقص ارتفاعها إلى أن تماسّ الأفق بقطب أوّل السموت. ثمّ تفعل دوراً آخر، كما قلنا، فتبلغ إلى الأفق قبل وصولها إلى قطب أوّل السموت، فيغرب مركزها دون تمام جرمها. ثمّ دوراً آخر أو دورين إلى أن يغرب تمام الجرم ويحدث الليل. ولا يخفى أنّ ظلّ وقت الطلوع يكون إلى ناحية القطب الخفي ثمّ إلى المغرب ثمّ إلى ناحية القطب الظاهر وعلى هذا يكون دائماً في الجهة المقابلة لجهة الشمس. ثمّ تتزايد قوس الليل بالتدريج إلى أن تصل إلى نقطة الاعتدال، فيتساوي الليل والنهار، ثمّ يزيد الليل. وإذا وصلت الشمس إلى المنقلب الخفي يكون الأمر

[xxi] الكلّي] - ب، - ك، هال

بالعكس لأنّ /مركزها بل مداره/[*] [xxii] في الدور الأوّل تماسّ[١٠٦] الأفق تحت الأرض؛ وفي الثاني تصل إلى الأفق قبل وصوله إلى قطب أوّل السموت فيطلع مركزها دون تمام جرمها؛ وفي الثالث أو الرابع يظهر تمام جرمها وتغرب سريعاً، ثمّ بعد ذلك ترتفع قليلاً قليلاً وتتزايد قوس النهار بالتدريج إلى أن تصل إلى نقطة الاعتدال فيتساوي الليل والنهار. ثمّ يزيد النهار، كما قلنا. **ويكون** هناك أيضاً **طلوع نصف دور من** فلك **البروج مع دور من معدّل النهار؛ وطلوع النصف الآخر من منطقة البروج لا في زمان.** وهذا الموضع هو نهاية العمارة في جانب الشمال ولا يمكن العمارة بعده لشدّة البرد، كما تقدّم.

[xxii] مركزها بل مداره] هاب، هاك

الباب **الخامس**

في خواصّ المواضع التي يجاوز عرضها عن **تمام الميل الكلّي ولا يبلغ ربع الدور**

[١] **في هذه المواضع** يكون /مدار/*[i] قطب البروج مائلاً عن سمت الرأس /في جهة القطب الخفي/*[ii] بقدر زيادة العرض على تمام الميل. فلا يكون للأجزاء الزائدة الميل على تمام العرض /ولا المساوية الميل له/*[iii] طلوع وغروب. ويكون الدائرة الأبدية الظهور أعظم من مدار المنقلبين. فـ**يكون** لا محالة **أعظم الأبدية الظهور قاطعاً لمنطقة البروج على نقطتين يتساوي ميلها في جهة القطب الظاهر؛ وأعظم المدارات الأبدية الخفاء قاطعاً لها على نقطتين** مقابلتين **لها في جهة القطب الخفي.** /وميل /كلّ من/†[iv] الأربع مساوٍ لتمام عرض البلد./*[v] **وتنقسم منطقة البروج إلى أربع قسيّ: إحداها أبدية الظهور، وهي التي يتوسّطها المنقلب الذي يكون في جهة القطب الظاهر،** ولذلك يكون طول يوم واحد من أيّام صيفهم هو زمان كون الشمس فيها؛ **والثانية أبدية الخفاء، وهي التي يتوسّطها المنقلب الآخر،** ولذلك يكون طول ليلة واحدة من ليالي شتائهم هو زمان كون الشمس فيها. **وطرفا القوس الأولى** في كلّ دور بحركة الكلّ **يماسّان الأفق** على قطب أوّل السموت الذي في جهة القطب الظاهر، **ولا يغيبان؛ وطرفا القوس الثانية يماسّانه** على القطب الآخر، **ولا يطلعان. وأمّا القوسان الباقيتان فالتي يتوسّطها أوّل الحمل تطلع معكوسة،** أي يطلع آخرها قبل أوّلها، **وتغرب مستوية،** أي يغرب أوّلها قبل آخرها، **إن كان القطب الظاهر شمالياً؛ وتطلع مستوية،** أي يطلع أوّلها قبل آخرها، **وتغرب معكوسة،** أي يغرب آخرها قبل أوّلها، **إن كان القطب**

---

[i] مدار] هاب، هاك

[ii] في جهة القطب الخفي] هاب، هاك

[iii] ولا المساوية الميل له] هاب، هاك

[iv] كل من] هاب، هاك، هال

[v] وميل الأربع مساوٍ لتمام عرض البلد] هاب، هاك

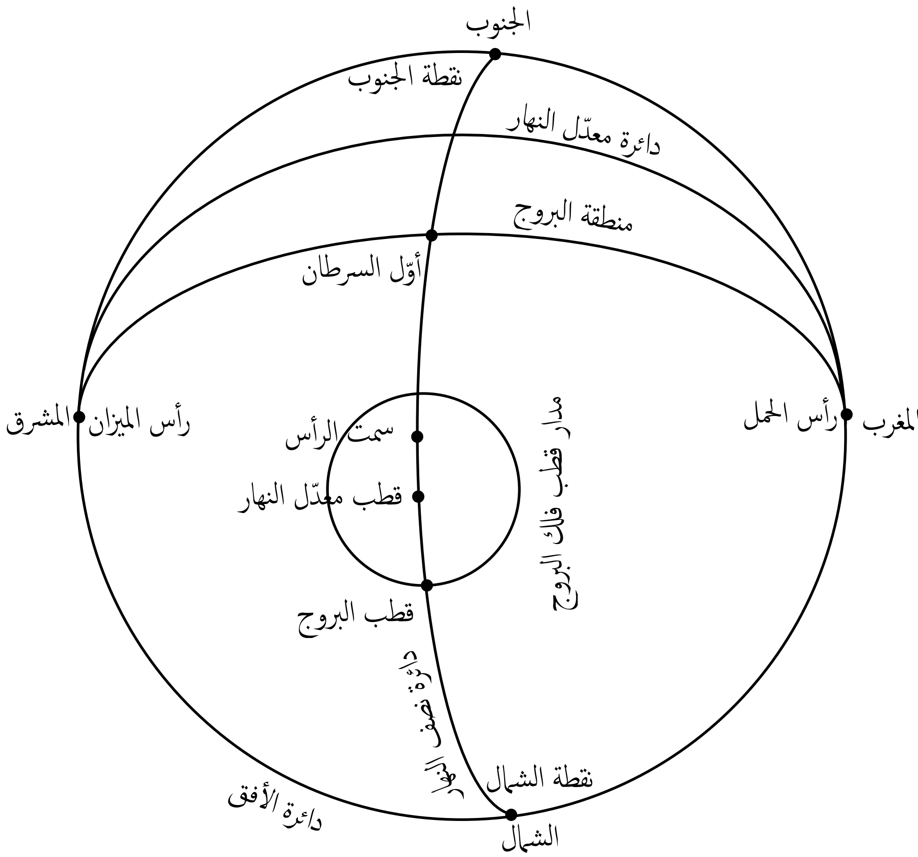
الظاهر جنوبياً. والتي يتوسّطها أوّل الميزان تكون بالضدّ من ذلك، وإنّما كان ما يطلع منكوساً يغرب مستوياً وبالعكس. لأنّ الغارب مقابل للطالع، فما يطلع منكوساً كآخر السنبلة§ [vi] مثلاً يغرب مقابله كآخر الحوت§ [vii] منكوساً وبالضدّ. فإذن الطلوع في إحدى القطعتين يوافق الغروب في الثانية في الاستواء وعدمه، لكنّه يخالف طلوع الثانية في الاستواء. فيلزم أن يكون طلوع كلّ قطعة يخالف غروبها، فما يطلع منكوساً يغرب مستوياً وبالعكس. **ويكون للمنقلب الظاهر ارتفاعان:** أحدهما **أعلى، وهو يكون بقدر مجموع الميل الكلّي وتمام عرض البلد على دائرة نصف النهار في جهة القطب الخفي؛** والآخر **أسفل، وهو يكون بقدر فضل عرض البلد على تمام الميل الكلّي على دائرة نصف النهار في جهة القطب الظاهر. ويكون لقطب فلك البروج أيضاً ارتفاعان: أعلى، وهو يكون بقدر مجموع تمام عرض البلد وتمام الميل الكلّي،** وذلك في جانب القطب الخفي؛ **وأسفل، وهو يكون بقدر فضل عرض البلد على الميل الكلّي،** وذلك في جانب القطب الظاهر. **ويكون القطب مع المنقلب على نصف النهار معاً ولكنّ في الجهتين المتقابلتين عن سمت الرأس والارتفاعين المتبادلين. وقِس عليه حال المنقلب الخفي والقطب الخفي.** وفي هذه الآفاق يطول الصبح والشفق، لما سيظهر عند وصفهما ــ إن شاء الله العزيزـــ ويقع الظلّ في جميع الجوانب، إلّا أنّ وقوعه في جانب القطب الخفي يكون أطول.

[٢] **ولكي نتصوّر[١٠٧] الأوضاع في هذه العروض نمثّل له مثالاً. وليكن العرض في الشمال سبعين: والقوس الأبدية الظهور الجوزاء والسرطان، والقوس الأبدية الخفاء القوس والجدي؛ والقوس التي تطلع معكوسة وتغرب مستوية من أوّل الدلو إلى آخر الثور، والتي تطلع مستوية وتغرب معكوسة من أوّل الأسد إلى آخر العقرب. فإذا كان أوّل السرطان على**

[vi] السنبلة] متغيّر إلى «الحوت»: ك، ر، ل

[vii] الحوت] متغيّر إلى «السنبلة»: ك، ر، ل

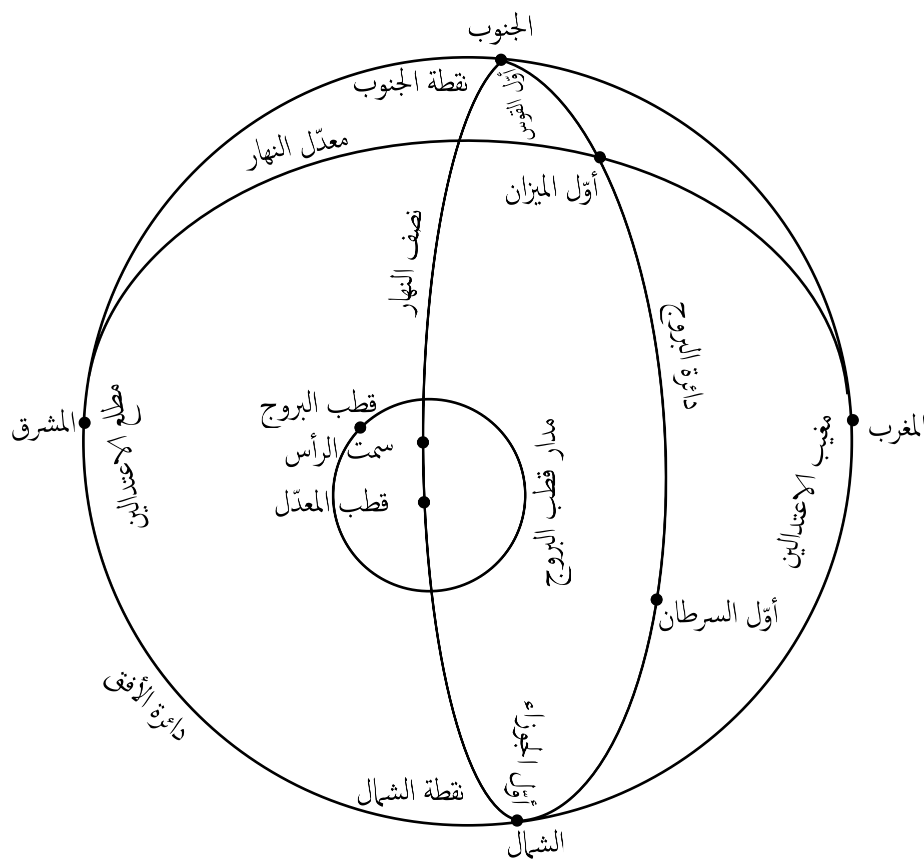
نصف النهار من جانب الجنوب وارتفاعه في غاية الزيادة وهو ثلاث وأربعون درجة وثُلث وربع، كان قطب فلك البروج الظاهر من جانب الشمال على نصف النهار أيضاً وارتفاعه في غاية النقصان وهو ستّ وأربعون درجة وربع وسدس. ويكون على مطلع الاعتدال أوّل الميزان يريد الطلوع، وعلى مغيبه أوّل الحمل يريد الغروب. ونصف فلك البروج الظاهر من المغرب إلى المشرق في الجنوب. وهذه صورتـه:



[شكل ٣]

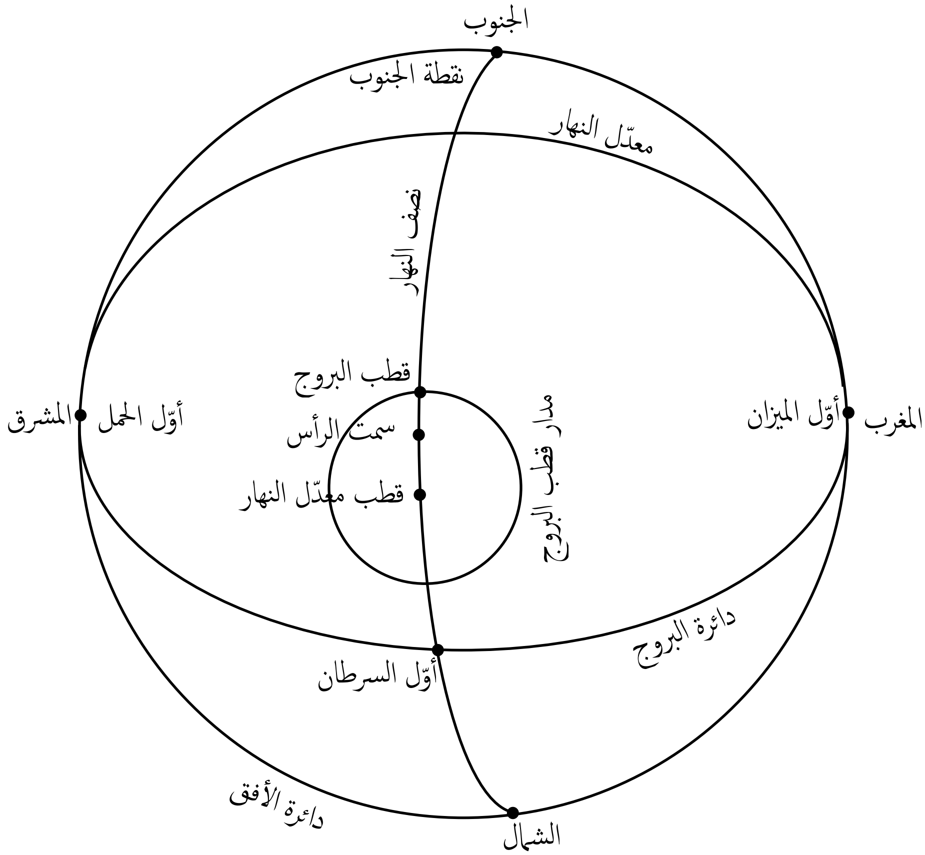
[٣] **ثم ليتحرّك الفلك بالحركة الأولى:** فـ**يأخذ أوّل السرطان في انحطاط نحو المغرب وقطب فلك البروج في ارتفاع نحو المشرق؛** ويغرب الاعتدال الربيعي ويطلع الخريفي وكذا القوسان المتّصلتان بهما؛ ويتزايد بعد مطلع كلّ[١٠٨] جزء ومغيب

نظيره من مطلع الاعتدال ومغيبه إلى أن تنتهي النوبة إلى الجزئين اللذين يماسّ أحدهما الأفق ولايغرب، والآخر يماسُّه ولايطلع. فيكون قد طلع **الميزان والعقرب مستويّين** ويستغرق **الربع الشرقي الجنوبي سعة مشرقهما؛** وغرب **الحمل والثور أيضاً مستويّين** ويستغرق **الربع الغربي الشمالي سعة مغربهما.** ويكون **أوّل القوس** يماسّ **الأفق على نقطة الجنوب وأوّل الجوزاء** يماسّه **على نقطة الشمال،** وقطب فلك البروج الظاهر في جهة الشرق بين ارتفاعيه الأعلى والأسفل على دائرة أوّل السموت ونظيره في مقابلته. **ويصير النصف الظاهر من منطقة البروج في الجانب الغربي من الجنوب إلى الشمال،** والخفي في مقابلته. فيكون تقاطع البروج والأفق على نقطتي الشمال والجنوب. و**هذه صورتـ**ـه:



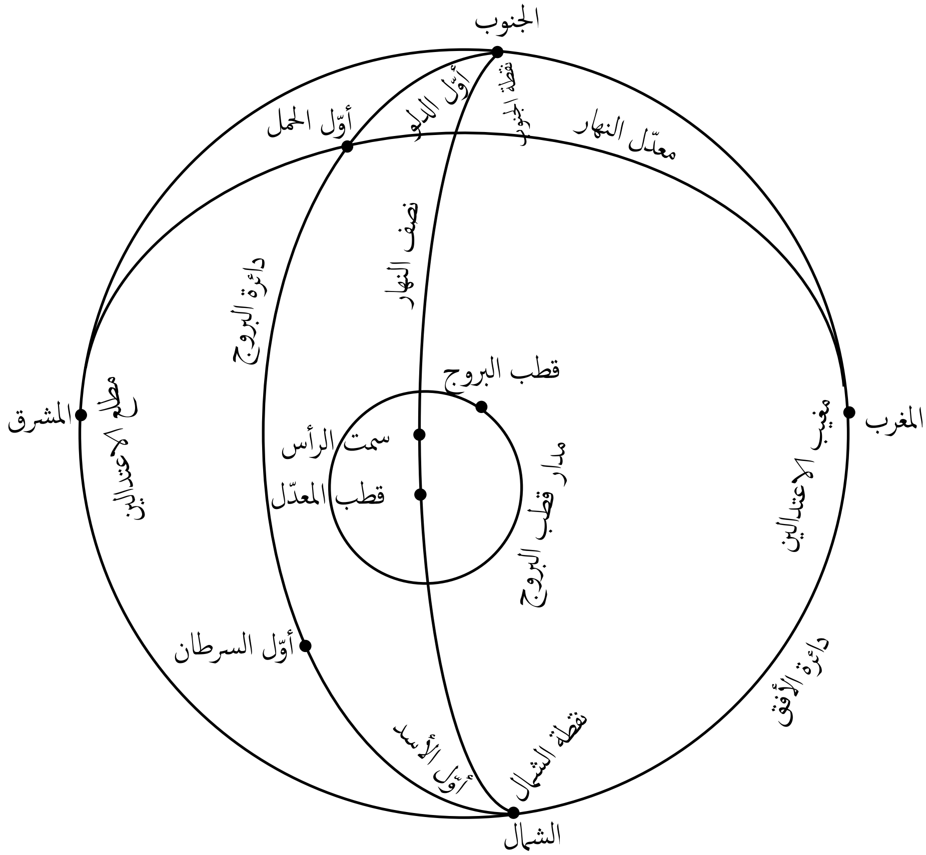
[شكل ٤]

[٤] **ثم ليتحرّك الفلك: فيأخذ أوّل الجوزاء في الارتفاع نحو المشرق ويطلع آخر الثور المتّصل به شيئاً بعد شيء،** بحيث يكون مطلع كلّ جزء أقرب إلى مطلع الاعتدال من مطلع الجزء المقدّم عليه في الطلوع، **إلى أن يطلع الثور. ثم يطلع آخر الحمل إلى أوّله، ويستغرق الربع الشمالي الشرقي سعة مشرق هذين البرجين، وينتهي أوّل الحمل إلى مطلعه. ويأخذ بإزاء ذلك أوّل القوس في الانحطاط تحت الأفق ويغرب آخر العقرب المتّصل به شيئاً بعد شيء إلى أن يغيب العقرب. ثم يغرب آخر الميزان إلى أوّله، ويستغرق الربع الجنوبي الغربي سعة مغربهما، وينتهي أوّل الميزان إلى مغيبه.** فتكون قد انتهت نوبة الطلوع والغروب المعكوسين إلى نقطتي الاعتدالين، وانتهى **أوّل السرطان إلى دائرة نصف النهار في جانب الشمال ويكون في ارتفاعه الأسفل وهو ثلاث درجات وثُلث وربع، وقطب فلك البروج** في **ارتفاعه الأعلى في جانب الجنوب وهو ستّ وثمانون درجة وربع وسدس. ويكون النصف من فلك البروج الظاهر في جانب الشمال بين مطلع الاعتدال ومغيبه على توالي**[١٠٩] **مخالف للمعهود،** والخفي مقابله. ويكون تقاطع البروج والأفق على نقطتي المشرق والمغرب، **على هذه الصورة:**



[شكل ٥]

[٥] **ثم ليتحرّك الفلك: فيطلع آخر الحوت إلى أوّله، ثم آخر الدلو إلى أوّله، ويستغرق الربع الشرقي الجنوبي سعة مشرقهما. ويغيب بإزائهما آخر السنبلة إلى أوّلها ثم آخر الأسد إلى أوّله، ويستغرق الربع الغربي الشمالي سعة مغربهما. ويصير أوّل الدلو على نقطة الجنوب مماسّاً للأفق، وأوّل الأسد على نقطة الشمال مماسّاً للأفق، ونصف دائرة البروج الظاهر فيما بينهما من جهة المشرق. وأول السرطان قد ارتفع في جانب المشرق، والقطب قد أخذ في الانحطاط في جانب المغرب.** وقد وصل إلى دائرة أوّل السموت في جهة الغرب،[١١٠] **على هذه الصورة:**



[شكل ٦]

[٦أ] **ثم ليتحرّك الفلك:** وليرتفع **أوّل الأسد عن**[١١١] **الأفق آخذاً نحو النصف الشرقي، فتطلع أجزاء الأسد على التوالي إلى آخره، ثم أجزاء السنبلة** كذلك، **ويستغرق الربع الشمالي الشرقي سعة مشرقها. وبإزاء ذلك ينخفض أوّل الدلو عن الأفق إلى تحت الأرض، فيغرب الدلو ثم الحوت على التوالي، ويستغرق الربع الجنوبي الغربي سعة مغربها.** و**ينتهي الطلوع إلى أوّل الميزان والغروب إلى أوّل الحمل،** لازدياد قرب مطلع الأجزاء ومغيبها من مطلع الاعتدال ومغيبه. **ويصير حينئذٍ أوّل السرطان إلى دائرة نصف النهار وارتفاعه الأعلى، والقطب الظاهر من فلك البروج إلى ارتفاعه الأسفل من نصف النهار. ويصير النصف الظاهر من فلك البروج في جانب الجنوب، ويعود الوضع إلى ما فرضناه مبدأ، فيتمّ الدور ويتّضح ما وصفناه.**

[٦ب] والضابط: أن ننظر إلى البروج الشرقية تحت الأفق؛ فإن كانت أواخرها أقرب إلى الأفق من أوائلها فطلوعها يكون منكوساً؛ وإن كان أوائلها أقرب إلى الأفق من أواخرها طلعت مستوية. وننظر إلى البروج الغربية فوق الأرض؛ فإن كانت أواخرها أقرب إلى الأفق من أوائلها غربت منكوسة؛ وإن كانت أوائلها أقرب إليه غربت مستوية، على ما اتّضح في الأمثلة. أو نقول إنّما يطلع منكوساً ما كان متّصلاً بالجزء الأبدي الظهور ممّا يلي الاعتدال الربيعي،[١١٢] ويغرب منكوساً ما كان متصلاً بالأبدي الخفاء ممّا يلي الخريفي،[١١٣] إن كان القطب الظاهر شمالياً وإلّا كان بالعكس. ولا يخفى أنّ الشمس إذا وصلت إلى الاعتدالين اعتدل الليل والنهار، ثم إذا جاوزت من الحمل في المساكن الشمالية ومن الميزان في الجنوبية يزداد النهار وينقص الليل إلى أن يفنى الليل ويصير كلّه نهاراً. ويبقى كذلك مدة كون الشمس في القوس الأبدية الظهور، ثم يبتدئ الليل ويتزايد إلى أن تصير إلى الاعتدال الآخر، فيتساويان. ثم يزيد الليل على النهار إلى أن يفنى النهار ويصير كلّه ليلاً. ويبقى كذلك مدة كون الشمس في القوس الأبدية الخفاء، ثم يحدث النهار ويتزايد إلى أن يتقابلا.

[٧] **وفي هذه الآفاق إذا قرب عرض البلد من النهاية وصار ارتفاع معدل النهار من الأفق قليلاً، فربّما ينتقل كوكب** يَقرُب[١١٤] **مداره من الأفق جدّاً إلى مدار آخر بحركته الثانية، فيغيب بعد ما كان ظاهراً وهو في النصف الشرقي أو يظهر بعد ما كان خفياً وهو في النصف الغربي. فيكون قد غرب في المشرق أو طلع من المغرب. وهذا أيضاً من المسائل المستغربة.**

الباب **السادس**

في خواصّ المواضع التي يكون عرضها ربعاً من الدور سواءً

[١] وذلك لا يكون على الأرض إلّا عند نقطتين يكون أحد قطبي معدّل النهار على سمت الرأس هناك. وتصير دائرة معدّل النهار منطبقة على الأفق، ويدور الفلك بالحركة الأولى دورة **رَحَوية ولا يبقى في الأفق مشرق ولا مغرب** متميّزَين، بل في جميع الجهات يمكن أن يكون طلوع وغروب. ولا نصف النهار أيضاً، بل في جميع الجهات يمكن أن تبلغ الشمس وغيرها من السيّارات غاية الارتفاع. وغاية ارتفاع الشمس هي بقدر الميل الكلّي، وكذا غاية انحطاطها. وأظلال المقاييس تفعل دوائر تامّة متوازية بالتقريب على مركز واحد هو أصل المقياس، بعضها داخل بعض، وأصغرها إذا كانت الشمس في المنقلب الذي في جهة القطب الظاهر، وأعظمها إذا صارت قريبة من الأفق بقرب أحد الاعتدالين. و**يكون النصف من الفلك الذي يكون من معدّل النهار في جهة القطب الظاهر أبدي الظهور والنصف الآخر أبدي الخفاء.**

[٢] والشمس ما دامت في النصف الظاهر من فلك البروج يكون نهاراً، وما دامت في النصف الخفي منه يكون ليلاً؛ فتكون سنتها كلّها يوماً وليلة **ويفضل أحدهما على الآخر من جهة** بطوء **حركتها وسرعتها. فيكون تحت القطب الشمالي في هذا التأريخ نهارهم أكثر من ليلهم بسبعة أيّام بلياليها من أيّامنا، وذلك لكون أوج الشمس في أواخر الجوزاء وحضيضها في أواخر القوس.** هذا إن اعتُبر ابتداء النهار من وصول مركز الشمس إلى الأفق، وأمّا إن اعتُبر ابتداؤه من ظهور الضوء واختفاء الثوابت، /وانتهاؤه من اختفاء الضوء وظهور الثوابت،/* [i] يكون نهارهم أكثر من سبعة أشهر[١١٥] /بالسبعة

[i] وانتهاؤه من اختفاء الضوء وظهور الثوابت] هاب، هاك

الأيّام،/‡[ii] وليلهم قريباً من خمسة أشهر، على ما حقّقه ثاوذوسيوس في *المساكن*. /فإن قلت:[١١٦]/*[iii] ولأنّ **مدّة غروب الشفق أو**[١١٧] **طلوع الصبح لهم** يكون **في خمسين يوماً من أيّامنا، على ما يتبيّن عند وصفها فيما بعد** ـــ إن شاء الله العزيز ـــ *[iv] يلزم أن يكون التفاوت بينهما أكثر ممّا حقّقه، لأنّه على هذا يكون سبعة§[v] أشهر وأربعين§[vi] يوماً من أيّامنا، قلت إنّما يلزم ذلك لو كان اختفاء الثوابت مع طلوع الصبح وليس كذلك بل هو متأخّر عنه وبينهما قريب من عشرين يوماً.§[vii] /وكذا ظهور الثوابت يتقدّم على غروب الشفق بمثله./*[viii] ولايطلع ولايغيب بالحركة الأولى جزء من أجزاء الفلك. **ويكون طلوع الشمس والكواكب بالحركة الثانية وغروبها لا في موضع** معيّن[١١٨] **من الأفق**. والكوكب الذي لا عرض له يكون اثنتا[١١٩] عشرة[١٢٠] ألف سنة فوق الأرض ومثله تحتها.

[٣] **ويكون للكواكب التي عرضها** أنقص **من الميل** الكلّي **طلوع وغروب؛ وتختلف مدّتا الظهور والخفاء بحسب بُعد مدارها** العرضي **عن فلك البروج وقربها إليه؛ والتي عرضها مساوٍ للميل كلّه تماسّ الأفق في دور واحدٍ من الحركة الثانية مرةً واحدة؛ ولا يكون لها ولا التي يزيد عرضها على الميل** كلّه **طلوع** و**غروب بل تكون إمّا ظاهرة وإمّا خفية أبداً. وليتذكّر ما قلنا في أوضاع الفلك بسبب الحركتين الأوليين، وليحكم هاهنا بحسب ذلك.**

[ii] بالسبعة الأيّام] - ب، - ك، هال

[iii] فإن قلت] فاب، هاك

[iv] إن شاء الله العزيز] + فإن قلت: شاب، شاك

[v] سبعة] متغيّر إلى «تسعة»: ر، ك، ل

[vi] أربعين] متغيّر إلى « سبعة عشر»: ر، ك، ل

[vii] عشرين يوماً] متغيّر إلى « شهر وثمانية أيام»: ر، ك = متغيّر إلى «خمسة وثلثون»: ل = + يوما إذ بين الاختفاء وطلوع الشمس خمسة عشر يوما على ما حققه أيضا: هال

[viii] وكذا ظهور الثوابت يتقدّم على غروب الشفق بمثله] هاب، هاك

[٤] **وهذا**[١٢١] **آخر** خواصّ **البقاع** المسامتة لـ**لمدارات اليومية وما يجري مجراها ـــ** والله أعلم بالصواب.

الباب **السابع**

في مطالع البروج

[١] المطالع أجزاء من معدّل النهار تطلع مع أجزاء مفروضة من فلك البروج، وتسمّى هذه درج السواء. والمطالع في خطّ الاستواء يكون لا محالة محصورة بين دائرتين من دوائر الميول، لأنّ أفقه من دوائر الميول أيضاً. أعني يكون ما بين دائرتي الميل من معدّل النهار مطالع لما بينهما من فلك البروج، وتسمّى بمطالع الفلك المستقيم ومطالع الكرة المنتصبة ومطالع خطّ الاستواء. وفي الآفاق المائلة /محصورة بين دائرتين تخرجان من قطب أوّل السموت وتمرّان بطرفي تلك القوس من البروج،/† [i] /لا/† [ii] محصورةً بين دائرتي الأفق والميل، /حتّى/‡ [iii] يكون ما بينهما من معدّل النهار مطالع لقوس من البروج مبدؤها على دائرة الميل ومنتهاها على الأفق، /على ما يوجد في بعض المصنّفات، فإنّه لا يصحّ. والسرّ فيه أنّ المطالع ودرج السواء لا يُتحدّد حدودهما ولا يُتوهّم حدوثهما على ما ينبغي، إلّا بفرض دائرة مقاطعة للأفق على قطبي أوّل السموت مارّة بآخر تلك القوس من البروج إن فُرضت تحت الأفق، وبأوّلها إن فُرضت فوقه، حتّى إذا تحرّكت هذه الدائرة بالحركة اليومية انتهت نهايتا قوسي المطالع ودرج السواء دفعة إلى الأفق. فيكون ما بينهما من المعدّل مطالع لما بينهما من البروج. ويستحيل أن يكون ما بين دائرتي الأفق والميل في الآفاق المائلة من المعدّل مطالع لما بينهما من البروج، أللهم إلّا إذا كانت دائرة الميل نصف النهار، فإنّ ما بينهما مطالع لما بينهما للسرّ المذكور، وهو تقاطعه مع الأفق على قطبي أوّل السموت، فأعرفه./† [iv] وتسمّى بمطالع

---

[i] محصورة بين دائرتين... تلك القوس من البروج] هاب، هاك، هال

[ii] لا] فاب، مضاف في المتن: ك، ل

[iii] حتّى] أعني: ب، ك، متغير من «أعني» في ل

[iv] على ما يوجد في بعض المصنّفات... فأعرفه] هاب، هاك، هال

الآفاق المائلة ومطالع الأفلاك المائلة لأنّ الآفاق المائلة تسمّى بالأفلاك المائلة، كالأفلاك المستقيمة التي يُقال لها الآفاق المستقيمة.

[٢أ] ولمّا كان فلك البروج غير مخطوطة على قطبي المعدّل وكان دورُها من المشرق إلى المغرب على قطبيه، استحال أن يجوز جميع الأجزاء المتساوية من فلك البروج في الأفلاك المستقيمة والمائلة جميعاً في أزمان متساوية بل مختلفة. ولهذا يخالف مطالع بعض البروج مطالع البعض الآخر. ثمّ المطالع مع اختلافها في نفسها تختلف باختلاف الآفاق لاختلاف قطعها المثلّث المذكور فيما تقدّم.[١٢٢] ومبدأ المطالع يأخذونه من الاعتدال الربيعي، ومنهم من يجعل المبدأ الانقلاب الشتوي لغرض يظهر في العمل. وإذا تحقّق ذلك، فنقول **أمّا في خطّ الاستواء فكلّ ربع يتحدّد بنقطتين من النقط الأربع،** الاعتدالين والانقلابين، **يطلع مع ربع لأنّ نقطة الاعتدال التي هي أحد حدّي الربعين من المنطقتين معاً إذا انتهت إلى سمت الرأس انطبقت الدائرة المارّة بالأقطاب الأربعة على الأفق؛** فيـ**كون الحدّان الآخران للربعين،** وهما نقطة الانقلاب الصيفي ونظيرتها من المعدّل **معاً على الأفق؛** ويكون قطع المنطقتين الأفق[١٢٣] على قوائم. **وقس عليه سائر الأرباع. ولا يطلع مع برج يلي إحدى نقط الأرباع، وهو نصف سدس منطقة البروج، ثلاثون زماناً أعني نصف سدس معدّل النهار؛ وذلك لأنّ البرج إن كان ممّا يلي نقطة الاعتدال كان أحد حدّيها مشتركاً وهو تلك النقطة. وإذا انتهى الحدّ الآخر للبرج إلى الأفق حدث من البرج والقوس الطالعة معه من معدّل النهار، أعني مطالعه، وممّا يقع بينهما من الأفق مثلّث زاويته التي يحيط بها معدّل النهار والأفق قائمة والباقيتان حادّتان.** و**لكون البرج وتر قائمة ومطالعه وتر حادّة، يكون البرج أعظم من مطالعه،** لما بيّنه مانالاؤس في *كريّاته*؛ **وكذلك القول في برجين يليان نقطة الاعتدال ومطالعها.** ومن هاهنا يمكن تركيب حجّة لنفي الجزء بأن يقال لو كان

/الجزء حقّاً لكان/†[v] المعدّل /وكذا دائرة البروج/†[vi] مركّباً من الأجزاء التي لا تتجزّئ. /وعلى هذا/†[vii] فإذا طلع من المعدّل ربع أوّله الاعتدال الربيعي إلّا جزءاً من الأجزاء المذكورة فما يطلع معه من البروج يكون أكثر منه، لأنّ درج السواء أكثر من المطالع وأقلّ من الربع، لأنّ الربع يطلع مع الربع. فيلزم انقسام الجزء الملاصق لأوّل السرطان، مع أن الفرض عدم انقسامه،†[viii] هذا خلف. وهذه النكتة، وإن لم تناسب ما نحن فيه بحسب الصورة، لكنّها تناسبه بحسب المادّة، فلذلك ولغرابتها ذكرتها ههنا هذا.

[٢ب] و**أمّا إن كان البرج ممّا يلي نقطة الانقلاب فيكون مطالعه أعظم منه، وذلك لأنّ الباقية إلى تمام الربع من مطالع البرجين التي هي أصغر من سدس الدور تكون أعظم من نصف**[١٢٤] **سدس الدور، و**[١٢٥]**هي تطلع مع البرج الباقي.** وتكون زيادة هذا كنقصان ذاك. ثمّ تطلع مع القسي المتساوية من البروج القسي المختلفة من المعدّل على النسق الذي في الربع الأوّل، إلّا أنّ مطالع أجزاء السرطان على الولاء تكون مثل مطالع اجزاء الجوزاء على خلاف الولاء، إلى أن يطلع الربع الآخر وينتهي الاعتدال الخريفي إلى الأفق. وقس عليه مطالع الربعين الآخرين. فـ**قد ظهر** ممّا ذكرنا من زيادة المطالع ونقصانها وتساوي مقداري الزيادة والنقصان **أنّ كلّ قوسين متساويتين متساويتي البعد عن إحدى النقط الأربع فمطالعهما في خطّ الاستواء متساوية.** أو نقول أمّا تساوي مطالع المتساوية البعد عن الاعتدالين فلتساوي المثلّثات الأربع الحاصلة عن جنبتيهما لأنّ كلّ مثلّثين تكون زاويتان منهما قائمتين وزاويتان متساويتين غير قائمتين وضلعان هما وتر القائمتين أيضاً متساويين، فإنّ

---

[v] الجزء حقّاً لكان] هاب، هاك، هال

[vi] وكذا دائرة البروج] هاب، هاك، مضاف بعد التحرير في ل

[vii] وعلى هذا] هاب، فال

[viii] انقسامه] + ايضا: ب، شاك، شال

الضلعين والزاوية الباقية منهما متساوية كلّ لنظيره لما بيّن مانالاؤس في *الأشكال الكرية*. وأمّا عن الانقلابين فلأنّه إذا نقص من المتساويين، وهما ربعا المعدّل متساويان، وهما مطالعا القوسين اللتين تليان الاعتدالين من إحدى جنبتي المعدّل، تبقى منهما متساويان،[١٢٦] وهما مطالعا[١٢٧] القوسين اللتين عن جنبتي الانقلابين. **ومنطقة البروج تنفصل إلى أربع قطع تكون مبادئها أواسط الأرباع. ويكون كلّ قطعة يقع في وسطها أحد الاعتدالين أعظم من مطالعها، وكلّ قطعة يقع في وسطها أحد الانقلابين أصغر من مطالعها.** وغاية التفاوت بين طلوع ربع وربع عشرة أجزاء، لأنّه عُلم بالاستقراء أنّ غاية التفاوت في كلّ ثُمن درجتان ونصف. لأنّ خمسة وأربعين درجة من فلك البروج، التي ابتداؤها من نقطة الاعتدال، تطلع مع اثنين وأربعين درجة ونصف من المعدّل، التي هي ثلاث ساعات إلّا سدس. وخمسة وأربعون درجة، التي انتهاؤها الانقلاب، تطلع مع سبع وأربعين درجة ونصف، التي هي ثلاث ساعات وسدس. فيكون قد طلع ربع تامّ مع ربع تامّ هو ستّ ساعات في ربع يوم بليلته. والربع الآخر الذي مبدؤه الانقلاب يكون بعكس هذا الترتيب. لأنّ الثمن الأوّل وهو خمسة وأربعون درجة من البروج يطلع مع سبع وأربعين درجة ونصف. والثمن الآخر الذي منتهاه الاعتدال الآخر يطلع مع اثنين[١٢٨] وأربعين درجة ونصف. وقس عليه حال الربعين الآخرين. فإذن كلّ ربع يتوسّطه أحد الاعتدالين يطلع مع خمس وثمانين درجة من المعدّل، وكلّ ربع يتوسّطه أحد الانقلابين يطلع مع خمس وتسعين درجة. فالتفاوت بينهما عشر درجات على ما قلنا.

[٣] **ومرور معدّل النهار ومنطقة البروج على دوائر أنصاف النهار في جميع البقاع يكون كطلوعهما**[١٢٩] **في خطّ الاستواء لأنّ كلّ واحدة منها أفق من آفاق خطّ الاستواء** لمرورها بقطبي الكلّ؛ **وكذلك الحكم في جميع دوائر الميول. والمغارب كالمطالع في تلك الآفاق؛** لأنّ مطالع كلّ برج كمطالع نظيره هناك، على ما تُبيّن، ومطالع نظير البرج كمغارب البرج في

جميع الآفاق. لأنّ طلوع كلّ جزء من فلك البروج في المشرق يكون مع غروب نظيره في المغرب. فيكون مغارب كلّ برج كمطالعه هناك. ولا يخفى بعد الإحاطة بما ذكرنا أنّه إذا علم مطالع ربع هناك، عُلم مطالع الأرباع الباقية. لأنّه إذا عرف مطالع الحمل مثلاً، عرف مطالع الحوت لتساوي بعدهما من أوّل الحمل؛ ومطالع السنبلة لتساوي بعدهما من أوّل السرطان؛ ومطالع الميزان إمّا من مطالع الحمل لكونه نظيره، أو من مطالع السنبلة لتساوي بعدهما عن أوّل الميزان. ويُعرف من معرفة مطالع الثور مطالع أربعة§ [ix] أخرى، ومن مطالع الجوزاء مطالع الأربعة§ [x] الباقية.

[٤] **وأمّا في الآفاق المائلة** فـ**يطلع نصف مع نصف إذا كانا متحدّدين بنقطتي الاعتدالين؛ ولا يطلع ربع مع ربع** لأنّ **سطح معدّل النهار غير قائم على سطح الأفق** ليلزم ذلك كما في خطّ الاستواء. بل **إذا طلع** ربع يـ**ـلي نقطة الاعتدال وكان من معدّل النهار في جهة القطب الظاهر،** كان **أعظم من مطالعه لأنّه في المثلّث المذكور** يـ**ـكون وترَ منفرجةٍ ومطالعه وترَ حادّةٍ. و**إن **كان من معدّل النهار في جهة القطب الخفي فمطالعه أعظم منه لأنّ الحكم يصير بضدّ ما كان.** وغاية التفاوت في كلّ ربع هو بقدر تعديل نهار المنقلبين المسمّى بتعديل النهار الكلّي. فكلّ[١٣٠] ربع أوّله الاعتدال الربيعي يطلع مع قوس من المعدّل[١٣١] ينقص عن ربعه بمقدار تعديل النهار. والربع الآخر المنتهي إلى الاعتدال الآخر يطلع مع قوس من المعدّل يزيد على ربعه بالمقدار المذكور. فإذن§ [xi] النصف الذي يتوسّطه الاعتدال الربيعي تنقص عن§ [xii] النصف الآخر بأربعة أمثال تعديل النهار. وبهذا الاعتبار **ينقسم** فلك البروج **إلى قطعتين: إحداهما التي يتوسّطها الاعتدال الذي إذا جاوزه الكوكب صار في**

[ix] أربعة] متغير إلى «ثلثه» في ر

[x] الأربعة] متغير إلى «الثلثه» في ر

[xi] فإذن] + مطالع: ر، هاك، هال

[xii] عن] + مطالع: هار، فاك، هال

جهة القطب الظاهر، والأخرى التي يتوسّطها الاعتدال الآخر. والأولى تكون أعظم من مطالعها والأخرى أصغر، بما ذكرنا. هذا حكم النصفين المتحدّدين بالانقلابين. وأمّا حكم النصفين المتحدّدين بالاعتدالين فواحد لكن في أحد النصفين على الولاء وفي الآخر لا على الولاء. ولهذا تكون مطالع القسي المتساوية المتساوية[١٣٢] الأبعاد عن أحد الاعتدالين متساوية، إمّا زائدة على مطالعها في المستقيم أو ناقصة عنها، كما عرفت.[١٣٣] وأمّا عن الانقلابين فتختلف؛ فالتي تلي الحمل تنقص مطالعها في الفلك المائل عن مطالعها في المستقيم، والتي تلي الميزان بالعكس. وزيادة هذه كنقصان تلك. ولهذا فإنّ كلّ برجين متساويي[١٣٤] البعد عن جنبتي أحد الانقلابين، كالحمل والسنبلة، إذا جُمع مطالعهما في البلد كان مساوياً لمطالعهما في خطّ الاستواء. ويلزم منه أن تكون مطالع كلّ برجين متقابلين، كالحمل والميزان، كذلك؛ لأنّ كلّ برجين بعدهما عن أحد المنقلبين واحد، فالبرج المقابل لأحدهما يكون بعده عن أحد الاعتدالين كبعد البرج الآخر عنه، ومطالعه مساوية لمطالعه. فيلزم أن تكون مطالع الحمل والميزان في الفلك المائل مساوياً لمطالعهما في المستقيم، وهما متساويان هناك. فتكون مطالع المتقابلين في المائل ضعفَ مطالع أحدهما في المستقيم، وكذا مطالع المتساويتي[١٣٥] البعد عن أحد الانقلابين، لما ذكرنا. ويلزم أيضاً أن تكون مطالع الحمل مثلاً ومغاربه في[١٣٦] المائل ضعف مطالعه في المستقيم لأنّ مغارب الحمل كمطالع نظيره، لما عرفت من أنّ مطالع كلّ برج كمغارب نظيره وبالعكس في كلّ أفق.[١٣٧] ولكون مطالع كلّ برج[١٣٨] تخالف مطالع نظيره في الآفاق المائلة المساوية لمغارب ذلك البرج، تكون مطالع كلّ برج فيها تخالف مغاربه. والمطالع /لكلّ برج/†[xiii] في الآفاق الجنوبية كالمغارب /لذلك البرج/†[xiv] في الشمالية /وبالعكس،/†[xv][١٣٩] إذا تساوي عرضا الأفقين. وكذا **مطالع القسي الشمالية في الآفاق الشمالية**

[xiii] لكلّ برج] هاب، هاك، هال

[xiv] لذلك البرج] هاب، هاك، فال

كمطالع نظائرها من الجنوبية في الآفاق الجنوبية. /وكذلك في الجنوبية/† [xvi] بالشرط المذكور. ولا يخفى بعد الإحاطة بما ذكرنا أنّا إذا عرفنا مطالع ربع من البروج يُحصل لنا مطالع الباقي؛ لأنّا إذا عرفنا مطالع الحمل في البلد عرفنا مطالع الحوت فيه، لأنّها مثلها؛ وإذا نقصنا مطالع الحمل من مجموع مطالعه ومطالع السنبلة في الفلك المستقيم يكون الباقي مطالع السنبلة في البلد المساوية لمطالع الميزان فيه.[١٤٠] وبهذا التدبير يُعرف من مطالع الثور مطالع الدلو والأسد والعقرب، ومن مطالع الجوزاء مطالع الجدي والسرطان والقوس.

[٥] **وأمّا في الآفاق التي يكون فيها**[١٤١] **مدارا نقطتي الانقلابين أعظم المدارات الأبدية الظهور والخفاء، فقد** سبق **أنّ نصفاً من فلك البروج يطلع مع جميع معدّل النهار والنصف الآخر** يظهر **لا في زمان؛ وفي الغروب يتبادل النصفان.**

[٦أ] وأمّا في الآفاق التي[١٤٢] **تكون فيها قسي من فلك**[١٤٣] **البروج أبدية الظهور والخفاء،** ينقسم المعدّل بقسمين أحدهما يطلع مع البروج التي تطلع معكوسة والآخر مع[١٤٤] التي تطلع مستوية. والتي لا تطلع ولا تغرب لا يكون لها حظّ من المطالع ولا من المغارب. **وليكن الأفق ما تمثّلنا به من الآفاق الشمالية، وهو أفق عرضه سبعون، والجوزاء والسرطان فيه أبديا الظهور، والقوس والجدي أبديا الخفاء. فإذا طلعت نقطة الاعتدال الربيعي طلع بعدها الحوت معكوساً من الآخر إلى الأوّل، ثمّ الدلو معكوساً من الآخر إلى الأوّل؛ ثمّ يبتدئ طلوع الأسد من أوّله مستوياً، ثمّ السنبلة، ثمّ الميزان، ثمّ العقرب كذلك. فإذا انتهى إلى أوّل القوس ابتدأ آخر الثور بالطلوع المعكوس ويطلع الثور والحمل معكوسين، فتعود نقطة الاعتدال**

[xv] وبالعكس] تاب، تاك، هال

[xvi] وكذلك في الجنوبية] هاب، هاك، هال

الربيعي إلى الأفق. وقِس عليه في سائر الآفاق، والغروب على الطلوع. وفي عرض تسعين لا يكون للبروج مطالع ولا مغارب، /إذ لا يكون لها طلوع ولا غروب./ † xvii

[٦ب] وإذا عرفت ما عرفت، فاعلم أنّ تعديل المطالع هو ما يزاد أو ينقص من مطالع الفلك المستقيم حتّى يجتمع أو يحصل مطالع البلد المفروض، وهو تعديل النهار كما عرفت. ومغارب القوس كمطالعها ثمّة. وتعديلها مساوٍ لتعديل المطالع إلّا أنّه إذا زيد على مطالع الفلك المستقيم نقص من مغاربه، وإن نقص من مطالعه زيد على مغاربه. ومطالع السمت قوس من المعدّل تقع بين الأفق وبين دائرة الارتفاع المارّة بجزء مفروض. والقطعة من قوس النهار بين دائرة ارتفاع الشمس ودائرة الأفق من ناحية المشرق هو الدائر؛ وما بينه وبين دائرة نصف النهار هو فضل الدائر. وقد يُقال هو قوس من مدار الشمس ما بين جزئها وأفق المشرق بالنهار، وما بين نظير جزئها وأفق المشرق بالليل من مدار نظير جزئها. ومقدار كلّ منهما شبيهتها من معدّل النهار. والطالع هو الجزء الموافي للأفق من فلك البروج ممّا يلي المشرق، والغارب مقابله على أفق المغرب. والذي على نصف النهار فوق الأرض هو العاشر، ويسمّى جزء وسط السماء. والذي عليه تحت الأرض هو الرابع، ويسمّى جزء وتد الأرض. وهذه النقط الأربع تسمّى الأوتاد الأربعة ـــ والله أعلم.[١٤٥]

---

xvii إذ لا يكون لها طلوع ولا غروب] هاب، هاك، هال

الباب **الثامن**

في مقادير الأيّام بلياليها

[١أ] **اليوم بليلته** زمان يتخلّل بين طلوع الشمس أو غروبها /أو مرورها بنصف النهار/† [i] وبين طلوعها أو غروبها /أو مرورها/† [ii] ثانياً.* [iii] لا ما هو المشهور **وهو** أنّه **الزمان الذي يقع بين كون الشمس إمّا على الأفق طالعة أو غاربة وإمّا على نصف النهار وبين عودها إلى هناك بعد دورة واحدة تامّة بالحركة الأولى؛ ومقداره دورة من أدوار معدّل النهار مع زيادة تطلع منه مع القوس التي تقطعها الشمس في ذلك اليوم بليلته.** لأنّه غير جامع إذ بقيد الواحدة يخرج اليوم بليلته في عرض تسعين ونحوه، لأنّ عودة الشمس إلى ما يُفرض مبدأ تكون هناك بعد دورتين وأكثر؛ وبقيد التامّة وتعيين مقداره بعض الأيّام بلياليها حيث تطلع البروج منكوسة وما يقرب منه، لأنّ العود هناك على ما لا يخفى بعد تصوّر تلك الأوضاع قد يكون بأقلّ من دورة بمقدار[١٤٦] /ما يقتضي مسير الشمس. فإنّ النقطة من المعدّل التي تكون على الأفق مع الشمس، ولتكن في العاشرة§ [iv] مثلاً، لا تعود معها إلى الأفق لانتقال الشمس إلى الحادية عشرة وطلوعها قبل العاشرة، بل نقطة أخرى تنتهي إلى الأفق مع الحادية عشرة. فما بين النقطتين من المعدّل هي ما نقص من دورته. ولو§ [v] أمكن اتّصال القوس التي تطلع معكوسة بالتي تطلع مستوية وفُرضت الشمس في يوم ما قاطعة للدرجة التي هي على الفصل المشترك بين القوسين، يتساوي عودتا الشمس

---

[i] أو مرورها بنصف النهار] - ب، هاك، هال

[ii] أو مرورها] - ب، هاك، هال

[iii] ثانياً] + بالحركة اليومية: ب، شاك

[iv] العاشرة] + من الحمل: هار، هاهاك، هال

[v] ولو] وليس لو: مضاف في: متن ر، متن ل، هاك

والمعدّل.§ [vi] /لأنّ/§ [vii] حركتها فيما يطلع مستوياً وإن اقتضت الزيادة على دور المعدّل، لكنّها فيما يطلع معكوساً يقتضي النقصان من دورة بقدر تلك الزيادة، فيتساقطان. ويكون العودة/* [viii] بدورة فقط، وهي مفارقة نقطة من المعدّل عن مسامتة نقطة[١٤٧] وعودها إليها. والزمان الذي يتخلّل بين المفارقة والعود هو زمان دورة تامّة للفلك الأعلى.§ [ix] وما ذكرناه جامع مانع. وإذا أطلقوا اليوم، أرادوا به اليوم بليلته، وكذلك الأيّام.

[١ب] وإذا عرفتَ ذلك، فاعلم أنّ اليوم بليلته /في المعمورة/* [x] ينقسم إلى حقيقي ووسطى، /ويسمّى اليوم الوسط أيضاً./† [xi] أمّا الحقيقي فهو زمان يتخلّل بين مفارقة الشمس نصف دائرة عظيمة تتوهّم ثابتة وبين عودها إليه، وهو دورة تامّة للمعدّل وما يجوز منه على ذلك النصف مع القوس التي تقطعها الشمس بحركتها الخاصّة في الزمان الذي تعود فيه إلى ذلك النصف. وإنّما قلنا «نصفاً من دائرة عظيمة» ليشمل نصف الأفق الشرقي إن جعل المبدأ الطلوع، والغربي إن جعل الغروب، ونصف النهار إن جعل المبدأ المرور به. وإنّما قلنا «ما يجوز منه» دون «ما يطلع منه»، على ما هو المشهور، ليشمل الطلوع والغروب والمرور بنصف النهار.[١٤٨] وإنّما كان الزمان أكثر من زمان دورة لأنّ الشمس لو كانت ساكنة لا تتحرّك، لكان زمان

[vi] المعدّل] + بناءً على: هار، هاك، هال

[vii] لأنّ] ان: ب = مضاف في: متن ر، متن ل، هاك

[viii] ما يقتضي مسير الشمس... ويكون العودة] هاب، هاك

[ix] الفلك الأعلى] + لأنّ هذا التفاوت إنّما يظهر في اليوم بليلته لا في بعضه نعم لو أمكن لكان عودتا الشمس في يومين متتاليين متساويتين لعودتين من المعدل على ما لا يخفى: هار، هاك، هال

[x] في المعمورة] هاب، هاك

[xi] ويسمّى اليوم الوسط أيضاً] وغيرهما: ب، طاك، طال = مضاف في المتن والهامش: ك، ل

عودتها إلى نقطة مفروضة جعلت مبدأ حركتها،[§] [xii] مساوياً لزمان عودة معدّل[١٤٩] النهار، لكنّها تتحرّك بخلاف حركة الكلّ. فإذا فرضناها على دائرة نصف النهار، كانت نقطة ما من المعدّل معها عليها. فإذا دار الفلك إلى أن عادت تلك النقطة إلى نصف النهار، لم تَعُد معها الشمس إليه؛ لأنّها قد سارت قوساً من فلك البروج بسيرها الخاصّ بها. فإذا تحرّك الفلك إلى أن عادت الشمس إليه، فتكون قد انتهت إلى نصف النهار نقطة أخرى من المعدّل. فما بين النقطتين هو الزيادة على دور المعدّل. وأمّا اليوم الوسط فهو زمان دورة للمعدّل، وقوس منه مساوية لحركة الشمس الوُسطى وهي ο نط ح ك. وهذا اليوم هو الذي يوضع عليه في الزيجات أوساط الكواكب وغيرها من الحركات التي لا تختلف، إذ لو وضعت على الحقيقية[١٥٠] لتعسّر أو تعذّر تركيب الجداول لاختلاف الحقيقية.[١٥١]

[١ج] وإنّما سمّي الأوّل بالحقيقي لاعتبار مسير الشمس الحقيقي، وهو مسيرها بالنسبة إلى مركز العالم؛ والثاني بالوسط لاعتبار مسير وسط الشمس؛ لا لما ذكره الخرقي، وهو: «أنّ عودة الشمس إلى نقطة بعينها من فلك البروج في السنة الواحدة تزيد على عودات معدّل النهار بعودة واحدة لزيادة عودتها كلّ يوم على عودة المعدّل بقوس صغيرة. إذا جُمعت تلك القسي في السنة ساوت عودة واحدة. فإذا قُسّمت تلك العودة الزائدة على أيام سنة الشمس أصاب كلّ يوم ο نط ح ك. فكان مقدار اليوم بليلته الوسط شس نط ح ك.» لأنّ هذا لا يصلح للتعليل، وبتقدير صلاحيته له، فعودات المعدّل تزيد على عودات الشمس، لا بالعكس كما ذُكر. لأنّ كلّ عودة الشمس إلى نصف النهار مثلاً، لمّا كانت أزيد من عودة المعدّل إليه، فتكون عودات المعدّل زائدة على عودات الشمس في السنة بعودة من المعدّل. ألا ترى أنّ الشمس لو كانت تقطع

[xii] حركتها] متغير إلى «اليوم بليلته»: ر، ك، ل

بسيرها الخاصّ في يوم ربعاً من البروج مثلاً لكانت تعود إلى نقطة من البروج بعينها بأربع عوداتها إلى نصف النهار المساوية لخمس عودات من المعدّل؟ لأنّ عودة الشمس على هذا الفرض تزيد على عودة المعدّل بربعها.

[١د] فهذان اليومان هما المستعملان عند أهل الصناعة، وأمّا غيرهما كالأيّام بلياليها في العروض التي لا عمارة فيها فبمعزِلٍ عن نظرهم.

[٢] وأمّا سبب اختلاف الحقيقية[١٥٢] فشيئان: أحدهما اختلاف **ما تقطعها الشمس** بسيرها الخاصّ **فإنّها تقطع في النصف البعيد قسيّاً أصغر وفي النصف القريب قسيّاً أكبر**؛ وثانيهما اختلاف **ما يطلع من معدّل النهار مع القسي من فلك البروج فإنّه تارة يكون أصغر منها وتارة أكبر.** وليس هذا لاختلاف مسيرها، /فيندرج في الأول،/[†] [xiii] لأنّها لو كانت تقطع في الأيّام قسيّاً متساوية لزم ذلك أيضاً؛ لأنّها لا تجوز على الدوائر في أزمان متساوية، لأنّها تجوز على الأفق الشرقي بمطالع البلد وعلى الغربي بمطالع /نظيرها/[*] [xiv] وعلى نصف النهار بمطالع الفلك المستقيم، وهذه المطالع مختلفة من أين أخذت. فلهذين يكون الأزمان الزائدة على مقدار دورة[١٥٣] للفلك[١٥٤]، بل **مقادير الأيّام بلياليها مختلفة؛ لكن اختلافها غير محسوس في يوم أو يومين لصغر التفاوت، ويحسّ به في أيام كثيرة. وأهل الحساب لمّا اضطرّوا** لما قلنا **إلى استعمال أيام بلياليها متساوية الأقدار لمعرفة حركات الأوساط وغيرها، أخذوا تلك الزيادة مقدار حركة الشمس الوسطى في يوم بليلته** من المعدّل، لما مرّ من العلة. وهذان اليومان قد يتساويان وقد يختلفان، لأنّ المطالع إمّا أن يكون مساوية لدرج السواء، أي للتقويم، أو زائدة عليه، أو ناقصة منه. وعلى كلّ تقدير فالتقويم إمّا مساوٍ للوسط، أو زائد عليه، أو ناقص منه. فالأقسام تسعة لا غير. والحقيقي

[xiii] فيندرج في الأول] هاب، هاك، هال

[xiv] نظيرها] نظيره: ب = متغير من «نظيره»: ك

مساوٍ للوسطى على الأول، وزائد عليه على الثاني، وناقص منه على الثالث. وأيضاً الحقيقي زائد على الوسطى على الرابع وعلى الخامس وعلى السادس إن كانت زيادة المطالع على التقويم أكثر من زيادة الوسط عليه، وناقص منه إن كان بالعكس، وتساويا إن تساوتا. وأيضاً الحقيقي ينقص من الوسطى على السابع وعلى الثامن إن كان نقصان المطالع من التقويم أكثر من نقصان الوسط منه، ويزيد عليه إن كان بالعكس، وتساويا إن تساويا. وعلى التاسع أيضاً، وهو ظاهر؛ هذا بالنظر المطلق وبالنسبة إلى نفس الأمر، **وأمّا التحقيق فمحوّج إلى معرفة جملة كلّ واحد من التفاوتين.**

[٣] **أمّا التفاوت الذي يكون بسبب اختلاف سير الشمس: فيكون في المدّة التي تسير الشمس من الأوج إلى البعد الأوسط الذي يليه زيادة وسط الشمس على تقويمها بقدر غاية الاختلاف،** وهي درجتان، **وفي المدّة التي من البعد الأوسط الآخر إلى الأوج مثل تلك.** فإن قيل هذا يدلّ على أنّ الوسط زائد على التقويم، إذا صعدت من البعد الأوسط إلى الأوج، وقولكم في هيئة أفلاك الشمس «والتعديل يزاد على الوسط ما دامت صاعدة» يدلّ على أنّ التقويم زائد على الوسط هناك، وهو تناقض، قلنا لا تناقض فيه إذ لا منافاة بين أن تكون القوس التقويمية زائدة على القوس الوسطية، كما قلنا هناك، وبين أن تكون الحركة التقويمية ناقصة من الحركة الوسطية، كما قلنا هاهنا. فـإذن **تكون زيادة الوسط على التقويم في القطعة البعيدة من الأرض من فلك الشمس بقدر ضعف الاختلاف؛ وتكون في القطعة القريبة زيادة التقويم على الوسط أيضاً بمثل ذلك. ويكون الفضل بين القطعتين بأربعة أمثال الاختلاف.**

[٤أ] **وأمّا التفاوت الذي يكون بسبب المطالع: فإن جُعل مبادئ الأيّام انتهاء الشمس إلى الأفق اختلف ذلك التفاوت بحسب اختلاف الآفاق، ولم يكن في جميع** الآفاق **شيئاً واحداً بعينه؛ ويكون ذلك إن كان المبدأ انتهائها إلى الأفق الشرقي**

بحسب التفاوت بين درج السواء ومطالعها في ذلك الموضع، وحينئذ يتركّب تفاوت سير الشمس مع تفاوت مطالع[١٥٥] البلد في الأفق المطلوب. وتفاوت سير الشمس في النصف الأوجي أو الحضيضي مع النصف الوسطي أربعة أجزاء. وتفاوت المطالع في النصف الحملي أو الميزاني مع النصف الوسطي ضعف[١٥٦] تعديل النهار الكلّي. ولمّا كان الأوج قريباً من الانقلاب الصيفي، ففي الربع الربيعي تنقص الحقيقية عن الوسطى بقدر مجموع اختلافٍ واحد وتعديل نهار واحدٍ؛ وفي الربع الصيفي تزيد بقدر فضل تعديل نهارٍ على اختلافٍ؛ وفي الربع الخريفي تزيد بمجموع اختلاف وتعديل نهار؛ وفي الربع الشتوي تنقص بفضل تعديل[١٥٧] نهار على اختلافٍ. وبسبب اختلاف مقادير تعديل النهار بحسب البقاع، تُرك هذا الاعتبار. ولو جعل المبدأ أفق الغرب يكون تفاوت تعديل الأيّام للنصف الحملي والميزاني في الزيادة والنقصان بخلاف ما في الأفق الشرقي، /لما تقدّم من أنّ مغارب القسي كمطالع نظائرها وأنّ مطالع النظائر مختلفة بالزيادة والنقصان. وأيضاً يكون أعني تفاوت تعديل الأيّام المأخوذ مبادئها من أفق الغرب في البلاد الشمالية مثل ما في البقاع الجنوبية المأخوذة مبادئ أيّامها من أفق الشرق إذا تساويا في العرض، لما تقدّم أيضاً أنّ مغارب القسي في الشمالية كمطالعها في الجنوبية بالشرط المذكور وبالعكس./[*] [xv] وقس التركيبات على ما ذكرنا.

[٤ب] **وإن جُعل مبادئ الأيّام انتهائها إلى نصف النهار اتّفق التفاوت في جميع الآفاق، ويكون ذلك بحسب مطالع خطّ الاستواء؛ فاختاروا ذلك دون الوجه الأوّل.** واعلم أنّ الذين جعلوا مبادئ أيّامهم من نصف النهار إليه فمبادئها في البلدان المتّفقة في الطول لا يكون بينها اختلاف أصلاً. وأمّا اختلاف مبادئها في البلاد المختلفة في الطول فقط، والمختلفة في الطول والعرض معاً، فإنّما يكون بقدر التفاوت في الطولين فقط. فإذن لا يخالف الأيّام المأخوذة مبادئها من نصف النهار الحقيقية منها

[xv] لما تقدّم من أنّ مغارب القسي... كمطالعها في الجنوبية بالشرط المذكور وبالعكس] هاب، هاك = + ويكون مثل ما في البقاع الجنوبية: شاب، شاك

الوُسطى إلّا بقدر /ما يخالف/* [xvi] مطالع مقوّم مسير الشمس بخطّ الاستواء لحركتها الوسطى فقط، وغايته نصف ساعة ونصف تسع ساعة مستوية. وأمّا الأيّام التي جُعلت مبادئها من الأفق الشرقي أو[١٥٨] الغربي فاختلاف مبادئها في المتّفقة العرض يكون بقدر ما بين الطولين؛ وفي المختلفة العرض /فقط/*[xvii] يكون الاختلاف كذلك في المبادئ /بقدر ما يقتضيه تفاوت العرض،/* [xviii] فإنّ الشمس تطلع على المتساوية في الطول التي هي أميل إلى الشمال قبل طلوعها على التي هي أقلّ ميلاً /إذا كانت في الشمال عن تقاطع الأفقين، كما تقدّم في أوائل الكتاب،/* [xix] وفي المقدار أيضاً لاختلاف مطالع مسير الشمس؛ وفي المختلفة طولاً وعرضاً يكون مركّباً من الاختلافات الثلاثة /المذكورة آنفاً./* [xx]

[٥] وقد مرّ أنّ فلك البروج ينقسم إلى أربع قطع: اثنتان منها اللتان يتوسّطها الاعتدالان تزيدان على مطالعيها، وهما من أواسط الدلو إلى أواسط الثور ومن أواسط الأسد إلى أواسط العقرب؛ ومقدار زيادة كلّ واحدة منهما على مطالعها[١٥٩] بخطّ الاستواء خمس درجات. والقطعتان الأخريان وهما اللتان يتوسّطها الانقلابان تنقصان عن مطالعيها، وهما من أواسط الثور إلى أواسط الأسد ومن أواسط العقرب إلى أواسط الدلو؛ ومقدار نقصان كلّ واحدة منهما من مطالعها[١٦٠] بخطّ الاستواء أيضاً خمس درجات.

[xvi] ما يخالف] هاب، هاك

[xvii] فقط] هاب، فاك

[xviii] بقدر ما يقتضيه تفاوت العرض] هاب، هاك

[xix] إذا كانت في الشمال عن تقاطع الأفقين كما تقدّم في أوائل الكتاب] هاب، هاك

[xx] المذكورة آنفاً] هاب، هاك

[٦] **وإذا تركّب التفاوتان بالجمع إذا كانا زائدين معاً أو ناقصين معاً أو بالتفريق إذا اختلفا، حصل مقدار التفاوت بين الأيّام الوُسطى والأيّام الحقيقية جملة في السنة.** ويسمّى هذا التفاوت تعديل الأيّام بلياليها. وغايته تسع درجات، لأنّ التفاوت بين النصف الأوجي أو الحضيضي والنصف الوسطى بقدر ضعف التعديل، وهو أربع درجات؛ وبين الربع الاعتدالي والانقلابي والربع الوسطى بخمس درجات. فإذن غاية التفاوت بين الأيّام الناقصة والوسطى أو الزائدة والوسطى بسبب الاختلافين تسع درجاتٍ. ويكون التفاوت بين الأيّام الناقصة والزائدة /الحقيقيتين/[*xxi] بثماني عشرة درجة. وإذا وصلت الشمس بحركتها الخاصّة إلى موضعها الأوّل وتمّ الدور، انتفى ذلك التفاوت وسقط هذا الاعتبار ويتساوي مجموع الوسطى مع مجموع الحقيقية بالتقريب إلّا القدر الذي يكون بسبب حركة أوج الشمس.

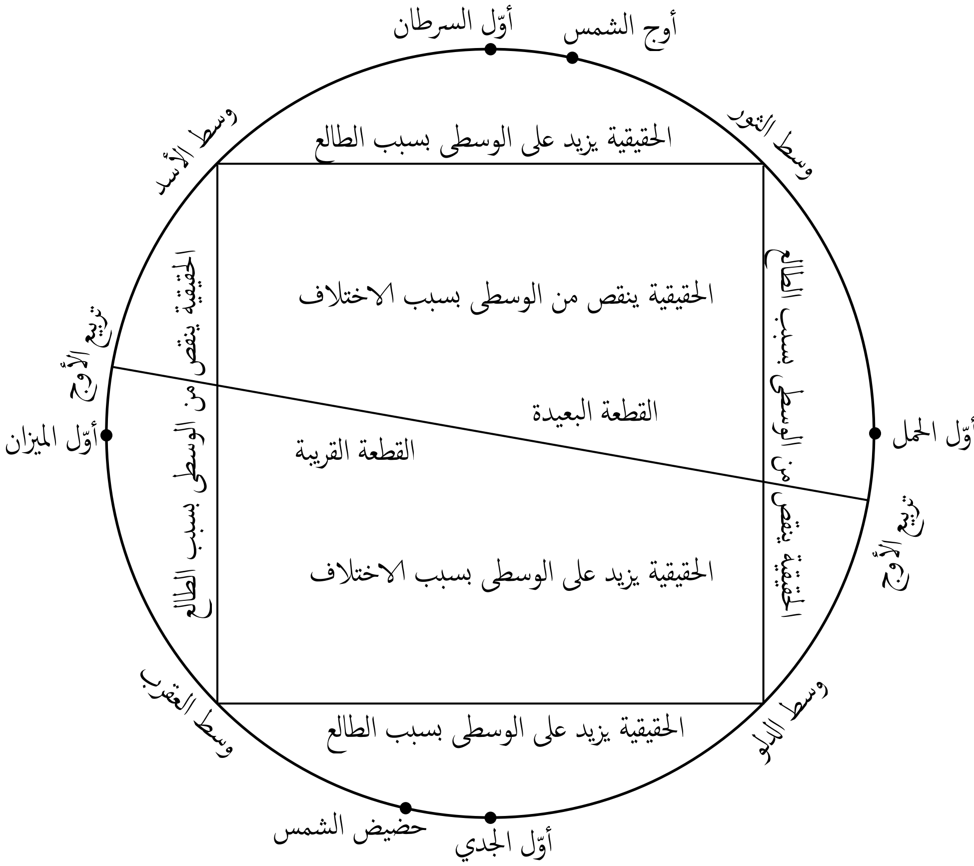
[٧] **ولا بدّ من يُوم يفرض مبدأً ويقاس سائر الأيّام إليه؛ فيكون نصف نهار ذلك اليوم مبدأً للأيّام الوسطى والحقيقية جميعاً. وكلّ يوم من السنة يفرض مبدأً يكون التفاوت بين الأيّام الماضية الوسطى والحقيقية**[١٦١] **الماضية من ذلك اليوم تارة زائداً وتارة ناقصاً إلّا أواخر الدلو وأوائل العقرب؛ فإنّ المبدأ إذا جُعل أواخر الدلو كانت الأيّام الحقيقية دائماً ناقصة من الوسطى** لاجتماع الزيادتين هناك، **وإذا جُعل أوائل العقرب كانت الأيّام الحقيقية دائماً زائدة على الوسطى.** وبيانه على سبيل التفصيل هو أنّه لمّا كان الأوج في الجوزاء كان نقصان المرئي من الوسطى بحسب التفاوت الأوّل في[١٦٢] النصف الذي من الحوت إلى السنبلة، وزيادته عليه في النصف الآخر. وإذا تركّب التفاوتان اجتمع فيما بين أوائل الحوت إلى أواسط الثور نقصانان بحسب الأمرين، ومنها إلى /أواسط/[†xxii] الأسد تلحق الزيادة بحسب المطالع بقدر ما لحقه النقصان بحسبها أيضاً

[xxi] الحقيقيتين] هاب، هاك

[xxii] أواسط] وسط: ب = متغير من «وسط»: ك، ل

في الربع الذي قبله. ويبقى النقصان المجتمع بحسب التفاوت الأوّل بحاله. ثمّ يجتمع النقصانان إلى أوائل السنبلة. ويأخذ اختلاف الشمس في الزيادة مع كون المطالع ناقصة إلى أن يتكافيا عند آخر الميزان. ثمّ تغلب الزيادة وتجتمع الزيادتان[١٦٣] فيما بين أواسط العقرب وأواسط الدلو. ثمّ يحدث النقصان بحسب المطالع. ويحصل من ذلك انقسام دائرة البروج بحسب هذا[١٦٤] الائتلاف إلى قسم يظهر فيه النقصان مطلقاً، وهو ما بين وسط الدلو وآخر الميزان، وقسم يظهر فيه الزيادة مطلقاً، وهو ما بين أوّل العقرب ووسط الدلو. ويظهر منه ما ذكرناه إلّا أنّ **أهل الصناعة** اتّفقوا **على جعله أواخر الدلو.** ولهذا يكون أبداً الأيّام الحقيقية ناقصة عن الوسطى. /وزيادة اليوم الحقيقي على الوسطى والشمس في القطعة الصغرى، كعاشرة الجدي مثلاً، لا ينافي كون الأيّام الماضية الحقيقية من أواخر الدلو إلى عاشر الجدي ناقصة عن الأيّام الوسطى التي بينهما، لأنّ النقصانات الحاصلة في القطعة الكبرى لا تنجبر إلّا إذا قطعت الشمس الصغرى ووصلت إلى المبدأ، أعني أواخر الدلو./[*] [xxiii] **وهذه صورة القطع على أنّ الأوج في آخر الجوزاء:**

[xxiii] وزيادة اليوم الحقيقي على الوسطى... إلى المبدأ أعني أواخر الدلو] هاب، هاك



[شكل ٧]

ويتغيّر تفاوت الاختلاف بسبب حركة الأوج ولكنّ في مدّة طويلة.

[٨] **فهذا بيان التفاوت في مقادير الأيّام. ووجود المقادير في كلّ وقت يتعلّق بكتب العمل،** فالأولى أن نترك بيانها إليها، والله أعلم.[١٦٥]

الباب **التاسع**

في الصبح والشفق

[١أ] إنّ الصبح والشفق استنارة في كرة البخار لإقبال الشمس في الأفق الشرقي ولإدبارها في الغربي. وهما متشابهان شكلاً /ومتقابلان وضعاً،/*[i] لأنّ هيئة /أوّل/*[ii] طلوع الفجر مثل /آخر/*[iii] غروب الشفق. ومختلفان لوناً لاختلاف /كيفية هواء/*[iv] الأفق الذي يظهران فيه، واختلاف لون الشمس عند الطلوع والغروب، وكذا شعاعها، وما يستضيء من الجوّ بضيائها، لاختلاف لون[١٦٦] البخار في كلتي الجهتين. إذ لون البخار في المشرق يكون إلى الصفاء والبياض للرطوبة المكتسبة من برودة الليل، وفي المغرب إلى الصفرة لغلبة الجزء الدخاني المكتسبة من حرارة النهار. مع أنّ الجسم[§][v] كلّما كان أكثر صفاءً وبياضاً، /كان أضوأ وكان/*[vi] الشعاع المنعكس منه أقوى ضياءً من الشعاع المنعكس من غيره. ولهذا ما تُرى[١٦٧] الأشياء المتساوية العظم والبعد الأبيض منها قبل الأحمر والأصفر وهما قبل الأدكن والأغبر.

[١ب] وأمّا كرة البخار فهي عبارة عن الهواء المتكاثف بما فيه من الأجزاء الأرضية والمائية المتصاعدة من كُرَتَيها بتبخير الشمس وغيرها إيّاها. وشكل هذا الهواء شكل كرة محيطة بالأرض على مركزها وسطح موازٍ لسطحها لتساوي غاية ارتفاعها عن مركز الأرض في جميع النواحي المستلزم لكريتها. لكنّها مختلفة القوام لأنّ ما كان منها أقرب إلى الأرض فهو أكثف ممّا بعد

---

[i] ومتقابلان وضعاً] هاب، هاك

[ii] أوّل] فاب، فاك

[iii] آخر] مضاف بعد التحرير في ب، ك

[iv] كيفية هواء] هاب، هاك

[v] الجسم] + الكثيف: هاب، هار، هاك، هال

[vi] كان أضوأ وكان] متغيِّر من «كان» في متن وهامش ب، ك

ـــ لأنّ الألطف يتصاعد ويتباعد أكثر من الأكثف، وهو واضح ـــ لكن لا يبلغ في التكاثف بحيث يحجب ما /ورائه./[†] [vii]

وهي تنتهي في ارتفاعها إلى حدّ لا تتجاوزه، وهو من سطح الأرض أحد وخمسون ميلاً وكسر على ما سنبيّن في الأبعاد والأجرام ـــ إن شاء الله العزيز. وكرة البخار تسمّى[١٦٨] أيضاً عالم النسيم، يعني مهبّ الرياح، إذ ما فوقها من الهواء الصافي عن الهباءات والأبخرة والأدخنة ساكن لا يضطرب. /وبعضهم يسمّيها كرة الليل والنهار إذ هي القابلة للنور والظلمة، دون ما عداها من الهواء الصافي، والزرقة التي يظنّ الناس أنّها لون السماء تظهر فيها. لأنّ الأجزاء القريبة من سطح كرة البخار أقلّ قبولاً للضوء لكثرة البعد واللطافة من الأجزاء القريبة من الأرض، فلهذا يكون كالمظلمة بالنسبة إلى هذه الأجزاء. وإذا نفذ نور البصر من الأجزاء المستنيرة بأشعة الكواكب إلى التي هي كالمظلمة، رأى الناظر ما فوقه من الجوّ المظلم بما يمازجه من الضياء الأرضي والضياء الكوكبي لوناً متوسطاً بين الظلام والضياء، وهو اللون اللازوردي. كما إذا نظر من وراء جسم مشفّ أحمر مثلاً إلى جسم أخضر فإنّه يظهر له لون مركّب من الحمرة والخضرة./[‡] [viii]

[١ج] ولأنّ أوّل الفجر وآخر الشفق إنّما يوجدان وانحطاط الشمس عن الأفق ثماني عشرة درجة أو تسع عشرة، وإذا كان بعدها من الأفق أكثر من ذلك لم يُر شيء من الضياء فيه، فعُلم أنّ الضياء من قبل الشمس. وإلّا لما أثّر قربها وبُعدها فيه؟ ولكنّ لا من ضيائها الواقع على سطح ظاهر الأرض، /لأنّه يعدّ مظلم،/[*] [ix] إذ الشمس على هذا تحت الأفق الحسّي /بكثير، وإذ ذاك فلا يقع شعاعها على سطحه الظاهر لا بالاستقامة لا بالانعكاس، مع أنّ/[*] [x] البصر إنّما يدرك ما فوقه

[vii] ورائه] خلفه: ب = متغيَّر من «خلفه»: ك، ل

[viii] وبعضهم يسميها كرة الليل والنهار... يظهر له لون مركب من الحمرة والخضرة] - ب، هاك، هال

[ix] لأنّه يعدّ مظلم] هاب، هاك

[x] بكثير وإذ ذاك فلا يقع شعاعها على سطحه الظاهر لا بالاستقامة لا بالانعكاس مع أنّ] هاب، هاك

بل من ضيائها الواقع على[١٦٩] /ما خشن وكثف من/[xi] سطح مخروط ظلّ الأرض المسمّى بالليل. لأنّ شعاع الشمس محيط بالمخروط ومنبثّ في جميع الأفلاك سوى ما يحويه مخروط ظلّ الأرض لكثافة جرمها، وهو مقدار يسير من فلكي القمر وعطارد. فما خلا هذا القدر من الفلك يكون مستضيئاً بضياء الشمس.[§] [xii] ومن أجل أنّها مشفّة في الغاية ينفذ فيها النور فلا ينعكس عنها، فلذلك لم نرها مضيئةً، وكذا الهواء المحيط بكرة البخار الخالي عن الهبآت. وأمّا المختلط بالهبآت /وهو الخشن الكثيف من سطح مخروط ظلّ الأرض،/[*] [xiii] فيُرى لكون الأجزاء الأرضية المستنيرة بضياء الشمس فيه كما يُشاهد عند دخول الشعاع من كوّة في بيت إلى ظلمة[١٧٠] ما هو.

[١د] ولأنّ أحوال الفجر والشفق متماثلة، غير أن الفجر يبدأ من ضياء ضعيف هو البياض المستدقّ المستطيل، ثمّ البياض العريض المنبسط، ثمّ الحمرة؛ والشفق يكون بعكس ذلك إذ بعد الغروب يكون حمرة، ثمّ البياض العريض المنبسط، ثمّ[١٧١] البياض[١٧٢] المستدقّ المستطيل إلى أن يخفى. لكن قلّ ما يدرك خفاء هذا البياض لكونه وقت النوم وتفرُّغ[١٧٣] الناس للسكون إلى أكنافهم، بخلاف البياض المستدقّ الأوّل، لأنّه وقت استكمال الراحة والاستعداد للمصالح، فكان الناس ينتظرون فيه طليعة النهار لطلوع الفجر ليأخذوا في الانتشار لحوائجهم. فإذن لتماثل أحوالهما، إذا بيّنا أمر أحدهما اكتفينا به في الآخر، ولأنّ الفجر أشرف والاعتناء به أشدّ، قدّمنا ذكره.[١٧٤] فنقول **إذا قربت الشمس من الأفق الشرقي مال مخروط ظلّ الأرض نحو المغرب، فيكون المرئي من الشعاع المحيط به،** /أعني بالكثيف منه،/[*] [xiv] **أوّلاً ما هو أقرب إلى البصر**، وهو ما

[xi] ما خشن وكثف من] هاب، هاك

[xii] الشمس] + أي واصلاً إليه شعاعها: هار، هاك، هال

[xiii] وهو الخشن الكثيف من سطح مخروط ظلّ الأرض] هاب، هاك

[xiv] أعني بالكثيف منه] هاب، هاك

فوق الأفق لا ما عنده بقرب الأرض؛ لأنّ **الأقرب من جوانب المخروط إلى البصر هو الجانب الذي يلي الشمس،** لميل المخروط إلى جهة الغرب والأقرب من هذا الجانب إلى البصر هو ما ذكرنا.

[١هـ] وليتوهّم لبيان ذلك **سطح** يمرّ **بمركزي الشمس والأرض وبسهم المخروط، وليحدث منه مثلّث حادّ الزوايا قاعدته على الأفق وضلعاه على سطح المخروط. ولا** يخفى **أنّ الأقرب من الضلع الذي يلي الشمس إلى الناظر يكون موقع العمود الخارج من النظر الواقع على ذلك الضلع، لا موضع اتّصال الضلع بالأفق؛** لأنّه أطول من العمود لكونه وتر قائمة والعمود وتر حادّة. وإنّما لا يقع العمود على موضع الاتّصال لكون تلك الزاوية حادّة /ومساوية لنظيرتها إذا كانت الشمس في وتد الأرض. وبعد انتقالها منه تزيد المشرقية حدّة والمغربية اتّساعاً، وليستا متساويتين في جميع الأوضاع على ما يسبق إلى الوهم. وإنّما يلزم ذلك لو كان قاعدة المثلّث، أعني قطر الأفق الحسّي، متحرّكة بحركة المثلّث، وليس كذلك. فلذلك، أعني لحدّة المشرقية، لا يقع العمود على موضع الاتّصال/ * [xv] ولا تحت الأفق على الضلع المذكور /أيضاً؛/ * [xvi] وإلّا لزم في مثلّث قائمة هي الحادثة من العمود، ومنفرجة تحت الأفق هي الحادثة من تقاطع قطر الأفق الحسّي والضلع المذكور، لأنّ الزاوية الفوقانية من تقاطعهما حادّة فبالضرورة يقع العمود على الضلع المذكور فوق الأفق. **فإذن أوّل ما يُرى نور الشمس يُرى فوق الأفق كخطّ مستقيم منطبق على الضلع المذكور، ويكون ما يقرب من** الأرض **بعدُ مظلماً. فلذلك يسمّى ذلك النور بالصبح الأول،** لأنّه

[xv] ومساوية لنظيرتها ... لا يقع العمود على موضع الاتّصال] هاب، هاك

[xvi] أيضاً] فاب، هاك

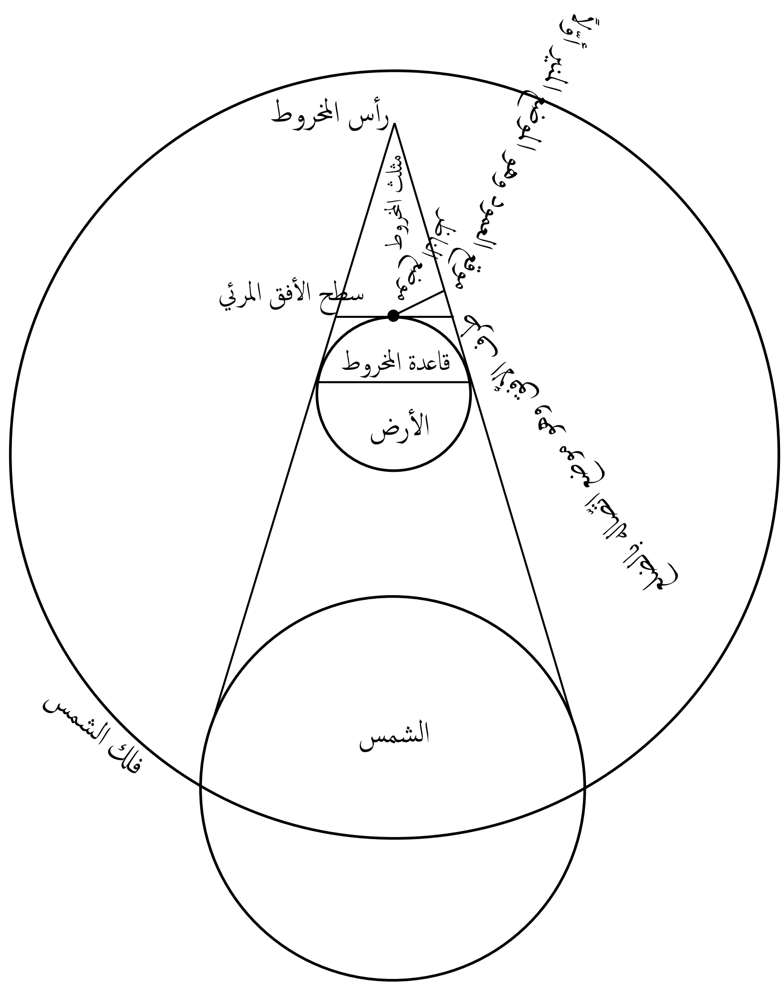
أوّل نور يظهر؛ وبذنب السرحان لدقّته واستطالته تشبيهاً له به؛ وبالصبح الكاذب **لكون الأفق مظلماً، أي لو كان يصدُق أنّه نور الشمس لكان المنير ما** يقرب من **الشمس** لا **ما يبعد منه.**§ [xvii] [١٧٥]

[٢أ] ثم إذا قربت الشمس جدّاً انبسط النور، فصار الأفق منيراً§[xviii] ذا بياض عريضٍ[١٧٦] **ويصير الصبح صادقاً؛** لأنّ ضيائه[١٧٧] أصدق من الضياء الأوّل، لا لأنّه لا تعقبه ظلمة بخلاف الكاذب، فإنّه يعقبه ظلمة تكذّبه على ما زعم بعضهم. لأنّ الصحيح، /على ما سنبيّن،/*[xix] أنّ الأوّل يكون موجوداً وإنّما يخفى لغلبة الضوء الشديد الطارئ عليه، كما يخفى ضوء الشمس أضواء المشاعل والنيران والكواكب. وإذا وصل نور الشمس إلى سطح مجاور للأفق ظهرت الحمرة. **والشفق يكون بعكس الصبح،** كما ذكرنا.[١٧٨] **وهذه صورة الأفق والمثلّث والعمود والشمس والأرض:**

[xvii] منه] متغير إلى «منها»: ل

[xviii] منيراً] متغير إلى «المنير»: ل

[xix] على ما سنبيّن] هاب، هاك



[شكل٨]

هذا هو المشهور عند الجمهور في هذا المقام.

[٢ب] وقال قوم سبب كلّ من الفجر الأوّل والشفق الأخير المستطيلين وقوع الشعاع من الشمس في ذلك الوقت على البحر من جهتي المشرق والمغرب. ثمّ ينعكس الشعاع إلينا من سطح الماء فيحصل الاستنارة. ثمّ ينقطع الشعاع المتّصل من الشمس الواقع على البحر ويقع على بسيط الأرض، فيمتنع انعكاسه ونفوذه إلينا زمان ما بين الفجرين. ثمّ يظهر شعاع

الشمس من نواحي الأفق، فيستنير بالسبب الأوّل. وكذلك في مغيب الشفق على نحو ذلك. وهذا وأمثاله أمور تخمينية تقريبية لا تحقيق فيها.

[٢ج] ونحن نقول ولأنّ قاعدة مخروط ظلّ الأرض هي دائرة عليها تكاد تكون عظيمة، وإن كانت ليست عظيمة لما تقدّم في كط،[١٧٩] ينقسم الأرض بها بقسمين أحدهما أكبر، وهو المستنير، والآخر أصغر، وهو المظلم المقابل للجهة المستنيرة. وهذان العرَضان، أعني الضياء والظلمة، متحرّكان على سطح الأرض في اليوم بليلته دورة واحدة. أمّا حركة الضياء فمن المشرق إلى المغرب، وأمّا حركة الظلمة فمن المغرب إلى المشرق. ولأنّ مخروط الظلّ قطع كرة البخار، وسهمه قائم على /مركز قاعدته،/*[xx] فالفصل[١٨٠] /المشترك/*[xxi] بينهما يكون دائرة موازية لقاعدة المخروط متحرّكة بحركة الشمس الحركة اليومية لحركة سهمها، فإنّ كلّ خطّ قائم على مركز دائرة يقال له سهمُها. ولنسمّها دائرة المخروط، وهي الفاصلة بين الهواء الذي لا يستضيء بضياء الشمس لكونه مشفّاً في الغاية، وهو ما وراء محيطها، وبين ما يقبل الضياء، وهو ما تحتها، أعني ما بينها وبين الشمس من كرة البخار، /لا ما فوقها منها لكونه داخل مخروط الظلّ أبداً./*[xxii] فتكون القطعة المحيطة بالمخروط المنفصلة به من كرة البخار بين سطح هذه الدائرة وقاعدة المخروط مستضيئة بضياء الشمس لكونها مشحونة بالأجزاء الأرضية. وإذا توهّم سطح الأفق الحسّي قاطعاً لكرة البخار، حدث على سطحها دائرة ثابتة لأنّها لا تفارق سطح الأفق، وسهمها الخطّ المارّ بسمت الرأس. ولنسمّها دائرة البخار، وهي تفصل بين ما يُرى من كرة البخار وهو ما فوقها وبين ما لا يُرى منها وهو ما تحتها.

[xx] مركز قاعدته] مركزها: ب = متغير من «مركزها»: ك

[xxi] المشترك] - ب، هاك

[xxii] لا ما فوقها منها لكونه داخل مخروط الظلّ أبداً] - ب، هاك

[٢د] ولكون دائرة البخار أصغر من دائرة المخروط، لما سنبيّن، فتكون في عامّة الليل دائرة البخار فوق دائرة المخروط. فلذلك لا يَعلو فوق دائرة البخار شيء من القطعة المضيئة المحيطة بالمخروط من كرة البخار ولا يُرى شيء من الهواء مضيئاً. ولنمثّل لذلك مثالاً: في بلدٍ لا يكون عرضه أكثر من الميل الكلّي لتكون الدائرة السمتية في ذلك البلد وقت مرور دائرة البروج على سمتهم هي دائرة البروج، فيسهل تصوّر ما نقول. فليكن الوقت نصف الليل ونتوهّم دائرة السمت، أعني دائرة البروج، قاطعة لكرة الأرض على دائرة ب ج؛ ولكرة الشمس على دائرة آ؛ ولكرة البخار على دائرة د ه؛ ولمخروط الظلّ على مثلث ز[١٨١] ب ج. وليكن الفصل المشترك بين دائرتي السمت والمخروط خطّ ح ط، /وهو موازٍ أبداً لخطّ ب ج، قطر قاعدة المخروط، لقيام سهم المخروط عليها أبداً وبحركتها مع حركته؛/*[xxiii] وبين دائرتي السمت والبخار خطّ ك ل. وظاهر أنّ ح ط ، ك ل قطران لدائرتي المخروط والبخار لمرور الدائرة السمتية بمركزهما، وأنّ المستنير من كرة البخار هو القطعة المضيئة المحيطة بالمخروط وهي ب د ح، ج ه ط، وما بينهما ممّا يلي جهة الشمس،[١٨٢] /وهو قطعة د ع ه ج ف ب./*[xxiv] ومركز الأفق، وهو موضع البصر م. والسطح الممتدّ من البصر هو المارّ بنقطتي ن، س، وهما في الهواء المشفّ فلا يرى البصر شيئاً منه يستضيء. فإذا تحرّك الشمس نحو المشرق،[١٨٣] مال الظلّ نحو المغرب[١٨٤] وارتفع الجانب الشرقي من دائرة المخروط إلى أن تصل نقطة ح إلى نقطة ك، فتصير ك مشتركة بين محيطي دائرة[١٨٥] المخروط والبخار. فلذلك يلوح أوّل الفجر مستدقّاً خفياً لتماسّ الدائرتين على نقطة. ثمّ يقطع أحدهما من الآخر جزءاً صغيراً. فيمتدّ ضياؤه[١٨٦] في طول مخروط الظلّ على الفصل المشترك بين الضياء المحيط بالمخروط وبين الظلمة التي في داخله. وكلّما أزداد ميل المخروط أزداد ارتفاع الجانب الشرقي من

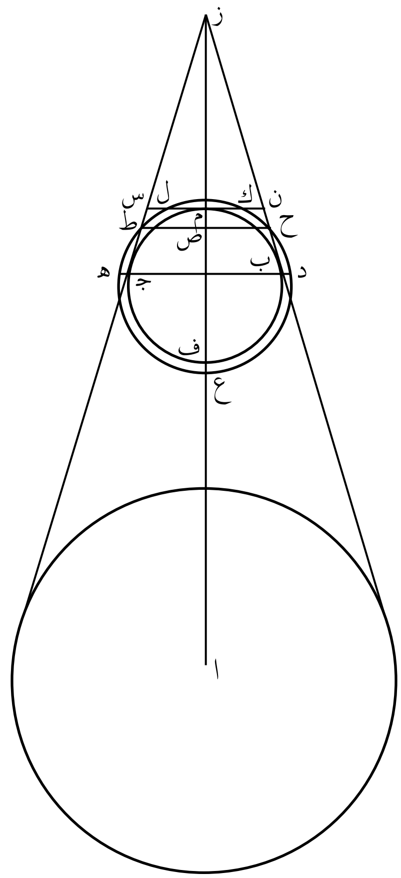
[xxiii] وهو موازٍ أبداً لخطّ ب ج قطر قاعدة المخروط لقيام سهم المخروط عليها أبداً وبحركتها مع حركته] - ب، هاك

[xxiv] وهو قطعة د ع ه ج ف ب] - ب، هاك

دائرته. فحصل فوق دائرة البخار من قطعة ب د ح شيء أكثر من الأوّل. فلذلك يتّسع الضياء في المشرق ويعترض، فيظهر ظهوراً بيّناً، وهو الصبح الصادق. ثمّ يرتفع من القطعة المضيئة المحيطة بالمخروط شيء بعد شيء ويصير كلّها فوق دائرة البخار، فيقوي الضياء ويزداد إلى حين طلوع الشمس. وعند قرب الطلوع تقوم دائرة المخروط على دائرة البخار[١٨٧] و[١٨٨]يكون أقلّ من نصفها فوقها وباقيها تحتها، لأنّ مركزها، /وهو ص،/* [xxv] تحت مركز دائرة البخار، /وهو م./* [xxvi] ثمّ ينحطّ جانبها نحو المغرب كلّما ارتفعت الشمس عن الأفق إلى حين وصولها أفق الغرب، فيكون حالها كما كان عند الطلوع. ثمّ تميل نحو المغرب إلى أن تنحطّ الشمس يط جزءاً، فتماسّ دائرة المخروط دائرة البخار على نقطة من جهة المغرب. ثمّ تنحطّ عنها فيصير كلّ دائرة المخروط تحت دائرة البخار. فيخفى الضياء إلى أن تماسّها بجانبها الشرقي قبيل الفجر، ويعود الأمر من الرأس.

[xxv] وهو ص] - ب، هاك

[xxvi] وهو م] - ب، هاك



[شكل ٩]

[٢هـ] وأمّا أنّ دائرة المخروط أعظم من دائرة البخار، /فلأنّها/‡ [xxvii] لو كانت مساوية لها لكانت إذا ماسّتها انطبقت عليها ـــ لأنّ كلّ دائرتين متساويتين في كرة متى ماسّت إحداهما الأخرى بعد أن تقاطعتا[١٨٩] انطبقت عليها ـــ فكانت الشمس متى صار بعدُها عن الأفق يط جزءاً استضاء الأفق من جميع جهاته، ولم يكن يغيب الشفق إلّا وقد طلع الفجر؛ ولو كانت أصغر، لكان في أكثر الأوقات الآفاق مستنيرة كضوء الصبح، والوجود بخلافه. فهي أعظم منها. ولذلك لا تزال هي

[xxvii] فلأنّها] لانها: ب، ك = متغيِّر من «لانها»: ل

تحت دائرة البخار بكلّها أو بجلّها ولا تطابقها ولا تصير فوقها أبداً إلّا قطعة منها أصغر من نصفها، لما مرّ، فهذا هو السبب الحقيقي في طلوع الفجر ومغيب الشفق، وتزايد نور الأوّل وتناقص ضوء الثاني، وأنّه لِمَ[١٩٠] لا يُرى قبل الوقت المحدود.

[٢و] وإذا عرفت ذلك، فاعلم أنّه **قد عُرف بالتجربة أنّ انحطاط الشمس من الأفق عند أوّل طلوع الصبح وآخر غروب الشفق يكون ثمانية عشر جزءاً** من دائرة الارتفاع المارّة بمركز الشمس. لكن لاختلاف مطالع قوس الانحطاط تختلف ساعات الصبح والشفق، أعني الساعات التي بين طلوعي[١٩١] الصبح والشمس والتي بين غروبي الشمس والشفق. أمّا في خطّ الاستواء فهذه الدرجات الثماني عشرة التي للانحطاط تنقطع بهذا القدر من حركة معدّل النهار إذا كانت الشمس في إحدى نقطتي الاعتدالين لاتّحاد دائرة الارتفاع ومعدل النهار حينئذ. وإذ ذاك تكون ساعات الصبح والشفق ساعة وخُمس ساعة لأنّها مقدار ثماني عشرة درجة. ولا يكون في موضع من سطح الأرض زمان الصبح والشفق أقلّ من هذا. وإذا كانت الشمس هناك في غير الاعتدالين، كانت دائرة الارتفاع غير المدار اليومي للشمس، فتزيد ساعات الصبح والشفق، على ما قلنا، بقدر ما يقع التفاوت بين هذه الثماني عشر درجة وما يطلع معها من المعدّل. وذلك يختلف باختلاف المدارات. /وذلك لأنّه يحدث من دائرة ارتفاع الشمس ومن مدارها المتقاطعتين على مركزها، وهي تحت الأفق، ومنه مثلّث زاويتاه اللتان عند الأفق قائمتان فوتراهما متساويان، لكن الذي من دائرة الارتفاع ثماني عشرة درجة منها، فيكون الذي من المدار أكثر من ثماني عشرة درجة منه، لكونه صغيرة والارتفاع عظيمة. فإذن يطلع من المعدّل مع قوس الانحطاط والشمس في غير الاعتدالين أكثر من ثماني عشرة لتساوي أحكام المدار والمعدّل في الطلوع والغروب. ولأنّ المدارات تتصاغر بالبعد عن المعدّل يكون

أكثر هذا التفاوت إذا كانت الشمس في إحدى المنقلبين. فاعرفه فإنّه من اللطائف./*[xxviii] ولا يخفى أن كلّ جزئين يتساوي بعدهما عن أحد الاعتدالين تتساوي ساعات صبحها وشفقها. وهذا[١٩٢] أيضاً من خواصّ خطّ الاستواء[١٩٣] إذ لا يوجد في غيره.

[٢ز] وأمّا في الآفاق المائلة فكلّما كان ارتفاع القطب الظاهر من فلك البروج أكثر والزاوية الحادثة من تقاطع الأفق والبروج أحدّ، كانت ساعات الصبح والشفق أكثر؛ وكلّما كان /ارتفاعه/*[xxix] أقلّ /كانت أقلّ./*[xxx] وذلك لأنّ الزاوية إذا كانت أحدّ كان ما بين مركز الشمس والأفق من دائرة البروج أكثر، ممّا إذا كانت أقلّ حدّة، لتساوي قوس الانحطاط فيهما. وإذا كانت القوس من البروج أكثر كان مطالعها بل الساعات أكثر؛ وإن كانت أقلّ كانت أقلّ. فلهذا ولأنّ انحطاط كلّ درجة تحت الأرض مثل ارتفاع نظيرتها فوقها أيضاً يكون في الآفاق المائلة مدّة الصبح والشفق في نصف البروج الذي ميله في جهة العرض أكثر من مدّتها في النصف الآخر. ألا ترى أنّ مدة الصبح والشفق في الإقليم الرابع، والشمس في أوائل السرطان، ساعتان،[١٩٤] وفي أوائل الجدي ساعة وثُلث.

[٢ح] **وفي** المواضع **التي تكون عروضها ثمانية وأربعين ونصفاً إذا كانت الشمس في المنقلب الصيفي**§ [xxxi] **يتّصل الشفق بالصبح.** ولا توجد ظلمة الليل عند وصول الشمس على دائرة نصف النهار تحت الأرض، لأنّ قوس انحطاطها من دائرة نصف النهار حينئذ على هذا الوضع تكون ثمانية عشر جزءاً. فالآن الذي يكون آخر غروب الشفق يكون هو بعينه

[xxviii] وذلك لأنّه يحدث من دائرة ارتفاع الشمس ... فاعرفه فإنّه من اللطائف] - ب، هاك

[xxix] ارتفاعه] ارتفاع: ب

[xxx] كانت أقلّ] هاك =كانت الساعات أقل: ب

[xxxi] الصيفي] متغير إلى « الذي»: ل = + في جهة العرض: هال

أوّل طلوع الصبح. **وفيما جاوزت عروضها ذلك المقدار يكون ذلك،** أعني اتّصال الصبح بالشفق، **في زمان أكثر بحسب تناقص انحطاط الشمس عن الأفق القدر المذكور** إذ على هذا الوضع يكون طلوع الصبح قبل تمام غروب الشفق، بخلاف الوضع الأوّل. فيكون زمان ما من ساعات الشفق وساعات الصبح أيضاً، ويكثر هذا الزمان لما ذكرنا.

[٢ط] وفي المواضع التي تكون عروضها مساوية لتمام الميل الكلّي إذا ماسّت الشمس الأفق في أوّل الجدي[xxxii] § ولاتطلع، تكون ساعات الصبح خمس ساعات وثُلثاً ومثلها تكون ساعات الشفق والباقي من أربعة وعشرين ساعة يكون ساعات الظلمة. /وذلك لأنّ الشمس في مدار المنقلب الشتوي إذا وصلت إلى محاذاة مطلع الاعتدال كان بُعدها من الأفق مثل الميل الأعظم، وإذا جاوزت عن محاذاتها عشر درجات تقريباً، صار بُعدها عن الأفق ثماني عشرة درجة. فيظهر الصبح ويدوم إلى أن تماسّ الشمس الأفق وهو بقدر ما تقطع الباقي من مداره إلى المماسّة، وهو ثمانون درجة أعني خمس ساعات وثُلثاً، إذ من المحاذاة إلى المماسّة تسعون جزءاً. وقس ساعات الشفق عليه./ * [xxxiii]

[٢ي] وفي المواضع التي تزيد عروضها على تمام الميل الكلّي إلى حيث يكون عرضه أربعاً وثمانين درجة[١٩٥] ونصفاً، يكون مجموع تمام الميل الكلّي والثماني عشرة درجة. /إذا كانت الشمس في القوس الأبدية الخفاء يكون الضوء/*[xxxiv] في مقدار كلّ يوم بليلته، /أي في مقدار دورة للفلك الأعظم،/ * [xxxv] يظهر * [xxxvi] من طرف مشرق الجنوب ويمرّ على الجنوب ويخفى

[xxxii] أوّل الجدي] متغيّر إلى «المنقلب الذي في»: ل = + خلاف جهة العرض: هال

[xxxiii] وذلك لأنّ الشمس في مدار المنقلب الشتوي ... وقس ساعات الشفق عليه] - ب، هاك

[xxxiv] إذا كانت الشمس في القوس الأبدية الخفاء يكون الضوء] - ب، هاك

[xxxv] أي في مقدار دورة للفلك الأعظم] - ب، هاك

[xxxvi] يظهر] + الضوء: ب، شاك

في الطرف الغربي. /لأنّ بعد الشمس عن الأفق في تلك العروض حينئذ إذا وصلت في مدارها تحت الأرض إلى حوالي نصف النهار من طرف الجنوب يكون أقلّ من ثماني عشرة درجة على ما لا يخفى؛ إلّا في العرض الأخير فإنّ بعدها منه عند وصولها إلى نصف النهار يكون ثماني عشرة؛ وفي باقي الأوضاع أكثر. ولا يخفى اختلاف مدّة ظهور الضوء باختلاف المدارات الأبدية الخفاء ولا أنّ المدار كلّما كان أعظم كانت المدّة أكثر. لأنّ الأعظم أقرب من الأفق وظهور الضوء فيه أقدم منه في الأصغر، عكس الاختفاء فيهما، إلّا أنّ الباقي من أربعة وعشرين ساعة بعد نقصان ساعات الضوء منها هو ساعات الظلمة./*[xxxvii] وهذا الصبح والشفق يكون متّصلاً أحدهما بالآخر، لأنّه ما دام في الطرف الشرقي يكون من حساب الصبح وما دام في الطرف الغربي يكون من حساب الشفق.

[٢ك] ثمّ إذا زاد العرض، على ما قلنا، فلا يظهر ذلك الضوء في مدّة تقرّب الشمس من المنقلب الشتوي ويظهر في جانبي تلك المدة، /لأنّ بعده وبعد ما يقرب منه من الأفق يكون أكثر من ثماني عشرة درجة لما يلوح من التقرير السالف آنفاً./*[xxxviii] وحيث العرض تسعون والقطب على سمت الرأس يكون زمان الصبح والشفق كلّ منهما خمسين يوماً بليلته، لأنّ دائرة الارتفاع هناك هي دائرة الميل. فالشمس إذا كانت في جزء ميله ثماني عشرة درجة، يكون أوّل الصبح وآخر الشفق، وذلك الجزء هو الخمسون من كلّ من الاعتدالين في الجهتين، فلذلك يكون الزمان ما ذكرنا /على ما وعدنا بيانه./*[xxxix] وفي مقدار كلّ يوم بليلته يدور النور على الأفق وبقدر اثنتي عشرة ساعة يكون نور الصبح على نصف الأفق الشرقي فرضاً

[xxxvii] لأنّ بعد الشمس عن الأفق ... هو ساعات الظلمة] - ب، هاك

[xxxviii] لأنّ بعده وبعد ما يقرب منه من الأفق يكون أكثر من ثماني عشرة درجة لما يلوح من التقرير السالف آنفاً] - ب، هاك

[xxxix] على ما وعدنا بيانه] - ب، هاك

وبقدر اثنتي عشرة ساعة على نصف الأفق الغربي كذلك، والشفق على هذا القياس. وهذا من نوادر نكت هذا /العلم./ *[xl]

ولايزيد الصبح والشفق في موضع من وجه الأرض على هذا. وهذا نهاية[١٩٦] الكلام على الصبح والشفق وأحوالهما ـــ وهو المشكور على نعمائه.[١٩٧]

[xl] العلم] - ب، هاك

الباب **العاشر**[١٩٨]

في معرفة أجزاء الأيّام وهي الساعات

وما يتركّب من الأيّام وهي الشهور والسنون وما يتعلّق بها من الكبيسة والتأريخ

[١أ] الساعات على قسمين: مستوية، وتسمّى معتدلة واستوائية واعتدالية أيضاً؛ وزمانية، وتسمّى معوّجة وقياسية أيضاً. فالمستوية جزء من أربعة وعشرين جزءاً من زمان يوم بليلته. فيزيد عدد النهارية والليلية منها بطول النهار والليل وينقص بقصرهما. ولا يتغيّر أجزاؤها بل هي خمسة عشر زماناً من المعدّل الحاصلة من قسمة دورة على أربعة وعشرين. هذا بالقول المطلق وأمّا في التحقيق فأجزاؤها أكثر من ذلك؛ لأنّها ربع سدس زمان اليوم[١٩٩] بليلته، وهو أكثر من دور المعدّل، إمّا الوسطى فلأنّه دور[٢٠٠] مع قوس منه يساوي وسط الشمس، وحصّة ساعةٍ مستوية على هذا خمسة عشر جزءاً ودقيقتان ونصف تقريباً؛ وإمّا الحقيقي فلأنّه دور[٢٠١] مع مطالع مقوّم الشمس في ذلك اليوم، وحصّة الساعة على هذا لا تنضبط لأنّها قد تزيد، على ما قلنا، إن زاد الحقيقي على الوسطى، وبالعكس إن كان بالعكس. لكن هذه الزيادة لم تعتبروا[٢٠٢] في قسمة الساعات[٢٠٣] إمّا لقلّتها أو لها و[٢٠٤]لعدم انضباطها، وأطلقوا القول بأنّ أجزاء المستوية أبداً خمسة عشر زماناً من المعدّل ولهذا سُمّيت مستوية ومعتدلة. وأمّا تسميتها بالاستوائية والاعتدالية فإمّا لتساوي الأجزاء أو لنسبتها إلى مساكن خطّ الاستواء، فإنّ الساعات هناك لا تختلف أجزاؤها ولا عددها؛ وقيل لأنّ عند استواء الملوَيْن تبطل المعوّجة وتبقى المستوية. والمنجّمون يقسمون كلّ ساعة مستوية بستّين قسماً يسمّى كلّ قسم دقيقة ثم الدقيقة بستّين على قياس ما في الدرج.

[١ب] والزمانية جزء من اثني عشر جزءاً من قوس النهار أو الليل فلا يزيد عددها بطولها ولا ينقص؛[٢٠٥] نعم تختلف أجزاؤها، فتكثر وتقلّ بطول النهار والليل وقصرهما، ولهذا[٢٠٦] سمّيت معوّجة. وأمّا تسميتها بالزمانية فلأنّها نصف

سدس زمان النهار أو الليل وبها تُعرف أبعاضها بالنسبة إلى كلّها، وأمّا بالقياسية فلكونها مخطوطة على الآلات القياسية. وكما أنّهم لم يعتبروا الزيادة على دور المعدّل في قسمة الساعات المستوية كذلك لم يعتبروها في قسمة الزمانية. ولهذا عُرفت **قوس النهار** في المشهور بأنّها نصف الدور إن لم يكن تعديل نهار أو هو مع ضعفه أو دونه إن كان. لأنّها بالحقيقة **هو ما يدور من معدّل النهار من وقت طلوع نصف جرم الشمس من الأفق إلى وقت غروب نصفه فيـه**؛ **وهو أزيد من** المشهور **بقدر مطالع ما تسيره الشمسُ** بالمسير المقوّم **في ذلك اليوم لتلك البقعة. وقوس الليل** على **حسب ذلك.** و**لأنّ أجزاء المستوية وعدد المعوّجة لا يختلفان** قيل **الفرق بينهما أنّ طول الأيام والليالي وقصرهما يكونان بعدد الساعات المستوية وأجزاء المعوّجة.** وعُرفت المعتدلة بأنّها التي يختلف عددها دون أزمانها والمعوّجة بعكس ذلك. وحُكم بأنّ كلّ ساعتين زمانيتين نهارية وليلية مساويتان لساعتين مستويتين إذ بمقدار ما تزيد أجزاء أحدهما[٢٠٧] على أجزاء المستوية نقصت أجزاء[٢٠٨] الأخرى عنها. ولهذا إذا قُسم قوس الليل على خمسة عشر أي فُصلت خمسة عشر خمسة عشر جزءاً[٢٠٩] كان ما يخرج عدد المستوية لتلك الليلة. وتمامها من أربعة وعشرين هي ساعات النهار المستوية. وإن قُسمت على اثني عشر أي فُصلت اثنى عشر قسماً متساوية كان الخارج، أعني أجزاء كلّ قسم،[٢١٠] أزمان الساعة الزمانية لتلك الليلة، وتسمّى أزمان الساعات. وتمامها من ثلاثين زماناً هو أزمان الساعة الزمانية للنهار. وفي خطّ الاستواء وعند استواء الملوين لا يكون بين الساعتين فرق لأنّ كلا من قوسي النهار والليل على الجليل من النظر مائة وثمانون، فإذا قُسم على اثني عشر كان كّل قسم خمسة عشر زماناً فتتساوي أجزاء المستوية والمعوّجة ولا يبقى بينهما فرق.

[١ج] ومبدأ النهار في عرف المنجّمين والفرس والروم من طلوع الشمس، وهو الوضع الطبيعي؛ وفي عرف أهل الشرع من طلوع الصبح الصادق. فزمان النهار على هذا يزيد على الأوّل بزمان من الليل معلوم المقدار محدود المبدأ، وهو ما بين طلوعي الفجر والشمس.[٢١١] ومبدأ الليل في عرف الأوّلَين عند غروب الشمس؛ وفي عرف المتشرعة من مجاوزة الشمس عن الأفق الغربي بحيث تظهر الظلمة في جانب الشرق ونزول الحمرة كما سيجيء مفصّلاً في آخر باب الأظلال.[٢١٢] وممّا ذكرنا يظهر مقدار[٢١٣] زماني النهار والليل عند الطائفتين. وأمّا مبدأ اليوم بليلته فأهل الحساب يأخذونه من وصول الشمس إلى دائرة نصف النهار لا الأفق، لئلا ينضاف تفاوت المطالع إلى تعديل الأيّام كما سبق مشروحاً، لا لأنّ جميع نقط الفلك لا تعود إلى الأفق فإنّه لا يحسن في التعليل.[٢١٤] أمّا المغاربة وأهل هذه الأقاليم فمن نصف النهار وأمّا المشارقة فمن نصف الليل. وغير الحُسّاب يأخذون المبدأ من وصول الشمس إلى الأفق[٢١٥] أو مجاوزتها عنه. أمّا العرب وأكثر أصحاب الشرائع فمن أوّل الليل لكون مبادئ شهورهم من رؤية الهلال، وهي في الغالب إنّما يكون بعد غروب الشمس. وقيل لأنّ الظلمة أصل في الرتبة والنور طار عليها والابتداء من الأصل أولى. وأمّا غيرهم فمن أوّل النهار، وقيل[٢١٦] لكون شهورهم مبنية على الحساب وهو من أوّل النهار والأولى[٢١٧] لأنّ النور وجودي والظلمة عدمي والابتداء من الوجود أولى.

[٢أ] وإذا عرفت ذلك، فاعلم أنّه لمّا كان أشهر الأجرام السماوية النيّرين، اعتبر أكثر الأمم في وضع شهورهم وسنيهم دور أحدهما أو كليهما. وأيضاً لمّا كان **الشهر مأخوذاً من تشكّلات القمر النورية،** وكان دوره يتمّ في قريب من ثلاثين يوماً، وفي مدّة اثني عشر دوراً منه تقريباً تتمّ **السنة** الـ**مأخوذة من عود الشمس إلى موضعها** من **فلك البروج المقتضي لعود حال السنة بحسب الفصول** صار مدار السنة على اثني عشر شهراً ومدار الشهر على ثلاثين يوماً تقريباً. ثمّ السنة إمّا شمسية

وإمّا قمرية، وكلّ منهما إمّا حقيقية وتسمّى طبيعية أو اصطلاحية وتسمّى وضعية. وكذا الشهر إمّا حقيقي طبيعي أو اصطلاحي وضعي. فالسنة الشمسية الحقيقية إن يُعتبر دور الشمس وعودها إلى موضعها من فلك البروج، لا عدد الأيّام والشهور. ويتمّ **ذلك في ثلاثمائة وخمسة وستّين يوماً وربع** الّا جزءاً من ثلاثمائة من يوم، وهو جزء وخُمس جزء من ثلاثمائة وستّين جزءاً من يوم، لأنّ الستّين خُمس ثلاثمائة فالجزء من ثلاثمائة يكون أكثر من الجزء من ثلاثمائة وستّين بخُمس. هذا عند بطلميوس، وأمّا عند غيره من أصحاب الأرصاد فالكسر الزائد على الأيّام التامّة، الناقص من الربع المسمّى بفضل الدور، مختلف فيه كما هو مذكور في كتبهم. والشمسية الاصطلاحية إن يُصطلح على مقدار قريب من مقدار الحقيقية، كما سيجيء مفصّلاً ـــ إن شاء الله العزيز.[٢١٨]

[٢ب] وأمّا القمرية الحقيقية فإن يُجعل وضع ما من أوضاع النيّرين مبدأ[٢١٩] إلى أن عاد القمر إليه اثنتي عشرة مرّة كـ**من يوم الاجتماع إلى يومه أو ليلة الهلال إلى ليلتـه أو من تشكّل آخر إلى مثله.** إلّا أنّه لمّا كان أبين أوضاعه منها وأقربها إلى الإدراك الهلال، مع أنّ القمر في هذا الوضع يشبه الموجود بعد العدم والمولود الخارج من الظلم، كان جعله مبدأ لحركته أولى على ما ذهب إليه مستعملوا الشهور من أهل الظاهر. وكلّ عودة من هذه العودات هو شهر قمري حقيقي طبيعي. **ويتمّ دوره إذا صار فضل حركة القمر على حركة الشمس الحقيقيتين دوراً؛ ووجوده متعذّر ومع تعذّره مختلف لاختلاف حركتها.** وإذا كان كذلك فلا يكون فضل حركة القمر الحقيقية على حركة الشمس الحقيقية مضبوطاً. فلا يمكن ضبط الدور به. فلذلك ولكون هذا الوضع، أعني الرؤية ممّا يختلف باختلاف أوضاع المساكن وباختلاف أبعاده من الشمس إذ ليس

لرؤية الأهلّة حدّ لا يتعدّاه، لم يلتفت الحسّاب إلى اعتبار الرؤية فيما لا تعلّق له بالأمور الشرعية وجعلوا مبدأ الشهر وقت الاجتماع وزمان الشهر ما بين الاجتماعين بالمسير الأوسط.

[٢ج] والقمرية الاصطلاحية أن تُعتبر الأيّام والأشهر، لا سير القمر الحقيقي ورؤية الأهلّة، كالمنجّمين وأهل الحساب. فإنّ سنة القمر عندهم ثلاثمائة وأربعة وخمسون يوماً وخُمس وسُدس يوم. والسبب فيه أنّهم لمّا جعلوا مبدأ الشهر الاجتماع، لما ذكرنا، وتعذّر عليهم أخذ الدور — وهو ما بين الاجتماعين — من فضل ما بين حركتي النيّرين الحقيقيتين، أخذوا الدور من الفضل بين حركتيهما الوسطيّتين بأن أسقطوا وسط الشمس من وسط القمر فبقي المقدار المسمّى بسبق القمر وصارت الشمس كأنّها ساكنة. ثمّ لمّا كانت نسبة اليوم الواحد إلى قوس السبق كنسبة الأيّام المطلوبة إلى الدور، ضُرب الأوّل في الرابع، وما غيّره عن حاله لكونه واحداً، وقُسّم على السبق، فخرج أيّام ما بين الاجتماعين تسعة وعشرين يوماً ونصفاً وكسراً، مجموعهما أحد وثلاثون دقيقة وخمسون ثانية من يوم. ثمّ ضُرب هذا المقدار في اثنى عشر، عدد أشهر السنة، فحصل أيّام السنة القمرية الاصطلاحية ما ذكرنا. ثمّ لمّا كان مجموع كلّ شهرين متواليين تسعة وخمسين يوماً، اصطلح أهل الحساب على أن جعلوا الشهر الأوّل من السنة، وهو المحرّم، ثلاثين يوماً، والثاني تسعة وعشرين يوماً، واستمرّوا على هذا الترتيب إلى آخر السنة، فصار ذو الحجّة تسعة وعشرين يوماً وخمس وسدس يوم أعني اثنتين وعشرين دقيقة من يوم، وهي الحاصلة من ضرب دقيقة[٢٢٠] وخمسين ثانية الزائد على نصف يوم في اثنى عشر. وفي سنة الكبيسة يصير ذو الحجّة ثلاثين يوماً، وذلك اليوم يسمّى كبيسة وتلك السنة سنتها. ولمّا كان الكسر الزائد أحد عشر جزءاً من ثلاثين، صار دور سني الكبس ثلاثين، والكبس فيها أحد عشر يوماً؛ لأنّ ثلاثين خُمساً ستّة أيام، وثلاثين سُدساً خمسة أيام. وسنوا الكبس

عند أهل هذه الصناعة على ترتيب حروف بهز يجوح ادوط، ولهذا قيل بَهَز يَجُوحُ اَدُوطٍ كبائس العرب؛ لأنّ في السنة الأولى لا يبلغ الكسر النصف[٢٢١] فلا يكبس فيها وفي الثانية يتجاوزه فيكبس فيها وقس الباقي عليه. وبعض الجماعة يكبس السنة الخامسة عشرة[٢٢٢] بدل السادسة عشرة؛[٢٢٣] لأنّهم لا يعتبرون في الكبس مجاوزة الكسر النصف بل يكبسون أيضاً إذا بلغ النصف، وفي الخامسة عشرة[٢٢٤] كذلك على ما يظهر بالاعتبار. وهذه الشهور قمرية اصطلاحية وتسمى وسطية أيضاً لاعتبار وسط النيّرين فيها. وظهر ممّا ذكرنا أنّ الكبيسة يوم يجتمع من الكسور الزائدة على الأيّام التامّة.[٢٢٥]

[٣] وأمّا التأريخ فهو في اللغة تعريف الوقت، وأمّا في الاصطلاح فقيل تعيين وقت لينسب إليه زمان يأتي عليه؛ وقيل يوم معلوم ينسب إليه زمان يأتي عليه؛ وقيل تعريف الوقت بإسناده إلى أوّل حدوث أمر شائع كظهور ملة أو دولة أو وقوع حادثة هائلة من طوفان أو زلزلة عظيمة ونحوهما من الآيات السماوية والعلامات الأرضية؛ وقيل مُدّة معلومة بين حدوث أمر ظاهر وبين أوقات حوادث أخر. ولكلّ وجه لاختلاف الاعتبارات لإطلاقهم التأريخ على معانٍ مختلفة على ما يشعر بها التعريفات المذكورة. ولفظة التأريخ معرّبة مأخوذة من ماهروز. والأصل فيه أنّ أبا موسى الأشعري كتب إلى عمر بن الخطّاب ــــ رضي الله عنهما ــــ أنّه يأتينا من قبل أمير المؤمنين كتب لا ندري على أيّها نعمل؛ قد قرأنا صكّاً محلّه شعبان، فما ندري أيّ الشعبانين، هو الماضي أو الآتي. وقيل أنّه رُفع إلى عمر صكّ محلّه شعبان فقال أيّ شعبان هذا هو الذي نحن فيه، أو الذي هو آت. ثمّ جمع وجوه الصحابة وقال أنّ الأموال قد كثرت وما قسمناه غير موقت، فكيف التوصّل إلى ما يضبط به ذلك. فقال[٢٢٦] الهرمزان، وهو ملك الأهواز وقد أُسر عند فتوح فارس وحُمل إلى عمر وأسلم على يده، أنّ للعجم حساباً يسمّونه ماه روز ويُسندونه إلى من غلب عليهم من الأكاسرة. فعرّبوا لفظة ماه روز بمُؤَرَّخ وجعلوا مَصدَرَه التأريخ واستعملوه

في وجوه التصريف. ثمّ شرح لهم الهرمزان كيفية استعمال ذلك. فقال عمر ـــ رضي الله عنه ـــ ضعوا للناس تأريخاً يتعاملون عليه وتصير أوقاتهم مضبوطة فيما يتعاطونه من معاملاتهم. فقال له بعض من حضر من مسلمي اليهود لنا حساب مثله نسنده إلى الإسكندر، فما ارتضاه[٢٢٧] الآخرون لما فيه من الطول. وقال قوم نكتب على تأريخ الفرس، فقيل أنّ تواريخهم غير مستندة إلى مبدأ معيّن بل كلّما قام فيهم ملك ابتدؤوا التأريخ من لدن قيامه وطرحوا ما قبله. فاتّفقوا على أن يجعلوا تأريخ دولة الإسلام من لدن هجرة النبي ـــ عليه السلام ـــ من مكّة إلى المدينة، لأنّ وقت الهجرة لم يختلف فيه أحد، بخلاف وقت مبعثه فإنّه مختلف فيه وكذا وقت ولادته، حتّى قيل أنّه وُلد ليلة الثاني من ربيع الآخر؛ وقيل ليلة الثامن؛ وقيل ليلة الثالث عشر منه. وكذلك اختلفوا في السنة التي وُلد فيها فقيل سنة أربعين من ملك نوشروان؛ وقيل سنة اثنتين[٢٢٨] وأربعين؛ وقيل سنة ثلاث[٢٢٩] وأربعين منه. وأمّا وقت وفاته ـــ عليه السلام ـــ وإن كان متعيّناً فلم يحسن أن يُجعل مبدأ التأريخ، فإنّ جعله أصلاً غير مستحسن عقلاً، ولأنّ جعل وقت الهجرة، لكونه وقت استقامة[٢٣٠] ملّة الإسلام وتوالي الفتوح وترادف الوفود واستيلاء المسلمين على رقاب المشركين، أصلاً أولى لأنّه ممّا يتبرّك به ويُعظم موقعه في النفوس. وكانت الهجرة يوم الثلثاء لثمان خلون من شهر ربيع الأوّل؛ وأوّل السنة، أعني المحرّم، هو يوم الخميس بحسب الأمر الأوسط وعلى قول أهل الحديث، وأمّا بحسب الرؤية وحساب الاجتماعات فهو يوم الجمعة. فعُمل عليه وأرّخ منها في مستأنف الزمان. وكان اتّفاقهم على هذا الأمر في سنة سبع عشرة من الهجرة. وإلى هذه السنة كانوا يسمّون كلّ سنة باسم الحادثة التي وقعت فيها ويؤرّخون بها، فسُمّيت السنة الأولى من سني مقام النبي ـــ عليه السّلام ـــ بالمدينة سنة الإذن بالرحيل أيّ من مكّة إلى المدينة، والثانية سنة الأمر بالقتال، وعلى هذا. ثمّ بعد ذلك تركوا تسمية السنين بالحوادث والتأريخ بها. وهذا التأريخ يعرف بتأريخ الهجرة.

[٤] وإذا عرفت معنى التأريخ فاعلم أن التواريخ المشهورة في زماننا ستّة: تأريخ الروم؛ والهجرة؛ والفرس؛ والملكي؛ واليهود؛ والترك.

[٥] أمّا تأريخ الروم، فسنوه شمسية اصطلاحية، لأنّ السنة[٢٣١] عندهم ثلاثمائة وخمسة وستّون يوماً وربع يوم تامّ من غير زيادة ونقصان.[٢٣٢] وكذا شهورهم الاثنا عشر اصطلاحية لأنّهم جعلوا سبعة منها أحداً وثلثين أحداً وثلثين، وأربعة ثلثين ثلثين، وواحداً ثمانية وعشرين. وليس لهذه الأوضاع مستند.[٢٣٣] وفي كلّ أربع سنين يجعلون الشهر الذي هو ثمانية وعشرون، تسعة وعشرين بسبب اجتماع الأرباع المذكورة، ويكون ذلك اليوم كبيسة، وتلك السنة سنتها. وتفصيل أسامي شهورهم وعدد أيّامها[٢٣٤] هو هذه: تشرين الأوّل، لا؛ تشرين الآخر، ل؛ كانون الأول، لا؛ كانون الآخر، لا؛ شباط، كح؛ آذار،[٢٣٥] لا؛ نيسان، ل؛ أيار، لا؛ حزيران، ل؛ تموز، لا؛ آب، لا؛ أيلول، ل. فأوّل سنتهم تشرين الأوّل ووقته قريب من وقت توسُّط الشمس الميزان على التقديم والتأخير، لأنّ الكسر الذي يأخذونه ربعاً هو[٢٣٦] أقلّ من الربع بقليل. فلذلك مبدأ سنيهم. وحساب النصارى على هذه الشهور إلّا أنّهم يجعلون عيدهم موافقاً لفصح اليهود بحساب يعلمونه ليس هاهنا موضع بيانه. وأوّل هذا التأريخ هو يوم الاثنين بعد اثنتي عشرة سنة شمسية من سنة وفاة إسكندر بن فيلقوس الرومي الذي استولى على ممالك الأقاليم السبعة.

[٦] وأمّا تأريخ الهجرة، فسنوه قمرية حقيقية وكذا شهوره. لأنّه لمّا لم يكن للعرب دربة بمراعاة حساب حركات النيّرين، جعلت مبادئ الشهور من رؤية الهلال وزمان الشهر بحسب ما يقع بين كلّ هلالين. فربّما كان بعض الشهور تامّاً، أعني ثلاثين يوماً، وربّما كان ناقصاً، أعني تسعة وعشرين يوماً. وربّما كانت أشهر متوالية تامّة أكثرها أربعة، وربّما كانت أشهر

متوالية ناقصة أكثرها ثلاثة. هذا إن اعتُبرت الرؤية وأمّا إن اعتُبر الاجتماع بحسب الأمر الأوسط فسنوه وشهوره قمرية اصطلاحية. وقد عرفت ذلك وكذا مبدأ هذا التأريخ وكيفية كبيسته ممّا تقدّم. واعلم أنّ العرب في الجاهلية كانت تستعمل شهور الأهلّة وتقصد مكّة للحجّ وكان حجّهم حينئذ عاشر ذي الحجّة كما رسمه إبراهيم ـــ عليه السلام. لكن لمّا كان لا يقع في فصل واحد من فصول السنة بل يختلف ويقع[٢٣٧] في الصيف تارة وفي الشتاء أخرى وكذا في الفصلين الآخرين، وأرادوا[٢٣٨] أن يقع في زمان واحد لا يتغيّر، وهو وقت إدراك الفواكه والغلّات واعتدال الهواء في الحرّ والبرد، ليسهل عليهم المسافرة ويتجرّوا بما معهم من البضائع والأزواد مع قضاء مناسكهم، قام في الموسم عند إقبال العرب من كلّ مكان خطيب، فحمد الله وأثنى عليه وقال لهم أنا أنسئ لكم في هذه السنة شهراً، أي أزيده[٢٣٩] فيها، وكذلك أفعل في كلّ ثلاث سنين حتّى يأتي حجّكم وقت إدراك الفواكه والغلّات فيقصدوننا بما معكم منها. فوافقوه على ذلك ومضّوا لسبيلهم. فنسء شهر المحرّم وجعله كبساً وأخّر المحرّم إلى صفر وصفر إلى ربيع الأوّل وكذلك بقيّة الشهور. فوقع الحجّ في السنة الثانية في عاشر المحرّم، وهو ذو الحجّة عندهم لأنّهم لمّا سمّوا صفر بالمحرّم وجعلوه أوّل السنة، يصير المحرّم الآتي ذا الحجّة وآخر السنة. ويقع في السنة الأولى محرّمان: الأوّل هو رأس السنة والآخر هو النَسِيءُ، وشهورها ثلاثة عشر. وعلى هذا يبقى حجّهم ثلاث سنين متوالية في المحرّم، ثم ينتقل إلى صفر ويبقى فيه ثلاث سنين، إلى آخر الأشهر. وتكون كبيسة سنيهم في كلّ ستّة وثلاثين سنة قمرية اثنى عشر شهراً قمرياً. ومن فعل هذا في كبيسة سنته فهو أقرب إلى أن يكون فصول السنة موافقة لفصول سنة الشمس ممن فعل خلافه، وهو أنّ العرب كانت تكبس أربعاً وعشرين سنة قمرية بأثني عشر شهراً قمرياً، ودور النسيء المشهور[٢٤٠] في الجاهلية هو هذا دون الأوّل وإن كان هو أقرب إلى مرادهم. وعلى التقديرين فبعد انقضاء سنتين أو ثلاث سنين وانتهاء نوبة الكبس إلى الشهر الذي كان يقع فيه الحجّ وانتقاله إلى الشهر الذي بعده، قام فيهم خطيب ويتكلّم بما أراد، ثمّ يقول: «إنّا جعلنا اسم

الشهر الفلاني من السنة الداخلة للشهر الذي بعده»، ولهذا فُسّر النسيء بالتأخير أيضاً، كما فُسّر بالزائد. ولأنّهم كانوا يديرون النسيء على جميع الشهور بالنوبة حتّى يكون لهم مثلاً في سنة محرّمان وفي أخرى صفران وعلى هذا، فإذا اتّفق أن يتكرّر شهر من الأربعة الحرم ـــ وهي رجب وذو القعدة وذو الحجّة والمحرّم، ولهذا قيل ثلاثة سَرْدٌ وواحد فَرْدٌ ـــ قام لهم خطيب فيُنبّهم أنّ هذه السنة قد تكرّر فيها الشهر الحرام فيُحرّم عليهم واحداً منهما بحسب رأيه وعلى مقتضى مصلحتهم. فلمّا انتهت النوبة في أيّام النبي ـــ عليه السلام ـــ إلى ذي الحجّة وتمّ دور النسيء على جميع الشهور، حجّ في تلك السنة، وهي العاشرة من الهجرة، لوقوع الحجّ فيها عاشر ذي الحجّة. ولهذا لم يحجج في السنة[٢٤١] منها، حين حجّ أبو بكر بالناس، لوقوعه في عاشر ذي القعدة. ثمّ خطب وأمر الناس بما شاء الله أن يأمر به وقال في جملة ما خطب به: «ألا إنّ الزمان قد استدار كهيئته يوم خلق اللهُ السموات والأرض»، يعني رجوع الحجّ واسماء الشهور إلى الوضع الأوّل. ثم تلا قوله[٢٤٢] ﴿إنّ عدّة الشهور عند الله اثنا عشر شهراً في كتاب الله يوم خلق السموات والأرض منها أربعة حرم ذلك الدين القيّم [...]﴾[i] إلى قوله ﴿إنّما النسيء زيادة في الكفر يضلّ به الذين كفروا يحلّونه عاماً ويحرّمونه عاماً ليواطئوا عدّة ما حرّم الله فيحلّوا ما حرّم الله زيّن لهم سوء أعمالهم والله لا يهدي القوم الكافرين﴾[ii] ومُنع العرب عن هذا الحساب. فصارت سنوهم وشهورهم دائرة في الفصول الأربعة والحجّ واقعاً في كلّ زمان يأتي منها مثل ما كان في زمان إبراهيم ـــ عليه السلام. وقد رأيت في بعض تعاليق من يوثَق بقوله أنّ العرب في الجاهلية كانت تكبس تسع عشرة سنة قمرية بسبعة أشهر قمرية حتّى تصير تسع عشرة سنة شمسية. فكانوا يزيدون في السنة الثانية شهراً ثم في الخامسة شهراً على ترتيب بهز يجوح كما تفعله اليهود. ويمكن أن يكون

[i] قرآن ٩: ٣٦
[ii] قرآن ٩: ٣٧

هذا هو سبب اختلاف الروايات عنهم في أنّهم كانوا يكبسون في كلّ سنتين شهراً أو في كلّ ثلاث سنين شهراً ـــ والله أعلم.

[٧] وأمّا تأريخ الفُرس، فسنوه شمسية اصطلاحية، وهي ثلاثمائة وخمسة وستّون يوماً. وكذا شهورهم الاثنا عشر، وهي فروردين اردیبهشت، خرداذ، تیر، مرداذ، شهریور، مهر، أبان،[٢٤٣] آذر، دی، بهمن، اسفندارمذ، اصطلاحية؛ لأنّها ثلاثون ثلاثون. وأوّل وضع هذا التأريخ كان في زمان جمشيذ.[٢٤٤] ثم كانوا يجدّدون في زمان كلّ سلطان عظيم لهم كما يفعله الروم. وكانوا يحفظون الكسر الزائد على السنة الذي هو الربع تقريباً ويأخذونه ربعاً تامّاً كالروميّين ويزيدون في كلّ مائة وعشرين سنة شهراً ليتوافق سنوهم بهذه الكبيسة مع سني الروم. وإنّما لم يزيدوا يوماً بعد تمام أربع سنين على الخمسة الزائدة على ثلاثمائة وستّين المسمّاة بالخمسة المسترقة واللواحق أو على آخر شهر من الشهور؛ لأنّ الفرس ما كانت لهم الأسابيع بل كان لكلّ يوم من أيّام الشهر اسم يخصّه، وكذا للخمسة الزائدة، وهذه الأسماء وكذا أسماء الشهور هي أسماء الملائكة بزعمهم وكان لهم زمزمة في كلّ يوم باسم ملك ذلك اليوم وعلى هذا لا تصحّ[٢٤٥] زمزمتهم[٢٤٦] إذا زيد في أيّام الشهر بزعمهم. وأسماء الأيّام هذه: أورمزد؛ بهمن؛ أرديبهشت؛ شهريور؛ إسفندارمذ؛ خرداذ؛ مرداذ؛ ديباذر؛ آذر؛ أبان؛ خور؛ ماه؛ تير؛ جوش؛ ديبمهر؛ مهر؛ سروش؛ رَش؛ فروردين؛ بهرام؛ رام؛ باذ؛ ديبدين؛ دين؛ أرد؛ أشتاذ؛ أسمان؛ زامياذ؛ ماراسفند؛ أنيران. وأسماء المسترقة هذه: أهْنَوذ؛ أشتوذ؛ إسفندمذ؛ وهشت؛ هشتويش. ويتكرّر دي بعد كلّ سبعة أيام، ويقيّدونه باسم اليوم الذي بعده، فيقولون ديبدين، أي دي الذي بعده دين، وكذلك ديباذر وديبمهر. ثمّ إنّهم كانوا ينقلون الشهر الزائد من شهر إلى شهر. فإذا تكرّر في سنة مثلاً فروردين فبعد مائة وعشرين سنة يتكرّر اردیبهشت وعلى هذا إلى آخر الأشهر. وكانوا

يأخذون الخمسة المسترقة مع ذلك الشهر الذي تكرّر حتّى تتحفّظ النوبة ولا يشتبه عليهم الأمر عند تطاول الزمان. ويأمنوا عن الغلط في تعيين الشهر المكبوس إذ كانوا لا يسمّونه باسم على حدّة ولا يكرّرون اسماً واحداً في السنة المستأنفة، بل يحفظون الشهر المكبوس على نوب متوالية حتّى إذا كان الكبس على فروردين ماه كانوا يعدّون أيّامه خمساً وثلاثين يوماً وكان مبدأ السنة أرديبهشت ماه ويسمّونه فروردين ماه إلى انقضاء مائة وعشرين سنة وعلى هذا الترتيب إلى أن تصير النوبة إلى إسفندارمذماه،[٢٤٧] فتصير أيّامه خمساً وثلاثين ومبدأ السنة فروردين وذلك في ألف وأربعمائة وأربعين سنة على الجليل من الحساب وتسمّى دورة الكبيسة. ولمّا كان الأمر على ما قلنا وانتهى الزمان إلى يزدجرد بن شهريار بن كسرى المعروف بالعادل، وجدّدوا التأريخ له، كان قد انتهى الشهر الزائد إلى أبان ماه إذ كان قد مضى من دور الكبيسة[٢٤٨] حينئذ تسعمائة وستّون سنة، وكانت الخمسة المسترقة في آخره. فلمّا ذهبت الدولة على يديه في زمان عثمان بن عفّان وقت محاربة العرب له وانهزامه من بين أيديهم وقتله في بيت طحّان بمرو الشاهجان، بقيت الخمسة اللواحق تابعة للشهر الثامن من غير نقل وكبس ولهذا يزيد بعضهم الخمسة دائماً في آخر أبان ماه إبقاءاً على حاله وبعضهم ينقلونه إلى آخر إسفندارمذماه لأنّه آخر السنة. وأوّل هذا التأريخ يوم الثلثاء وهو أوّل يوم من السنة التي ملك فيها يزدجرد بن شهريار آخر ملوك الفرس، وهو اليوم الثاني والعشرون من ربيع الأوّل سنة إحدى عشرة من الهجرة. وإنّما اشتهر التأريخ به من بين سائر ملوك الفرس لذهاب الدولة على يديه، كما قلنا، وعدم مَن يجدّد له التأريخ قائماً مقامه. ولخلوّ سني هذا التأريخ وشهوره عن الكسر صار استعمال المنجّمين له أكثر من غيره وكان جلّ الأزياج بل كلّها مبنياً عليه.

[٨] وأمّا التأريخ الملكي، فهو منسوب إلى السلطان جلال الدولة ملك شاه بن ألب أرسلان السلجوقي. والسبب فيه أنّه قد اجتمع في حضرته جماعة من الحكماء منهم عمر الخيّام والحكيم اللوكري وغيرهما، وهم ثمانية. فوضعوا تأريخاً ابتداؤه نزول الشمس الحمل، وأوّل يوم من السنة هو أوّل يوم تكون الشمس في نصف نهاره في الحمل، ويسمّى ذلك اليوم بالنيروز السلطاني. فسنوه شمسية حقيقية. وأمّا شهوره،[٢٤٩] فبعضهم يجعل أيّامها بحيث يتّفق حلول الشمس أوائل البروج مع أوائل الشهور وعلى هذا يكون الشهور أيضاً شمسية حقيقية. وفصول السنة حقيقية. وأسماء شهوره[٢٥٠] هي أسماء شهور الفرس إلّا أنّ شهور الفرس يقيّد بالقديم وهذه بالجلالية، فيقال مثلاً فروردين القديم وفروردين الجلالي. وكان قد انتهى في ذلك الوقت نزول الحمل في ثمانية عشر يوماً من فروردين القديم، فهم جعلوه أوّل فروردين الجلالي، وجعلوا هذه الثمانية عشر كبيسة. ولذلك يقولون مبدأ التأريخ الجلالي هو الكبيسة الملكشاهية أو الجلالية. وبعضهم، وهم أكثر المنجّمين، يجعلون أيّام شهوره ثلاثين ثلاثين حتّى لا يختلف عدد الأيّام في أوراق التقويم، ويزيدون الخمسة المسترقة في آخر إسفندارمذ، وعلى هذا تكون شهوره اصطلاحية، وفي كلّ أربع سنين يكبسون يوماً وتصير أيام السنة ثلاثمائة وستّة وستّين. ولأنّ الكسر الزائد أقلّ من ربع بقليل فتكون الكبيسة التي يجعلونها في كلّ أربع سنين يوماً أقلّ من يوم. فحينئذ قد يُتّفق في بعض الأوقات أن تكون الكبيسة بعد خمس سنين، وذلك إنّما يتّفق بعد أن يكبس بعد أربع سنين سبع مرّات أو ثمان مرّات. وهذا إنّما يُعرف بالاستقراء، وكذا معرفة أوائل سني[٢٥١] هذا التأريخ. وممّا ذكرنا يُعرف خطأ عمر الخيّام في زيجه الذي وضعه حيث ذكر أنّ أربع سنين تكون كبيسة دائماً وتوافق نزول الشمس أوّل الحمل. وهو خطأ فاحش سببه عدم تنبّهه بما[٢٥٢] نبّهناك عليه ـــ والله الموفّق للصواب.

[٩] وأمّا تأريخ اليهود، فسنوه شمسية وشهوره قمرية. وكان سبب وضعه هكذا هو أنّ موسى[٢٥٣] خرج مع بني إسرائيل من مصر ليلة الخميس خامس عشر نيسن وكانت الشمس في الحمل والقمر في الميزان، فقال له عظماء بني إسرائيل هذه الليلة وصبيحتها لا تصلحان للسفر، فسكت ومضى إلى سبيله[٢٥٤] وجاوزوا البحر وكانوا في شدّة وضيق وقد أكلوا الفطير، فاتبعهم فرعون وجنوده إلى آخر الحكاية من نجاته وغرق عدوّه. فاستبشر موسى بذلك اليوم وقال: «احتفظوا به واذكروا هذا الوقت في جميع زمانكم واجعلوه لكم عيداً كلّ سنة في هذا الوقت ولا تغيّروا وضعه من زمانه». وكان في ذلك الوقت طلوع القمر مع غروب الشمس، وكانوا يفركون سنبلة الحنطة بأيديهم فيأكلونها، وهذا الوقت في مصر يكون بقرب نزول الشمس الحمل. فاحتاج حُسّابهم إلى استعمال سني الشمس وشهور القمر وكبس بعض السنين بشهر زائد حتّى لا يتغيّر وقت عبادتهم. وسَمّوا سنة الكبس عَبُوراً، والتي لا تُكبس بسيطة، وشهور هذه اثنا عشر وشهور تلك ثلثة عشر. وجعلوا دور سني الكبس تسع عشرة سنة. ورتّبوا سني الكبائس مع البسائط على نحو ترتيب كبائس العرب في الجاهلية التي على ترتيب بهز يجوح. والفرق بينهما أنّ العرب كانت تُدير الشهر الزائد على جميع الشهور واليهود لا يديرونه على الجميع كذلك بل يكرّرون الشهر السادس فقط، وهو آذر، ويؤخّرون السادس إلى السابع. ويصير في السنة آذران: الأوّل آذر الكبس، وهو الذي يعدّونه زائداً؛ والثاني آذر الأصل وهو الذي يعدّونه من أصل السنة، ثم يتلوهما نيسن. ورأس سنيهم متردّد بين أواخري آب وأيلول من سنة الروم. فمداخل سنيهم متقدّم على رأس سنة الروم بشهر تقريباً. ويتردّد مدخل نيسن من شهورهم بين آذار ونيسان من سنة الروم. واعلم أنّ في أيام موسى ـــ عليه السلام ـــ كان ابتداء الشهور من رؤية الأهلّة. ثم من بعد ذلك تفرّق اليهود، فالقرّاؤون يعتبرون رؤية الأهلّة ولا يلتفتون إلى التفاوت الواقع في الأقاليم كالمسلمين؛ والربّانون، وهم معظم اليهود، يجعلون شهراً ثلاثين وشهراً تسعة وعشرين على ترتيب أهل الحساب حتّى لا يتغيّر ابتداء

الشهور في جميع العالم. فشهورهم على هذا كالشهور العربية بحسب الأمر الأوسط إلّا أنّهم جعلوا كلّ واحدة من السنين البسيطة والكبيسة ثلاثة أنواع: ناقص؛ ومعتدل؛ وزائد. فالبسيطة الناقصة شنج يوماً؛ والمعتدلة شند يوماً؛ والزائدة وتسمّى الكاملة أيضاً شنه يوماً. والكبيسة الناقصة شفج يوماً؛ والمعتدلة شفد يوماً؛ والكاملة شفه يوماً. وهم يجعلون مبدأ تأريخهم من آدم ـــ عليه السلام ـــ ويزعمون أن بين هبوطه وزمان موسى ـــ عليهما[٢٥٥] السلام ـــ ألفين وأربعمائة وثماني وأربعين سنة، وبين موسى والإسكندر ألف سنة أخرى. وأسماء شهورهم هذه: تشري؛ مرحشوان؛ كسليو؛ طيبت؛ شفط؛ آذر؛ نيسن؛ إيّر؛ سيون؛ تمّز؛ أوب؛ إيلُل.

[١٠] وأمّا تأريخ الترك، فمثل تأريخ اليهود في كون السنين شمسية والشهور قمرية إلّا أنّ مبدأ الشهور يأخذون من الاجتماع الحقيقي الذي يقتضي حساب تقويمهم، والشهر الزائد حيث يتّفق بحسب حساب اجتماعاتهم، فلا يقع في موضع واحد بعينه من السنة بل يقع في كلّ موضع منها.

[١١] وهذا أنموذج من التواريخ وهو كافٍ بحسب هذا الفن إذ معرفة كلّ على ما هو عليه واستخراج بعضها من بعض وغيره من الأعمال المتعلّقة بالتواريخ ممّا يتعلّق بكتب العمل، فليطلب من هناك من أراد ذاك.

الباب **الحادي عشر**

في درجات ممرّ الكواكب بنصف النهار وطلوعها وغروبها

[١] أمّا درجة ممرّ الكوكب[٢٥٦] فهي ما يمرّ[٢٥٧] من دائرة البروج بدائرة نصف النهار مع مرور الكوكب بها. وتحدّها الميل، وقد عرفت أن درجة الطول تحدّها دائرة العرض، فإن اتّحدت الدائرتان، كما إذا كان الكوكب على الدائرة المارّة بالأقطاب الأربعة، اتّحدت الدرجتان فتكون درجة الطول هي درجة الممرّ. وكذا إن كان الكوكب عديم العرض، لأنّ درجة ممرّه تكون موضعه من البروج وهو درجة طوله. وفي غير هذين الوضعين[٢٥٨] تختلف الدرجتان، ويكون أكثر هذا الاختلاف فيما يقرب من أوّل الحمل والميزان، وأقلّه[٢٥٩] فيما يقرب من أوّل السرطان والجدي. وما بين الدرجتين يُقال له اختلاف الممرّ. ويُقال للقوس من المعدّل التي[٢٦٠] بين تقاطعه مع دائرة عرض الكوكب وتقاطعه مع دائرة ميل الكوكب تعديل درجة الممرّ. وإذا عرفت ذلك فنقول **إذا كان قطبا البروج على دائرة نصف النهار ـــ وذلك يكون عند كون نقطتي الانقلابين عليها أيضاً ونقطتي الاعتدالين على الأفق ـــ فمرور الكواكب[٢٦١] حينئذ مع درجاتها[٢٦٢] الطولية لأنّ دائرة نصف النهار تكون دائرة عرضها. وإذا كان القطب الظاهر من** قطبي **البروج شرقياً عن نصف النهار ـــ وذلك** إنّما **يكون عند مرور النصف من فلك البروج الذي يتوسّطه الاعتدال الخريفي وطلوع النصف الجنوبي منه إن كان القطب الظاهر شمالياً، أو مرور النصف الآخر وطلوع النصف الآخر إن كان جنوبياًـــ فالكوكب الذي يكون عرضه في جهة القطب الظاهر يمرّ على دائرة نصف النهار بعد درجته لأنّ دائرة عرضه الخارجة من القطب** الأقرب **تلاقي الكوكب،** وهو في نصف النهار أوّلاً، ثمّ تلاقي درجته وقد مرّت وصارت غربية عن نصف النهار. فعند موافاة **درجته نصف النهار** يكون **الكوكب شرقياً** عنه **بَعدُ. والكوكب الذي يكون عرضه في خلاف جهة القطب الظاهر يمرّ عليها قبل درجته لأنّ دائرة العرض المذكورة تلاقي درجة الكوكب الكائنة على نصف النهار**

أوّلاً، ثم تلاقي الكوكب وقد مرّ وصار غربياً قبل ذلك. وإذا كان القطب الظاهر غربياً ـــ وذلك يكون عند مرور النصف من فلك البروج الذي يتوسّطه الاعتدال الربيعي وطلوع النصف الشمالي منه إن كان القطب شمالياً، أو مرور النصف الآخر وطلوع النصف الآخر إن كان جنوبياًـــ فالكوكب الذي يكون عرضه في جهة القطب الظاهر يمرّ قبل درجته والذي يكون عرضه في خلاف تلك الجهة يمرّ بعدها لما ذكرنا بعينه.

[٢] وأمّا درجة طلوع الكوكب وغروبه فهي ما يطلع ويغرب من دائرة البروج مع الكوكب. فإن كان الكوكب عديم العرض كانت درجة طوله[٢٦٣] هي درجة الطلوع والغروب، وكذا إن كان الكوكب يوافي الأفق مع قطب البروج لكون الأفق دائرة عرضه حينئذ لمرورها بالكوكب وقطب البروج. وإنّما تُتصوّر موافاة القطب والكوكب معاً على الأفق إذا كانت درجة الكوكب أحد الانقلابين في خطّ الاستواء، ومن أجزاء ما بين أوّل الميزان وآخر القوس إن كانت الموافاة في[٢٦٤] ناحية الشرق، ومن أجزاء ما بين أوّل الجدي وآخر الحوت إن كانت الموافاة في جهة الغرب في المساكن التي لا تزيد عروضها على الميل الكلّي. لأنّ قطب البروج الشمالي يطلع قبل أوّل الجدي ويغرب بعده وفي غير هذين الوضعين تكون درجة الطلوع والغروب غير درجة الطول. وعند هذا نقول الأفق إمّا أن لا يكون له عرض أو كان. فإن لم يكن، كآفاق خطّ الاستواء، فـ**طلوع الكواكب وغروبها فيـ**ها **كمرورها على نصف النهار في سائر الآفاق. فالكوكب الذي يوافي الأفق مع الانقلاب** يوافيه مع **القطب** أيضاً و**يطلع أو يغرب مع درجته،** لما ذكرنا، **والذي يكون في جهة القطب الظاهر** من قطبي البروج **يطلع قبل درجته ويغيب بعدها، والذي يكون في جهة القطب الخفي** منهما **يطلع بعد درجته ويغيب قبلها.** لأنّ دائرة العرض الخارجة من القطب الظاهر تنتهي إلى الكوكب على الأفق قبل درجته في الشمالي وفي الجنوبي تنتهي إلى الدرجة على الأفق والكوكب بعد

تحت الأرض. **ويكون هناك القطب الشمالي ظاهراً مدة طلوع النصف الذي يتوسّطه الاعتدال الربيعي ومرور النصف الجنوبي على نصف النهار من فوق، والقطب الجنوبي ظاهراً مدة طلوع النصف الآخر ومرور النصف الآخر.**

[٣] وإن كان للأفق عرض كان حكم الـ**طلوع والـغروب كما في خطّ الاستواء إلّا في مرور الأنصاف وطلوع الأنصاف من فلك البروج؛ فإنّ ذلك يختلف،** فـ**ربّما يكون أحد القطبين ظاهراً والمارّة أو الطالعة قوس أصغر من النصف أو أكبر.** ثمّ عرض الأفق[٢٦٥] إمّا إن يكون أكثر من الميل الكلّي أو مساوياً أو أقلّ. فإن كان أكثر كان الاختلاف على وتيرة واحدة لأنّ **أحد قطبي البروج يكون أبدي الظهور،** فالكوكب الذي عرضه في جهة القطب الظاهر يطلع قبل درجته ويغرب بعدها، وما هو بالخلاف فعلى الخلاف. ويكون أكثر هذا الاختلاف إمّا عند الطلوع ففي الحمل وإمّا عند الغروب ففي الميزان، إن كان عرض الأفق شمالياً، وبالعكس إن كان جنوبياً لمثل ما تقدّم[٢٦٦] في درجة الممرّ. فإن كان الكوكب في أوّل السرطان والجدي كان الاختلاف في الطلوع والغروب متساويين، لكون دائرة العرض هي دائرة الميل حينئذ، لكونهما المارّة؛ بخلاف ما لو لم يكن الكوكب في أحدهما فإنّ الاختلافين لا يستويان. وإن كان العرض مساوياً للميل الكلّي[٢٦٧] فلا يخفى حكمه. وإن كان أقلّ منه كان الاختلاف على وجهين لأنّ قطب البروج لا يكون أبدي الظهور بل يكون له طلوع وغروب. ويكون طلوعه قبل أوّل الجدي وغروبه بعده إن كان عرض الأفق شمالياً، وبالعكس إن كان جنوبياً. ويكون بعد درجتي طلوع القطب وغروبه من أوّل الجدي بمقدار واحد لمثل ما ذكرنا. وإذا كان كذلك فالقطب إن كان ظاهراً فالكوكب الذي يكون عرضه في جهته يطلع قبل درجته ويغرب بعدها، وإن كان عرضه في خلاف جهته فبالعكس. وإن كان القطب خفياً فعلى العكس فيهما، أعني يطلع الكوكب بعد درجته ويغرب قبلها إن كان عرضه في جهته، ويطلع قبلها ويغرب بعدها إن كان

في خلافها. ولا يخفى أنّ درجة الطلوع إن كانت بين الشمس ونظيرها طلع الكوكب نهاراً، وإن كانت بين النظير والشمس طلع ليلاً. ودرجة الغروب إن كانت بين النظير والشمس غرب الكوكب نهاراً، وإن كانت بين الشمس والنظير غرب ليلاً. ولا إن ما كان من الكواكب على دائرة عظيمة قاطعة لأعظم الأبدية الظهور، فأقربها من القطب الظاهر يطلع قبل أبعدها ويغرب بعده؛ ولهذا يكون التفاوت بين درجتي الطول والطلوع للأقرب من القطب أكثر ممّا بين درجتي الأبعد منه، يظهر[٢٦٨] بالتأمّل ـــ إن شاء الله العزيز.

الباب الثاني عشر
في الأظلال وأحوالها

[١] واعلم أوّلاً أن الضوء هو الكيفية التي لا يتوقّف إبصارها على إبصار شيء آخر. وهو ينقسم إلى أوّل وثان. فالأوّل هو الضوء الحاصل من المضيء لذاته، والثاني هو الضوء الحاصل من المضيء لغيره؛ مثلاً ضوء كرة البخار عند الإسفار هو الأوّل لأنّه من الشمس، وضوء وجه الأرض حينئذ هو الثاني لأنّه ليس من الشمس ـــ لأنّها لا تضيء إلّا المقابل ـــ بل من البخار المستضيء بضيائها المضيء لوجه الأرض بالانعكاس. فإنّ الشعاع إذا لاقى كثيفاً انعكس عنه، ثمّ الشعاع المنعكس إذا لاقى كثيفاً آخر انعكس عنه ثانياً شعاع أضعف من الأوّل، وكذا القول في الثالث والرابع إلى أن ينعدم، لأنّه يضعف كلّما بَعُدَ عن المبدأ إلى أن يفنى، فتحدث الظلمة، لأنّها عبارة عن عدم الضوء عمّا من شأنه أن يستضيء. والظلّ هو الضوء الثاني، وهو يقبل الشدّة والضعف، وطرفاه اللذان في غاية التباعد عنه النور والظلمة.

[٢] وثانياً أن المقياس هو شخص مستوٍ قائم على زوايا قائمة إمّا على سطح موازٍ لسطح الأفق كخشب يغرز في الأرض على سطح مستو، وإمّا على سطح قائم على سطح الأفق كوتد في حائط. فالأوّل قائم على الأفق والثاني موازٍ له.

[٣] وثالثاً أنّ الظلّ الذي نحن نتكلّم فيه هو[٢٦٩] ضوء ثانٍ يخرج من أصل المقياس، وهو الفصل المشترك بين السطح الذي عليه المقياس وبين سطح دائرة الارتفاع، لأنّها أبداً تمرّ بالشمس وبالمقياس، فتقطع السطح القائم هو عليه. وطرف الظلّ هي نقطة التقاطع بين السطح الذي عليه المقياس وبين الخطّ المخرج من مركز الشمس المارّ برأس المقياس إلى ذلك السطح. وهي بالحقيقة ظلّ طرف المقياس، ولهذا سمّي طرف الظلّ، لأنّ ظلّ الطرف يكون طرف الظلّ كما أنّ ظلّ الوسط، وسط الظلّ. وقطر الظلّ هو الخطّ الواصل بين رأس المقياس وطرف الظلّ من الخطّ المذكور. فيحدث من ارتفاع

كلّ شخص ومن ظلّه وقطره مثلّث قائم الزاوية وهي التي بين المقياس والظلّ. وقوس الظلّ هي قوس الارتفاع الذي يكون بحسبه[٢٧٠] الظلّ، إذ لكلّ ارتفاع لم يبلغ النهاية، أعني تسعين، ظلّ. وكما أنّ نهاية ارتفاع الشمس في التباعد عن الأرض تسعون درجةً وبدايته حيث الشمس على الأفق، فنهاية الظلّ حيث لا نهاية وبدايته حيث لا ظلّ.

[٤] ثمّ المقياس إن كان موازياً للأفق، /وكان مع الشمس في سطح دائرة الارتفاع،/† [i] فالظلّ الحادث منه، وهو موازٍ لجيب الارتفاع، يسمّى ظلاً أوّلاً، لأنّ أوّل ما يظهر يكون وقت طلوع الشمس؛ ومعكوساً ومنكوساً لأنّ رأسه من تحت ممّا يلي الأفق؛ ومنتصباً إمّا لكونه منتصباً على الأفق لا منبسطاً عليه أو لكون مقياسه منصوباً على وجه الشمس. وإن كان المقياس قائماً على الأفق فالظلّ الحادث منه، وهو موازٍ لجيب تمام الارتفاع، يسمّى ظلّاً ثانياً ومستوياً قياساً على الآخر، لأنّه يسمّى أوّلاً ومعكوساً؛ وأيضاً مبسوطاً لانبساطه على سطح الأفق الحسّي، ولهذا أيضاً يسمّى بالمستوي. /والسطح الذي يقع عليه هذا الظلّ ثابت بخلاف الذي يقع عليه الظلّ الأوّل فإنّه يتحرّك دائماً بحيث يكون أبداً قائماً على سطحي الأفق ودائرة الارتفاع./† [ii] والظلّ الثاني يُستعمل في معرفة الأوقات، كما سنقوله، والأوّل في الأعمال النجومية، على ما هي مشهورة في كتب العمل. وإذا أطلق الظلّ في كتب العمل أريد به الأوّل، وإن أطلق في هذا الفنّ أريد به الثاني في نصف النهار ومن جهتيه جهة الشمال والجنوب.

[٥] ولأنّ بداية أحد الظلّين كنهاية الآخر وبالعكس، لأنّ عند كون الشمس على الأفق تكون بداية الأوّل ونهاية الثاني، ثمّ لا يزال يتزايد الأوّل ويتناقص الثاني بحسب ارتفاع الشمس حتّى إذا وصلت الشمس إلى سمت الرأس كانت نهاية

---

[i] وكان مع الشمس في سطح دائرة الارتفاع] هاك، هال

[ii] والسطح الذي يقع عليه هذا الظلّ ... على سطحي الأفق ودائرة الارتفاع] هاك، هال

الأوّل وبداية الثاني ـــ وقس الربع الآخر عليه ـــ يكون الظلّ الأوّل لكلّ ارتفاع هو الظلّ الثاني لتمام ذلك الارتفاع وبالعكس. وظلّ ثمن الدور، أوّلاً كان أو ثانياً، يساوي المقياس. وإذا انطبق الظلّ على خطّ المشرق والمغرب يكون الارتفاع عديم السمت، وإن انطبق على خطّ نصف النهار كانت الشمس في نصف النهار.

[٦] واعلم أن الظلّ أبداً يقدّر بما قدّر[٢٧١] به المقياس. والمقياس بأيّ أجزاء فُرضت يمكن أن يؤخذ بها الظلّ. لكن جرت العادة بأن يؤخذ مقياس الظلّ الأوّل ستّين جزءاً، وبعضهم يأخذه درجة واحدة،[٢٧٢] وأن يقسم مقياس الثاني تارة باثني عشر جزءاً، وتسمّى أصابع، لأنّ أوّل ما يقدر به الانسان شبره، ومقداره اثنا عشر اصبعاً. أو لأنّ من أراد أن ينصب عموداً على سطح الأفق أو على سطح قائم عليه فإنّه يتوخي في مقداره أن يكون شبراً في الغالب، وأخرى بسبعة أو ستّة ونصف، وتسمّى أقداماً، لأنّ طول الشخص المعتدل القامة هو ستّة أقدام ونصف أو سبعة، مع أنّ الانسان إذا أراد أن يعرف صيرورة ظلّ كلّ شيء مثله فإنّه يعتبر ذلك بقامته، ثمّ بأقدامه. وقد يُقسم أيضاً مقياسه بستّين وتسمّى أجزاء. والأوّل يسمّى ظلّ الاصابع، والثاني ظلّ الأقدام، والثالث الظلّ الستّيني.

[٧] ولأنّ غاية ارتفاع الشمس، على ما علمت من الفصول المتقدّمة، تكون بقدر ميل درجة الشمس، وتمام عرض البلد إن كانت الشمس في جهة القطب الظاهر من المعدّل، وبقدر فضل[٢٧٣] تمام عرض البلد على الميل إن كانت في الجهة الأخرى، فيكون أطول ما يكون الظلّ في المساكن الشمالية ذوات الظلّ الواحد ظلّ رأس الجدي، لأنّ ارتفاعه أصغر الارتفاعات، فيكون ظلّه أطول الأظلال؛ وأقصرها ظلّ رأس السرطان، إذ ارتفاعه أعظم الارتفاعات؛ والمتوسّط بين الظلّين ظلّ الاعتدالين، لتوسّط ارتفاعها بين الارتفاعين. وقس عليه أحوال أظلال المساكن الجنوبية وذوات الظلّين.

[٨] وقد عرفت في خواصّ الآفاق من أحوال الظلّ ما فيه مقنع وكفاية، فاسمع الآن أنموذجاً من أحوال طرفه. فنقول أنّ أطراف أظلال المقاييس تفعل الخطوط الخمسة ذوات النظام، أعني محيطات القطوع الثلثة، الزائد والناقص والمكافي، والدائرة والخطّ المستقيم، إذ ليس في الخطوط ما له نظام غير هذه الخمسة أو ما يتركّب منها. والحُجَّة عليه هو أنّه لا يخفى عليك بعد الإحاطة بما سبق من الفصول المتقدّمة أنّ رأس المقياس بمنزلة مركز الأرض، إذ لا قدر لها بالنسبة إلى فلك الشمس؛ وأنّ الأفق الحسّي على هذا هو كسطح تحت مركز العالم؛ وأنّ الشمس تفعل في أربعة وعشرين ساعة مستوية دائرة موازية لمعدّل النهار، وإن كان[٢٧٤] تقريباً لا تحقيقاً؛ وأنّ الخطّ الخارج من مركز الشمس، أعني من محيط مدارها اليومي، المارّ برأس المقياس إذا أنفذ في الجهة الأخرى انتهى إلى نظير المدار المذكور، لكون رأس المقياس بمنزلة المركز. /وذلك إذا كان المدار غير المعدّل وإلّا انتهى الخطّ المذكور في الجهة الأخرى إلى المعدّل أيضاً ويمرّ بالضرورة على الفصل المشترك بينه وبين الأفق؛ فاحفظه فإنّك ستنتفع به ـــ إن شاء الله العزيز./[†] [iii] وأنّ الخطّ المذكور بدورانه دورة تامّة يفعل مخروطين رأسها رأس المقياس وقاعدتها المداران المتساويان الموازيان للمعدّل من جهتيه وسهمها محور العالم، أحدهما الذي على بسيطه الشعاع والآخر الذي على بسيطه ظلّ طرف المقياس. فلنسمّ الأوّل، وهو الذي يلي الشمس، مخروط الشعاع، والآخر مخروط الظلّ. وأنّ سطح نصف النهار لمروره بسهمها، وهو محور الكلّ، يُحدِث فيها مثلّثين. وأنّ تقاطع الأفق مع نصف النهار بل مع المثلّثين، لكونها في سطح نصف النهار، هو على قوائم.

[٩] وإذا كان كذلك فالأفق الحسّي المنصوب عليه المقياس المفروض كأنّه تحت مركز العالم إمّا أن يقطع المثلّثين أو أحدهما فقط. فإن كان الأوّل أحدث في المخروطين قطعين زائدين لكون الفصل المشترك بين كلّ من المثلّثين وبين السطح

[iii] وذلك إذا كان المدار غير المعدّل ... إن شاء الله العزيز] هاك (بدون «العزيز»)، هال

القائم عليه، أعني الأفق، قاطعاً لأحد ضلعيها وملاقياً للآخر من جمة رأس المثلّث، ويكون قطرهما المجانب قطعة من خطّ نصف النهار بين نقطتي تقاطع الأفق وضلعي المثلّثين. ومركز القطعين هو منتصف هذا القطر. وإن كان الثاني فالفصل المشترك بينهما، أعني بين الأفق والمثلّث، لا يخلو إمّا أن يوازي الضلع الآخر أو يقطعه من جمة القاعدة، إذ لا احتمال لقطعه إيّاه من جمة رأس المثلّث على هذا الفرض، وإلّا كان قاطعاً للمثلّثين، والتقدير بخلافه. فإن كان الأوّل أحدث في المخروط قطعاً مكافياً لكون الفصل المشترك بين مثلّثه والسطح القائم عليه ملاقياً لأحد ضلعيه وموازياً للآخر. وإن كان الثاني فلا يخلو إمّا أن يكون الفصل المشترك بين المثلّث والسطح القائم عليه موازياً لقاعدة المثلّث أو لا. فإن كان الأوّل أحدث في المخروط دائرة، لما تقدّم في لط. وإن كان الثاني أحدث فيه قطعاً ناقصاً لكون الفصل المشترك بين المثلّث والسطح القائم عليه قاطعاً لضلعي المثلّث من جمة القاعدة وغير موازٍ لها. ولا يمكن أن يقع مخالف الوضع، فيُحدث دائرةً لأنّ المخروط متساوي الساقين، وذلك إنّما يمكن حدوثه في المخروط المختلف الأضلاع. ويكون قطره الأطول قطعة من خطّ نصف النهار بين تقاطعي الأفق وضلعي مثلّثه.

[١٠] وإذا عرفت ذلك فنقول الشمس لا تخلو إمّا أن تكون في أحد الاعتدالين أو في غيره. فإن كان الأوّل فإنّ طرف ظلّ المقياس يفعل في جميع الآفاق غير عرض تسعين، إذ لا يكون هناك لشيء والحالة هذه طرف ظلّ، خطّاً مستقيماً. لأنّ الشمس أبداً مع الشيء المستضيء[٢٧٥] والساتر في سطح إذا كان الساتر نقطة أو خطّاً. فكلّ سطح يقع عليه

ظلّ رأس المقياس، فلا بدّ و[٢٧٦] أن يقطع سطح المعدّل، والظلّ يقع على الفصل المشترك بينهما، /وهو خطّ مستقيم،/[§ iv] /و/[§ v] ممرّ طرف الظلّ يكون عليه، فيرسم خطّاً مستقيماً.

[١١] وإن كانت الشمس في غير الاعتدالين فأطراف أظلال المقاييس من خطّ الاستواء إلى عرض تمام الميل كلّه تفعل القطوع الزائدة المتقابلة، أي التي تفعلها وهي في الشمال تكون مقابلة للتي تفعلها وهي في الجنوب. لأنّ هذه الآفاق تقطع جميع مدارات الشمس اليومية، إذ لجميعها طلوع وغروب في تلك البقاع. فتقطع آفاقها المثلّثين ويحدث ما ذكرنا، لأنّ كلّ سطح يقطع مخروطين متقابلين من غير أن يمرّ برأسيهما فإنّه يُحدِث فيهما قطعين زائدين إلّا[§ vi] في يومي الاعتدالين فإنّها[§ vii] تفعل فيهما الخطّ المستقيم وهو السهم القائم للقطوع المذكورة لمروره بمركزها وهو منتصف المجانب، أعني الخطّ الذي يقع فيما بين موضعي طرف الظلّ في أوقات نصف النهار في تلك الأيّام.

[١٢] و[§ viii] في رأس المنقلب الذي يكون في جهة القطب الظاهر، كرأس السرطان في الشمال في هذا العرض، وهو عرض تمام الميل كلّه، فإنّها تفعل القطع المكافي. لأنّ الخطّ الخارج من مركز الشمس، وهي في نقطة الشمال، المارّ برأس

[iv] وهو خطّ مستقيم] - ب، شاك، شال = + لما تقدّم من أن الخطّ الشعاعي يمر على الفصل المشترك بين المعدّل والأفق وهو خطّ مستقيم منطبق في خطّ الاستواء عليه مار بأصل المقياس وفي غيره موازٍ له شمالي عن أصل المقياس في البلاد الشمالية وجنوبي عنه في الجنوبية لا مار به على ما سبق إلى الوهم وإلّا امتنع حدوث ظل الاستوائيين [الاعتدالين؟] وقت انتصاف النهار في غيره والوجود بخلافه: ب، هار، هاك، هال

[v] و] ولان: ب، ر = +لان: مضاف بعد التحرير في ك ول

[vi] إلّا] واما: ب = متغير إلى «واما»: ر، ك، ل

[vii] فإنّها] +كما علمت: ب، فار، هاك، فال

[viii] و] - ب، شار، شاك، شال = + فإن قيل إنّما يكون الخطّ المستقيم السهم القائم لها لو كانت حدبات القطوع الشمالية إلى الشمال والجنوبية إلى الجنوب مع كون الجميع في شمال المقياس لكون السهم المذكور شمالياً عنه في هذه العروض كما بينا قلنا هو كذلك لأنّ الشمس إمّا أن تصل إلى سمت الرأس أم لا فإن

المقياس المنتهي إلى نقطة الجنوب يوازي السطح القائم مقام الأفق، وهو الذي نصب فيه المقياس. فالفصل المشترك بين هذا السطح وسطح نصف النهار، وهو ملاقٍ لأحد ضلعي المثلّث، يوازي الخطّ المذكور الذي هو الضلع الآخر من المثلّث. فيحدث الأفق قطعاً مكافياً ويكون ممرّ طرف ظلّ المقياس على محيطه هذا إن كانت الشمس في المنقلب الذي في جهة القطب الظاهر. وإن كانت في الآخر فلا يقع لشيء ظلّ لكونها تحت الأرض حينئذ.

[١٣] وفيما جاوز هذا العرض ولم ينته إلى الربع حيث ينفصل فلك البروج إلى أربع قطع إحديها،[٢٧٧] ـــ وهي التي يتوسّطها المنقلب الذي في جهة القطب الظاهر ـــ أبدية الظهور، وثانيتها مقابلتها ـــ وهي التي يتوسطها الآخرـــ أبدية الخفاء، والباقيتان لهما طلوع وغروب، فطرف ظلّ المقياس يفعل القطوع الزائدة متى كانت الشمس في القوس التي لها طلوع وغروب، لأنّ الأفق يقطع جميع مدارات أجزاء تلك القوس؛ والقطوع المكافية متى كانت في طرفي القوس الأبدية الظهور، لأن الأفق يماسّ مدار كلّ من النقطتين؛ والقطوع الناقصة متى كانت في باقي القوس الأبدية الظهور، لأنّ الأفق يقطع جميع أضلاع مخروط الظلّ ولا يوازي قاعدته، لأنّ القطب ليس على سمت الرأس فيُحدِث القطع الناقص. ويكون قطره الأطول من نصف النهار وطرفاه هما اللذان يقع عليهما طرف الظلّ إذا كانت الشمس في نصف النهار في ذلك اليوم ومركز القطع

وصلت إليه كانت حدبة القطع حينئذ على أصل المقياس لانطباقه على سطح مخروط الظلّ وإلّا كانت الحدبات في شمال المقياس وإلى جهة القطب الظاهر إذا كانت الشمس في المدارات الشمالية لكون المقياس داخل مخروط الظلّ وانقطاع ما يلي الشمال منه بالأفق وإلى جهة الخفي إذا كانت في الجنوبية لكون المقياس خارجاً عنه وانقطاع ما يلي الجنوب منه بالأفق ولا يخفى أن القطوع تتزايد تحدّبها والبعد بين رؤوسها والسهم بحسب تزايد البعد بين قاعدتي المخروطين وغايته إذا كانت الشمس في المنقلب ويتناقصان بحسب تناقص البعد بينهما وغايته إذا كانت في المدار الذي ينتقل منه إلى المعدّل لكون محيط القطع حينئذ قريباً من الاستقامة حتّى إذا انتقلت إليه انطبقت القاعدتان عليه وصار ما كان محيط القطع خطّاً مستقيماً لما تقدّم ولبطلان المخروطين أيضاً فاعرفه فإنّه من التصوّرات اللطيفة هذا وأمّا: ب، هار، هاك، هال

منتصف هذا القطر. وأمّا إن كانت في مقابل القوس الأبدية الظهور فطرف الظلّ لا يفعل شيئاً إذ لا ظلّ لشيء من الأشياء حينئذ.

[١٤] وفي عرض تسعين حيث يكون النهار ستّة أشهر وسبعة أيّام وذلك قفز يوماً والليل قعح يوماً وربع بالتقريب، يفعل طرف الظلّ دوائر تامّةً متوازيةً بالتقريب كلّها على مركز واحد هو مركز أصل المقياس وبعضها داخل بعض وأصغرها ما إذا كانت الشمس في المنقلب الظاهر وأعظمها ما إذا صارت قريب الأفق فوق الأرض. وإنّما يرسم دائرة لأنّ الأفق يقطع مخروط الظلّ موازياً لقاعدته لكون سهمه قائماً على سطح الأفق. ولأنّ ممرّ طرف الظلّ يكون على الخطوط الخمسة المذكورة من الخطّ المستقيم والدائرة والقطوع الثلاثة، صحّ أنّ طرف الظلّ يفعل الأشكال ذوات النظام الأربعة والخطّ المستقيم. وهذا نهاية الكلام في هذا.

[١٥] وأمّا معرفة الأوقات الموعود بيانها، فاعلم أنّ الكلّ اتّفقوا على أنّ وقت صلوة الظهر هو بعد الزوال ولو بدقيقة، لا حيث كانت الشمس على نصف النهار. وإنّما يُعرف ذلك الوقت بأن يميل الظلّ عن خطّ نصف النهار إلى جهة الشرق. وإن لم يكن خطّ نصف النهار مستخرجاً فبحدوث الظلّ إن لم يبق منه شيء وقت انتصاف النهار، أو بازدياده على ما كان إن بقي منه شيء حينئذ. ثمّ إن أزداد الظلّ بقدر المقياس على ما بقي منه أو حدث مثله إن لم يبق منه شيء فهو أوّل وقت العصر عند أئمة الحجاز، وهو مذهب الشافعي ـــ رضي الله عنه. وإن حدث أو زاد بقدر مثلي المقياس فهو أوّل وقته عند أئمّة العراق، وهو مذهب أبي حنيفة ـــ رضي الله عنه. ووجه معرفته بأسهل طريق أن يُنصب مقياس محدّد الرأس مخروطي الشكل على سطح الأفق على قوائم ويقسم باثني عشر قسماً أو بسبعة أقسام. فما دام الظلّ يتناقص فالشمس بَعدُ لم تنته إلى

نصف النهار. فإذا وقف الظلّ ولم يزد شيء فتكون الشمس قد انتهت إلى نصف النهار. فإذا أخذ الظلّ في أدنى زيادة فهو أوّل وقت الظهر. فنعلّم على رأس الظلّ بعلامة ونسمّى ذلك قدر الزوال. ثم ننتظر إلى أن يصير الظلّ من موقع العلامة مثل المقياس أو مثليه فيكون أوّل العصر على المذهبين. وأمّا أوّل وقت المغرب فبغروب الشمس إن ظهر غروبها كما في الصَّحاري، وإن لم يظهر كما في خلال الجبال والعمران فبأن لا يبقى على رؤوس الجدران وقُلل الجبال شيء من الشعاع، ويُقبل الظلمة والسواد من طرف الشرق.[٢٧٨] وأمّا أوّل وقت العشاء فبغروب الشفق، وهو الحمرة التي تلي الشمس عند الشافعي والبياض عند أبي حنيفة ـــ رضي الله عنهما. وأمّا أوّل وقت صلوة الصبح فبطلوع الصبح الثاني الصادق، وهو البياض المنبسط العريض، لا الأوّل الكاذب، وهو البياض المستطيل المستدقّ.

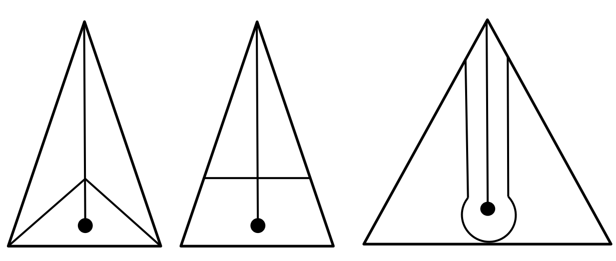
[١٦] فهذا ما أردنا من بيان أحوال الظلّ وما يتعلّق به.

الباب الثالث **عشر**

في معرفة خطّ نصف النهار المسمّى بخطّ الزوال أيضاً

وفي سمت القبلة

[١أ] يحتاج في هذا الباب إلى السطح الموزون. وطريق تحصيله أن نسوّي مكاناً بأن نأخذ مسطرة مصحّحة. ونضع وسطها على نقطة في وسط ذلك المكان وندير المسطرة عليه إلى أن يماسّ[٢٧٩] المسطرة في جميع الدور ولا يَبِينُ بينهما ضوء. ثمّ نزن هذا الوجه الصحيح بالأفاذين ويسمّى بالگونيا أيضاً، وهذه صورها، بأن نضع قاعدة، أيّها حضر، على ذلك الوجه ونعتبر مطابقة خيط الشاقول لعمود المثلّث. ونعدّل ما انخفض من السطح ونسوّي ما ارتفع إلى أن يصير بحيث إذا ما دارت قاعدة المثلّث على جميع السطح لا يميل الخيط عن العمود. فهذا هو المسمّى بالسطح الموزون، وهو المعتمد عليه عند الرُصّاد وأهل العمل، لا ما هو المشهور وهو أن نسوّى أرضاً بحيث لو صُبّ فيها ماء سال من جميع الجهات بالسوية، أو إذا أُلقي في موضع منها شيء متدحرج، كالبندقة مثلاً، وقف مهتزّاً مرتعداً لا يميل إلى جهة ما؛ فإنّه لا يُجدي بطائل على ما لا يخفى. ثمّ السطح الموزون إن لم يكن على الأرض بل كان على حجر ونحوه، نثبته بحيث لا يتغيّر وضعه ولا وزنه.



[شكل ١٠]

[١ب] ونخطّ على السطح الموزون دائرة أصغر من أعظم دائرة تُخطّ فيه بمقدار إصبع لنتبيّن موضع دخول الظلّ وخروجه. ونعمل مقياساً من نحاس أو خشب مخروطاً بالشِهر مستدقّ الرأس لئلّا يكون الظلّ غليظاً. وينبغي أن لا تكون دقّته في الغاية لئلّا يخفى ظلّه. ونجعل سعة قاعدته بحيث إذا وضعناه على السطح ثبت قائماً عليه غير متزلزل، بأن نحفر في وسط قاعدته، إن كان من خشب لا من نحاس ونحوه، حفراً ونقلب فيه شيئاً من رصاص ليثقل فيثبت. والمشهور أنّ طول المقياس ينبغي أن يكون ربع قطر الدائرة المرسومة على السطح أو أكثر بشرط أن لا يصل إلى نصف القطر. وإنّما اشترط ذلك لأنّ طوله لو كان مثل نصف القطر وظلّ كلّ شيء مثله إذا كان الارتفاع خمسة وأربعين، لما قدّمنا في باب الظلّ أن ظلّ ثُمن الدور يساوي المقياس، لمّا وصل طرف الظلّ إلى محيط الدائرة في البلاد والأوقات التي لا يصل الارتفاع فيها إلى خمسة وأربعين، ولمّا تمّ العمل بهذا الوجه. والأولى أن يُقال يجب أن يكون طول المقياس بمقدار ما يقصر ظلّه عن محيط الدائرة وقت نصف النهار ويتجاوز عنه في جنبتي نصف النهار.

[١ج] ثمّ ندير على المركز المذكور دائرة مساوية لقاعدة المقياس أو أكبر منها بقليل بحيث إذا وضعنا القاعدة عليها انطبقت عليها أو نراها محيطة بالقاعدة من جميع الجهات وموازية لها. ويكون حينئذ مركز قاعدة المقياس منطبقاً على مركز الدائرة والمقياس قائماً على السطح. وهذا هو المعتبر المعمول عليه في كون المقياس قائماً لا امتحانه بالشاقول، ولا بأن يُقدَّر ما بين رأس المقياس والمحيط بمقدار واحد من ثلاث نقط من المحيط وإن اشتهرا. ثمّ نرصد قبل نصف النهار وصول طرف الظلّ إلى محيط الدائرة من جهة المغرب. فعند وصوله إليه قبل دخوله فيها ننصّف عرض الظلّ ونعلّم عليه. فإنّ منتصفه هو نقطة الدخول. وكذا نعمل في الطرف الآخر. فإنّ منتصفه نقطة خروج الظلّ. وننصّف إحدى القوسين ونصل بين منتصف إحداهما

والمركز بخطّ مستقيم. فإنّه يكون خطّ نصف النهار، أعني الفصل المشترك بين دائرتي الأفق ونصف النهار. وذلك لأنّ الظلّين متساويان لكونهما مساويين لنصف قطر دائرة واحدة، والأظلال المتساوية إنّما يكون لارتفاعات متساوية. وهذا وإن بُرهن عليه لكنّه لا يتقاصر عن الأوّليات عند من تصوّر زيادة الظلّ ونقصانه بحسب نقصان الارتفاع وزيادته. فارتفاعا هذين الظلّين متساويان، فجيبا تماميهما متساويان، وهما مساويان للخطّين الخارجين من مركز المقياس على استقامة الظلّين، لأنّ الظلين على الفصل المشترك بين دائرتي الارتفاع والأفق، وكذا الخطّان المذكوران. ونهايتا هذين الخطّين هما مسقطا حجري الارتفاعين، أعني جيبيهما. والخطّ[٢٨٠] الواصل بين هاتين النهايتين هو مساوٍ لوتر الدائر من الفلك بين وقتي الارتفاعين في المدار وموازٍ له. لأنّ الخطوط الواصلة بين أطراف الخطوط المتساوية المتوازية، كالجيبين في مثالنا لتساويهما وتوازيهما لكونهما عمودين على الأفق، متساوية متوازية.

[١د] ولأنّ كلّ نقطتين في مدار واحد متساويتي مقدار الارتفاع مختلفتي جهتيه من المشرق والمغرب، فإنّ بعديهما عن نصف النهار متساويان لتنصيف نصف النهار القطعة من المدار التي بين النقطتين. إذ لتساوي[٢٨١] ارتفاعهما تكون مقنطرة ارتفاعهما المقاطعة للمدار واحدة. ولتقاطعهما ومرور نصف النهار بقطبيهما، يُنصّف قِطَعَهُما، لما تقدّم في حَ. فسطح نصف النهار ينصّف وتر الدائر من الفلك بين الارتفاعين، والخطّ الموازي له الواصل بين نهايتي جيبي تمامي الارتفاعين. فينصّف أيضاً الخطّ الواصل بين طرفي الظلّين لتشابه المثلّثين لتوازي قاعدتهما، على ما يظهر بالتطبيق، لتساوي زاوية الرأس فيهما وكونهما متساويّي[٢٨٢] الساقين. وإذا كان نصف النهار ينصّف الخطّ الواصل بين طرفي الظلّين فالخطّ الواصل بين منتصفه ومركز

المقياس يكون في سطح نصف النهار. وهو المطلوب، ونحن إنّما نصّفنا القوس، لأنّه لا[٢٨٣] يحتاج إلى عمل آخر. بخلاف تنصيف الخطّ الواصل فأنّه يحتاج إلى إخراجه.

[١هـ] ولنا أن نقرّر المطلوب بوجه آخر. ونقول فلأنّ نصف النهار ينصّف القطعة من المقنطرة التي بين دائرتي الارتفاع، كما تقدّم تقريره، ونصف النهار ودائرتا الارتفاع مرّت بقطبي الأفق والمقنطرة المتوازيّين؛ فينفصل فيما بينهما[٢٨٤] من المتوازية قسيّ متشابهة، لما بُيّن في *الأكر*. فتكون القوسان من المقنطرة المتساويتان شبيهتين بنظيرتيهما من الأفق؛ فهما أيضاً متساويتان. ولتساويهما وكون الأفق موازياً للدائرة المرسومة على السطح الموزون لكون مركزهما، وهو أصل المقياس، واحداً، إذا وصل بين المركز وطرفي كلّ من[٢٨٥] القوسين[٢٨٦] من الأفق بخطّين مستقيمين، يفصلان من الدائرة المرسومة قوسين متساويتين. لأنّ الخطوط الخارجة من مركز الدوائر المتوازية تفصل فيما بينها من محيطاتها قسيّاً متشابهةً. فإذن نصف النهار ينصّف القوس التي بين طرفي الظلّين فالخطّ المارّ بالمركز المنتصف للقوس المذكورة يكون في سطح نصف النهار وخطّه، وهو المطلوب.

[٢أ] ولا يخفى بعد الإحاطة بما ذكرنا أنّ طول المقياس لو كان نصف القطر، فإذا وصل طرف الظلّ إلى محيط الدائرة، كان الظلّ في سطح نصف النهار إن كان غاية الارتفاع ثمن الدور، لما تقدّم. والخطّ **المارّ بمركز الدائرة** المرسومة وفي سطحها عموداً على خطّ نصف النهار، يكون في سمت دائرة أوّل السموت، وهو **خط المشرق والمغرب** وخطّ الاعتدال. **ويُربّعان الدائرةَ، ثمّ يقسم كلٌّ ربع تسعين قسماً متساويةً لتعرف مقادير السموت من خطوط الظلّ الواقعة على المحيط لأنّ ما بين نقطتي المشرق والمغرب وخطّ الظل من تلك الأقسام سمت. وهذه الدائرة تُعرف بالهندية.**

[٢ب] واعلم أن أصلح الأوقات لأخذ الظلّ أن يكون ارتفاع الشمس قيد رُمحَين. لأنّها إذا كانت قريبةً من الأفق، كانت الأظلال طوالاً متشتّتة الأطراف، فلا تُتحقّق أطرافها عند الحسّ. وإذا كانت قريبة من نصف النهار، يكون الأظلال، مع كونها مُشبّعة في الظلمة، بطيئة التقلّص، فلا يُتحقّق آنُ دخول الظلّ ولا آنُ خروجه. فلا يتحقّق تساوي زماني البعد عن نصف النهار ولا خطّ نصف النهار. وأمّا الأمر المتوسّط فيجتمع فيه سرعة الحركة وصبغ الظلّ ويَسلَمُ عن تشتُّت طرف الظلّ وبطوء حركته. وأن يكون أيضاً الشمس في الانقلاب الصيفي أو قريباً منه. لئلّا يكون لميلها عن الموازية للمعدّل في زمان سيرها فيما بين دخول الظلّ وخروجه قَدرٌ يُعتدّ به، فيُخلّ بالمقصود؛ لابتناء البرهان على أنّ الشمس تدور في اليوم الواحد على دائرة موازية للمعدّل في الحسّ. ولأنّ ضيائها حينئذ أشدّ من ضيائها في الجدي، لما تقدّم من اجتماع الأشعّة في الصيف دون الشتاء. وإذا كان الضوء أكثر كان الفصل بين الشعاع والظلّ أظهر.

[٢ج] ويجب أن تعلم مع ما قد علمت أنّه كما تكون للأظلال المتساوية ارتفاعات متساوية، كذلك تكون للارتفاعات المتساوية أظلال متساوية. وإذا كان كذلك، فلو رُصد في يوم واحد ارتفاعان متساويان للشمس عن جنبتي غاية ارتفاعها ويُخطّ على سطح موزون سمتا ظلّيهما عن مقياسٍ واحدٍ، ثمّ تُنصَّف الزاوية الحادثة بينهما بخطّ، كان ذلك الخطّ في سطح نصف النهار، ولميّته معلومة ممّا تقدّم. وأمّا تنصيف الزاوية، فبأن يُفرز من الظلّ مقداران متساويان من أصل المقياس ويوصل بينهما بخطّ، ثمّ يُنصّف ذلك الخطّ ويوصل بين المنتصف والزاوية بخطّ. والأسهل أن تُجعل نقطة الزاوية مركزاً وتُرسم دائرة تقطع الظلّين وتنصّف القوس التي بينهما ويوصل، كما مرّ.

[٢د] قال كوشيار: «نُسَوّي موضعاً من الأرض حتّى يصير سطحه موازياً للأفق وندير فيه دائرةً ونغرز في المركز إبَرَة مستوية القامة ونقدّر قيامها على السطح من ثلاثة مواضع متباعدة على محيط الدائرة. ثمّ إذا كان بالقرب من نصف النهار رصدنا رأس ظلّ الإبرة، وهو متناقص، بأن نعلّم على مواقعه، كما تدور، علاماتٍ متقاربةً جدّاً برأس إبرة أخرى، ونستقصي فيه حتّى يأخذ الظلّ في الزيادة. ثمّ نصل بين أقرب العلامات من المركز وبين المركز بخطّ مستقيم فيكون خطّ نصف النهار. وجه آخر وهو أن نسوّي الأرض والدائرة والشخص، كما قلنا، إلّا أنّ الدائرة تكون مساوية لدائرة الارتفاع التي على ظهر الأمّ من اسطرلاب يحضر. وطول الشخص بحيث لا ينقص ظلّه عن محيط الدائرة عند نصف النهار. ثمّ نستخرج سمت ارتفاع عن أحد جنبتي نصف النهار، ونعلّم عند وجود ذلك الارتفاع على موقع الظلّ من محيط الدائرة علامة. ونأخذ من دائرة الارتفاع على الاسطرلاب بالبركار مثل تمام السمت، ونضع أحد رجلي البركار على العلامة والرجل الآخر حيث وقع من محيط الدائرة في جهة الارتفاع، شرقياً كان أو غربياً، ونخرج من موقعه خطّاً إلى مركز الدائرة فيكون خطّ نصف النهار. فإن كان الارتفاع هو الارتفاع الذي لا سمت له، كان سمت الظلّ خطّ المشرق والمغرب، والخطّ الخارج من منتصف نهايتيه[٢٨٧] إلى مركز الدائرة خطّ نصف النهار. ولاستخراج هذا الخطّ وجوه كثيرة إلّا أنّ كلّها دون هذين الوجهين في الاستقصاء والقرب من الصواب، إذا أخذناه من حيث العمل فأمّا من حيث العلم فكلّها صحيحة مبرهنة». هذا كلّه لفظه وإنّما نقلته على ما هو عليه لنعتبر أنّه هل يصحّ ما قاله أم لا. إذ الظاهر أنّهما لا يكونان في القرب من الصواب مثل الوجهين المتقدّمين، يُظهر بالاعتبار لمن وُفّق له.

[٣أ] وأمّا سمت القبلة، فهي نقطة تقاطع أفق البلد المفروض والدائرة السمتية المارّة بسمتي رأسي البلد ومكّة. والخطّ الواصل بين مركز الأفق وتلك النقطة هو خطّ سمت القبلة، وهو سهم لقوس يُبنى أساس المحراب عليها ومنصّف لها. فالمصلّي إذا جعله بين رجليه ساجداً عليه يكون قد صلّى على محيط دائرة على بسيط الأرض مارّةً بموضع سجوده وما بين قدميه ووسط البيت، أو يكون قد استقبل الخطّ الواصل بين البيت والنقطة التي تسامته من السماء المسمّاة[٢٨٨] بسمت رأس مكّة. لا أنّه يكون قد استقبل البيت بمعنى أنّ الخطّ المستقيم الخارج من بصره يقع على البيت، لأنّ أفق مكّة يكون تحت أفق المصلّي، فلا يسامت نظره البيت بل الخطّ المذكور. ومنه تطّلع على فساد تفسير سمت القبلة بأنّها نقطة في الأفق إذا واجَهَها الإنسان كان مواجهاً للكعبة. اللّهم إلّا أن تُأوّل المواجهة وتُنزّل على ما قلنا. وأمّا سمت القبلة عن البلد المسمّاة بقوس الانحراف أيضاً، فهو قوس من الأفق بين تقاطعه مع السمتية المذكورة وبين إحدى النقط الأربع أعني المغرب والمشرق والجنوب والشمال. وهو مقدار ما يجب أن ينحرف[٢٨٩] المصلّي عن مواجهة إحدى النقط لتواجه البيت كما ذكرنا. وتمام الانحراف هو قوس منه أيضاً بين نقطة سمت القبلة وإحدى النقط.

[٣ب] وإذا عرفت ذلك فاعلم أنّه لابدّ في معرفة سمت القبلة وسمتها عن بلد آخر من معرفة طول مكّة وعرضها وطول البلد المفروض وعرضه. أمّا **طول مكّة ـــ حماها الله ـــ فعن جزائر الخالدات سبع وسبعون جزءاً وسدس جزء، وعن ساحل البحر الغربي سبع وستّون جزءاً وسدس جزء. وعرضها أحد وعشرون جزءاً وثُلثا جزء. فكلّ بلدة يكون**[٢٩٠] **طولها أقلّ من طول مكّة فمكّة شرقية عنها؛ وكلّ بلدة يكون طولها أكثر من طول مكّة فمكّة غربية عنها.**[٢٩١] وإن كان عرضها أقلّ من عرض مكّة فمكّة شمالية عنها، وإن كان أكثر منه فجنوبية. ثمّ البلدة المفروضة مع مكّة لا يخلو من[٢٩٢] أن تكونا مختلفتين[٢٩٣]

إمّا في العرض فقط أو في الطول فقط أو في كليهما. فإن كان الأوّل، كانتا تحت نصف نهار بعينه ولا يكون لإحداهما سمت عن الأخرى بل يكون سمتهما على خطّ نصف النهار. فتوجّه[٢٩٤] المصلّي نقطة الجنوب إن كان عرض مكّة أقلّ، ونقطة الشمال إن كان أكثر.

[٣ج] وإن كانت [كذا] الثاني، **كانتا تحت مدار واحد يومي.** وقد ظنّ قوم ومنهم كوشيار وقد صرّح به في مواضع، أنّ السمت بينهما يكون على خطّ المشرق والمغرب، والقبلة إلى حقيقة المشرق إن زاد طول مكّة، وإلى حقيقة المغرب إن نقص. وهو ظنّ باطل وخطأ فاحش إذ لاختلاف طوليهما يكون أوّل السموت لإحداهما يماسّ المدار المذكور على نقطة غير التي يماسّها أوّل السموت للأخرى، لقطع أوّلي السموت للمعدّل على نقطتين مختلفتين. فيتقاطع أوّلا السموت لهما على غير نقطتي المشرق والمغرب. فلا يكون خطّ مشرقهما ومغربهما واحداً؛ ولا السمت بينهما ذلك؛ ولا القبلة إلى حقيقة المشرق أو المغرب، بل كانت **عن يسار مشرق الاعتدال لتلك البلدة إن كان طولها أقلّ من طول مكّة،** و**عن يمين مغرب الاعتدال إن كان طولها أكثر.** لأنّ سمت رأس مكّة يستحيل أن يكون على دائرة أوّل السموت للبلدة المفروضة؛ وإلّا لكان عرضها أقلّ من عرض تلك البلدة، إذ كلّ نقطة عليها، غير سمت الرأس، عرضها أقلّ. وأن يكون بين دائرة أوّل السموت والمعدّل، بطريق الأولى، فيقع سمت رأس مكّة بالضرورة خارجاً عن أوّل السموت. ويلزم ما ذكرنا نعم ما ظنّ: إنّما يصحّ في مساكن خطّ الاستواء، وإن اختلفت في الطول، حتّى صار نصف نهار القبّة أفقاً للمشرقيّين والمغربيّين؛ لا لكون خطوط مشرقهم ومغربهم جميعاً في سطح معدّل النهار، على ما يسبق إلى الوهم لأنّه في غير خطّ الاستواء كذلك، بل لأنّ سمت رؤوس الجميع على المعدّل إذ هو بمنزلة أوّل السموت لهم.

[٤أ] وإن كان الثالث، فلا يكونان لا تحت نصف نهار ولا مدار يومي بعينهما. ويحتاج فيه وفي الثاني إلى معرفة قوس الانحراف ولها **طرق كثيرة لا يليق إيرادها هاهنا. فلنقتصر على** وجوه سَهلةٍ، منها **أنّ الشمس تكون مارّة بسمت مكّة عند كونها في الدرجة الثامنة من الجوزاء والثالثة والعشرين من السرطان وقت انتصاف النهار هناك،** لأنّ ميل هذين الجزئين يساوي عرض مكّة المذكور. **والفضل بين نصف نهارها وبين نصف نهار سائر البلدان يكون بقدر التفاوت بين الطولين. فليؤخذ التفاوت وتؤخذ لكلّ خمسة عشر جزءاً ساعة ولكلّ جزء أربع دقائق؛ فيكون ما اجتمع ساعات البعد عن نصف النهار. وليُرصد في ذلك اليوم ذلك الوقت قبل نصف النهار إن كانت مكّة شرقية أو بَعده إن كانت غربية. فسمت الظلّ ساعتئذ يكون سمت القبلة.**

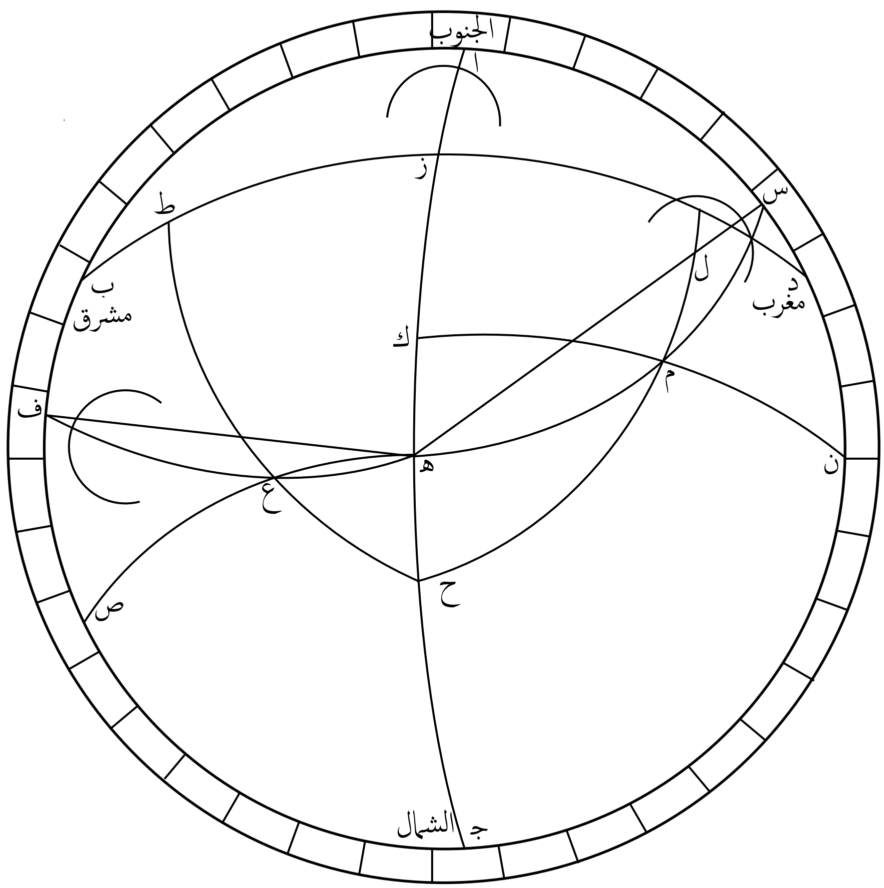
[٤ب] ومنها أن نضع أحد الجزئين اللذين يسامتان مكّة من البروج، وهما ز كا من الجوزاء و كب لط من السرطان، على وسط السماء في اسطرلاب بلدنا، ونعلّم على المُريّ. ثمّ ندير العنكبوت بقدر ما بين الطولين إلى المغرب إن كان بلدنا شرقياً من مكّة وبالخلاف إن كان غربياً منها. فحيث انتهت الأجزاء من مقنطرات الارتفاع، رصدنا بلوغ الشمس إليه ونصبنا مقياساً. فظلّه في ذلك الوقت هو سمت القبلة، وهو قريب من الأوّل. ومنها أن نعدّ أجزاء ما بين الطولين والعرضين من أجزاء الدائرة الهندية ونخرج من منتهى الأجزاء خطّين يوازي أحدهما لنصف النهار والآخر لخطّ المشرق والمغرب. فيتقاطعان لا محالة. ونصل بين المركز ونقطة التقاطع بخطّ مستقيم، وننفذه إلى المحيط فإنّه يكون خطّ سمت القبلة.

[٤ج] ومنها أن نقسم خطّ نصف النهار بأقسام متساوية ونأخذ منها بقدر تفاضل ما بين عرض البلد ومكّة مع كسر إن كان ونقيم عموداً على طرفه الشمالي، إن كان عرض البلد أقلّ من عرض مكّة؛ وعلى الجنوبي إن كان أكثر؛ وفي جهة

المشرق إن كان طول مكّة أكثر؛ وفي جهة المغرب إن كان أقلّ. ونقسمه بمثل ما قسمنا به الخطّ الأوّل. ثمّ نأخذ منه بمقدار ما بين الطولين من هذه الأجزاء ومع كسر إن كان، ونصل بين ما انتهى إليه وبين النقطة الأخرى من نصف النهار بخطّ. فيُحصل مثلّث قائم الزاوية ويكون سمت القبلة على الخطّ الثالث الذي هو وتر القائمة. وهذه الطريقة وما قبلها تقريبية ولا يتمشّي في البلد الذي يساوي عرضه عرض مكّة ولا طوله طولها، لابتنائهما على تفاضل ما بين الطولين والعرضين.[٢٩٥]

[٤د] ومنها أن نأخذ كرة صحيحة الاستدارة عليها عظيمة مقسومة بثلاثمائة وستّين جزءاً بمنزلة أفق البلد وهي ا ب جـ د. ونقيم عليها نصفَ نصفِ النهار وهو ا هـ جـ وهـ سمت رأس البلد. ونفصل منه جـ ح بقدر عرض البلد بأن نأخذ بالبركار من أجزاء الأفق من نقطة الشمال مثل العرض، فـ ح قطب المعدّل. فنرسم عليه عظيمة ب ز د قاطعاً للأفق على د ب، المغرب والمشرق، ولنصف النهار على ز. فإن وجدنا ما بين ز وهـ، سمت الرأس، مثل ارتفاع القطب، فقد صحّ العمل، وإلّا فلا. ثمّ البلدان إن اختلفا عرضاً فقط، فخطّ نصف النهار هو خطّ سمت القبلة. فنستخرجه وهو الذي لا بدّ منه في جميع الوجوه. وإن اختلفا طولاً فقط، فنرسم على ح وببُعد هـ موازية هـ ع ص. فتمرُّ بسمت رأس مكّة. ونفصل من المعدّل من عند نصف النهار مقدار ما بين الطولين في الجهة التي مكّة فيها. فيكون شرقي نصف النهار إن كان طول مكّة أكثر مثل ز ط، وإلّا غربية إن كان أقلّ من طول البلد. ونرسم عظيمة تمرّ بنقطتي ح ط وقطبها على المعّدل، وهي ح ع ط، فـ ع سمت رأس مكّة. ونرسم عظيمة تمرّ بسمتي الرأس وهما هـ ع وتقطع الأفق على ف. فـ اف قوس السمت وهي معلومة من اجزاء الأفق المقسوم، وف نقطة السمت. ولأنّها قطعت الأفق على ف دون ب ص فلا يكون سمت القبلة على خطّ المشرق والمغرب، على ما ظُنّ، ولا على الفصل المشترك بين الموازية والأفق. وإن اختلفا طولاً وعرضاً فليكن فضل ما بين الطولين ز ل وعرض مكّة ز ك.

ونرسم على ح وببُعد ك موازية ك م ن وعظيمة ح م ل، ف م سمت رأس مكّة. ثم نرسم عظيمة ه م س. ف اس قوس السمت وهي معلومة من أجزاء الأفق. وإذا صارت قوس السمت معلومة فإمّا أن نفصل مقدارها من الدائرة الهندية ونخطّ خطّ السمت، أو نوضع نصف نهار الكرة على خطّ نصف النهار وسمت الرجل منها على مركز الهندية فنعلّم نقطة السمت ونخطّ الخطّ، وهو ظاهر. وإنّما أوردت هذا الوجه وإن كان يوهم أنّ فيه صعوبة لغرابته، ولأنّه لا يتقاصر عن غيره في السهولة يظهر لمن له أدنى دربة بأعمال اليد. وهذا آخر المقالة الثالثة ـــ والحمد لله واهب العقل وباسط الجود والفضل.



[شكل ١١]

Apparatus

[١] وهو مع] ومع: ر
[٢] لأنّ ما بين نصفي النهارين للمغربي أكثر منه للمقيم بقدر حركته، وللمقيم أكثر منه للمشرقي بقدر حركته] هاب
[٣] السنة] هاب
[٤] أن يكون] هار
[٥] الدورة] الدور: ب
[٦] وللمشرقي] + في: ر
[٧] كانت] كان: ب، ك
[٨] المغرب] الغرب: ب، ك
[٩] الوضع] الموضع: ب
[١٠] لشخص] + مقدار: شال
[١١] أو] و: ب
[١٢] كقدر] ل، «ک» مضاف بعد التحرير = قدر: ب، ك
[١٣] امتياز] هال
[١٤] الشمال] + أي في أنصاف النهار إذا كانت الشمس في إحدى الاعتدالين: هاب
[١٥] المعمور] هال
[١٦] أقدامهما] قدميهما: ب
[١٧] منه] هار، فال
[١٨] بين] هار، تاك، تال
[١٩] ارزن الروم] أرزنروم: ب = متغيّر من «ارزنروم»: ل
[٢٠] الأخضر] الأدخضر: ل
[٢١] طنجة] + خلنجة: هاب، مع رمز «خ»
[٢٢] وعرضه عند قسطنطينية فرسخ ولا يزال يتضايق حتّى يقع في بحر مصر] هار، هال
[٢٣] الغُزية] الغزنه: ب، ل= الغَزْنَةِ: ك = الغزنه: ر
[٢٤] مائة] + خمسمائة: هاب، مع رمز «خ»
[٢٥] تُبُتْ] تَبت: ك = تبت: ل
[٢٦] معبد] معهد: ب
[٢٧] في] من: ب
[٢٨] إشراقاً] أثراً: ب
[٢٩] كما] لما: ب
[٣٠] قيل] كان: ب
[٣١] منه] + فيكون لحرارة بكل المواضع سببان كون الشمس في المنقلب وكونها أقرب إلى الأرض... (غير مقروء): هاب
[٣٢] يجيء] سيجيء: ب

٣٣ محاذاتها] محاذاتهما: ك، ل
٣٤ التاسعة عشر] التاسعة عشرة: ب، ك
٣٥ ثلاث] ثلثة: ر، ل
٣٦ كسر] + على تقدير عدم اعتبار العمارة التي في ناحية الجنوب: هاب
٣٧ موضع] موضعه: ك = متغيّر من «موضعه»: ل
٣٨ وتسامتها] ويسامتها: ب
٣٩ لها] + إنما يعرف ارتفاع منطقة المعدل من معرفة ارتفاع الشمس إذا كانت في إحدى الاعتدالين: هاب
٤٠ وعرض] عرض: ب، ك، ل
٤١ نصف النهار] + ما: ب
٤٢ محصورة] محصور: ب = متغيّر من «محصور»: ك
٤٣ فمبدأه] ومبدأه: ل
٤٤ فمبدأه] ومبدأه: ل
٤٥ فمبدأه] ومبدأه: ل
٤٦ بقبائل] متغيّر من «بقابل»: ر، ك، ل
٤٧ فمبدأه] ومبدأه: ل
٤٨ خرخيز] جرجير: ب
٤٩ همذان] همدان: ب
٥٠ قاليقلا] شال
٥١ فمبدأه] ومبدأه: ل
٥٢ إحدى] احد(ى: شا): ل
٥٣ إسبيجاب] اسبيجاب: ب، ك
٥٤ ميّافارقين] شال
٥٥ فمبدأه] ومبدأه: ل
٥٦ خمس عشرة وربع والعرض ثلاث وأربعون وربع وثمن ووسطه حيث النهار] هال، على يد ق
٥٧ فمبدأه] ومبدأه: ل
٥٨ وربع] + والعرض سبع وأربعون ونصف وربع: شال
٥٩ اَلَمان] الشام: ب، ر، ك = متغيّر من «االشام»: ل
٦٠ ونصف] + وثلث: هاب
٦١ هـ] بياض: ب
٦٢ د] بياض: ب
٦٣ منها] - ر، - ل
٦٤ النهار] + نحترز عن الظل الذي يحصل حينئذ على سطح الجدار من نحو وتد: هاب
٦٥ د] بياض: ب
٦٦ ح] بياض: ب

[٦٧] كان] كانت: ك، ل
[٦٨] كان] كانت: ب، ك، ل
[٦٩] د] بياض: ب = ه: ك
[٧٠] يب] بياض: ب
[٧١] من البقاع لأنّ هاتين العلّتين لا تجتمعان في غيرها] هار، هاك، هال
[٧٢] نهرهم] نهارهم: ب
[٧٣] لا تسامتهم] هال
[٧٤] لتكاثف] لتتكاثف: ب = متغيّر من «لتتكاثف»: ك، ل
[٧٥] أكثر] كثيرة: ر
[٧٦] شتاء] +في: ر
[٧٧] بأنا] بان: ب، ك = متغيّر من «بان»: ل
[٧٨] أهل] -ر
[٧٩] متساويي] متساوىى: ب، ك، ل
[٨٠] الخفي] هاك
[٨١] يتوسطه] يتوسط: ك
[٨٢] وإن] وإذا: ر
[٨٣] متساوياً] مساوياً: ر، ل = متغيّر من «مساوياً»: ك
[٨٤] كانت] كان: ب، ر، ك = متغيّر من «كان»: ل
[٨٥] بقطبي] + المعدل وهما قطبا: هاب
[٨٦] بعده] هاب، فاك
[٨٧] أو] و: ب، ك، ل
[٨٨] بعد] هار، فاك، هال
[٨٩] إحداهما] احدهما: ر
[٩٠] بما] مما: ب
[٩١] الكواكب] الكوكب: ر
[٩٢] ممّا] فيما: ب
[٩٣] أعني النهار المعتدل لأنّ قوس نهار كل جزء في خط الاستواء مثل قوس نهار نقطة الاعتدال] هار، هال
[٩٤] المائلة] فاب، هاك
[٩٥] لما] كما: ر
[٩٦] الظاهر] فال
[٩٧] الرأس] الرؤس: ب = متغيّر من «الرؤس»: ك
[٩٨] للسخونة] متغيّر من «السخونة»: ك
[٩٩] عن] من: ب
[١٠٠] للميل الكلي في الجنوب يكون أحرّ من الذي عرضه مساو] هال

١٠١ اشترطه] متغيّر من «اشترط»: ر، ل = اشترط: ك
١٠٢ لازديادها] لازدياده: ب، ر، ك = متغيّر من « لازدياده »: ل
١٠٣ وماسّ] وماست: ب
١٠٤ إذا] إن: ب، ك
١٠٥ و] +لا: ب
١٠٦ تماسّ] بماس: مضاف بعد التحرير في ب، ك
١٠٧ نتصوّر] سصور: ب = نُتصوّر: ر، ك =تُصوَّر: ل
١٠٨ كلّ] - ب
١٠٩ توالي] توالٍ: ب، ک = توال: ر = متغيّر من «توالٍ»: ل
١١٠ الغرب] المغرب: ب، ك
١١١ عن] من: ر، ك، ل
١١٢ الربيعي] + وهو من آخر الثور إلى أول الحمل: هاك
١١٣ الخريفي] + وهو من آخر العقرب إلى أول الميزان: تاك
١١٤ يَقرُب] نقرب: ب = نقرُب: ر = متغيّر إلى «يَقرب»: ك = متغيّر إلى «يَقرُب»: ل
١١٥ أشهر] هاب، هاك
١١٦ قلت] فال
١١٧ أو] و: ر، ل
١١٨ معيّن] بعينه: ب
١١٩ اثنتا] اننا: ب
١٢٠ عشرة] عشر: ر = متغيّر من «عشر»: ك
١٢١ هذا] هذه: ب = متغيّر من «هذه»: ك
١٢٢ تقدّم] + أي في باب الثالث في خواص المواضع التي لها عرض كلي والمراد بالمثلث المذكور هو الذي أحد أضلاعه (تاک) ميل الجزء والضلعان آخران قوسان بين دائرة الميل وبين نقطة الاعتدال الربيعية أحدهما من فلك البروج وهو درج السواء والآخر من معدل النهار وهو مطالع الجزء: هاك
١٢٣ الأفق] للأفق: ب
١٢٤ نصف] هال
١٢٥ و] مضاف بعد التحرير: ل
١٢٦ متساويان] متساويين: ب
١٢٧ مطالعا] متغيّر من «مطالع؟»: ل
١٢٨ اثنين] متغيّر من «اثنتين؟»: ل
١٢٩ كطلوعهما] متغيّر من «كطلوعها»: ر، ك = كطلوعها: ل
١٣٠ فكلّ] وكل: ر، ل = متغيّر من «وكل»: ك
١٣١ من المعدّل] -ك = + من معدل النهار: هاك = من معدل النهار: ر، ل
١٣٢ المتساوية] فاب

[١٣٣] عرفت] + لأن مطالعها ههنا ضلع الزاوية المنفرجة وثمة ضلع القائمة والأول أصغر: هاك
[١٣٤] متساويي] متساويتي: ب، ر، ل
[١٣٥] المتساويتي] المتساويي: ر = متساويتي: ب، ك = متغيّر من «متساويتي» ل
[١٣٦] في] + المائل ضعف مطالع أحدهما في المستقيم وكذا مطالع المتساويتي البعد عن أحد الانقلابين لما ذكرنا ويلزم أيضاً أن يكون مطالع الحمل مثلاً ومغاربه في: شال
[١٣٧] أفق] + ومطالع البرج مع مطالع نظيره في المائل ضعف مطالع البرج في المستقيم لما بينا فكذا مع مغاربه: هاك
[١٣٨] كمغارب نظيره وبالعكس في كل أفق ولكون مطالع كل برج] هال
[١٣٩] الشمالية] + لأن مطالع البرج في الآفاق الجنوبية مساوية لمطالع نظيره في الآفاق الشمالية بالشرط المذكور ومطالع نظيره في تلك الآفاق مساوية لمغاربه في تلك الآفاق ويلزم منه المطلوب: هاك
[١٤٠] فيه] + بناءً على ما بيّنا أن مجموع مطالع الحمل والسنبلة في البلد مساوٍ لمجموعها في الفلك: هاك
[١٤١] فيها] -ل
[١٤٢] التي] هال
[١٤٣] فلك] هاك، هال
[١٤٤] مع] فال
[١٤٥] أعلم] + واحكم: ك، ل
[١٤٦] بمقدار] بمقدا: ب
[١٤٧] نقطة] + من الأفق مثلاً: هاب
[١٤٨] النهار] مضاف بعد التحرير: ك
[١٤٩] معدّل] هاك
[١٥٠] الحقيقية] متغيّر من «الحقيقة»: ب، ك
[١٥١] الحقيقية] متغيّر من «الحقيقة»: ب، ك
[١٥٢] الحقيقية] متغيّر من «الحقيقة»: ب = الحقيقة: ك
[١٥٣] دورة] متغيّر من «دور»: ر
[١٥٤] للفلك] متغيّر من «الفلک»: ر، ل
[١٥٥] مطالع] هال
[١٥٦] ضعف] هال
[١٥٧] تعديل] هال
[١٥٨] أو] و: ل
[١٥٩] مطالعها] متغيّر من «مطالعها»: ب، ك = مطالعها: ر، ل
[١٦٠] مطالعها] متغيّر من «مطالعها»: ب، ك = مطالعها: ر
[١٦١] جميعاً وكل يوم من السنة يفرض مبدأً يكون التفاوت بين الأيّام الماضية الوسطى والحقيقية] هال
[١٦٢] في] من: ب، ك
[١٦٣] الزيادتان] متغيّر من «الزيادة»: ل
[١٦٤] هذا] هذه: ك = متغيّر من «هذه»: ل

[١٦٥] والله أعلم] -ل
[١٦٦] لون] متغيّر من «الكيفية؟»: ب، ك
[١٦٧] تُرى] نرى: ب
[١٦٨] تسمّى] هال
[١٦٩] على] فال
[١٧٠] ظلمة] الظلمة: ب، ك = لظلمة: ل
[١٧١] ثم] مضاف بعد التحرير: ل
[١٧٢] البياض] هار، هال
[١٧٣] تفرُّغ] ل = نفرع: ب = تفرّع: ر = تَفْرُغُ: ك
[١٧٤] ذكره] + فنقول إذا قدمنا ذكره: شال
[١٧٥] منه] عنه: ر
[١٧٦] عريضٍ] عريضاً: ك
[١٧٧] ضيائه] ضياؤه: ب
[١٧٨] ذكرنا] قلنا: ب
[١٧٩] كط] بياض: ب
[١٨٠] فالفصل] متغيّر من «الفصل»: ل
[١٨١] ز] ا: ب
[١٨٢] الشمس] هال
[١٨٣] المشرق] الشرق: ب، ك
[١٨٤] المغرب] الغرب: ب، ك
[١٨٥] دائرة] دائرتي: ب، ك
[١٨٦] ضياؤه] «ه» مضاف بعد التحرير: ل
[١٨٧] البخار]+ أعني سطحها على سطحها لا محيطها على محيطها على ما ظن لأن قيام السطحين إنما يكون عند وصول الشمس إلى الأفق الحقيقي في جهة الشرق المعتبر عنه بقرب الطلوع ووصولها إليه هو بعد تماس المحيطين وكيف كان يكون: هاك
[١٨٨] و] - ك
[١٨٩] تقاطعتا] تتقاطعا: ب = متغيّر من «تقاطعا»: ك
[١٩٠] لِمَ] - ب
[١٩١] طلوعي] متغيّر من «طلوع»: ل
[١٩٢] هذا] هذه: ب = متغيّر من «هذه»: ر، ل = هذ: ك
[١٩٣] الاستواء] + أيضا: ب، شاك
[١٩٤] ساعتان] «ن» مضاف بعد التحرير: ل
[١٩٥] درجة] درجا: ب
[١٩٦] نهاية] متغيّر من «تمام»: ك
[١٩٧] وهو المشكور على نعمائه] والله اعلم: ب

[198] تغيير الخط (خط قطب الدين ← خط كاتب نسخة ر)
[199] اليوم] يوم: ر، ك
[200] دور] متغيّر من «دورة»: ك
[201] دور] دوره: ر، ل = دورة: ك
[202] تعتبروا] يعتبر: ك
[203] الساعات] + امّا لقلتها: شاك
[204] لها و] - ك
[205] ينقص] +بقصرهما: ك، ل
[206] ولهذا] وهما: ب
[207] أحدهما] احديها: ك
[208] أجزاء] مضاف بعد التحرير: ل
[209] جزءاً] - ب
[210] أعني أجزاء كل قسم]: هال
[211] الفجر والشمس] الشمس والفجر: ب
[212] كما سيجيء مفصّلاً في آخر باب الأظلال] هال
[213] مقدار] هال
[214] في التعليل] للتعليل: ب
[215] وغير الحُسّاب يأخذون المبدأ من وصول الشمس إلى الأفق] هال
[216] وقيل] قيل: ر، هاك، فال
[217] والأولى] هال
[218] كما سيجيء مفصّلاً ـــ إن شاء الله العزيز] هال
[219] مبدأ] هال
[220] دقيقة] دقيقتين: ب = دقيقةٍ، متغيّر من «دقيقتين»: ر
[221] النصف] نصفاً: ب
[222] عشرة] عشر: ب
[223] عشرة] عشر: ب
[224] عشرة] عشر: ب، ر
[225] التامّة] + لسنة: ك، ل
[226] فقال] + له: ك، ل
[227] ارتضاه] ارضاه: ب، ر
[228] اثنتين] اثنين: ر، ل
[229] ثلاث] ثلثة: ر، ل
[230] استقامة] + أمر: ك
[231] السنة] سنة الشمس: ب

[٢٣٢] ونقصان] ولا نقصان: ب
[٢٣٣] مستند] مستندة: ب
[٢٣٤] أيّامها] أيامهم: ب = متغيّر من «ايامهم»: ل
[٢٣٥] آذار] اذار: ب، ك، ل
[٢٣٦] هو] او: ب
[٢٣٧] ويقع] فيقع: ك
[٢٣٨] وأرادوا] فأرادوا: ك
[٢٣٩] أزيده] أزيد: ب، ر
[٢٤٠] المشهور] + عن العرب: ك، ل
[٢٤١] السنة] + التاسعة: ك، ل
[٢٤٢] قوله] + تعالى: ك
[٢٤٣] ابان] آبان: ل
[٢٤٤] جمشيذ] جمشيد: ل
[٢٤٥] تصح] ك = بصح: ب، ر = يصح: ل
[٢٤٦] زمزمتهم] متغيّر من «زمزمهم»: ل
[٢٤٧] إلى إسفندارمذماه] لإسفندارمذماه: ك، ل
[٢٤٨] الكبيسة] الكبس: ك
[٢٤٩] شهوره] شهورهم: ب
[٢٥٠] شهوره] الشهور: ك
[٢٥١] سني] - ك
[٢٥٢] بما] لما: ر، ك، ل
[٢٥٣] موسى] + عليه السلم: ك = + علسلم: فال
[٢٥٤] إلى سبيله] لسبيله: ر، ك، ل
[٢٥٥] عليهما] عليه: ب، ك
[٢٥٦] الكوكب] متغيّر من «الكواكب»: ك
[٢٥٧] يمر] بمرّ: ب، ك = تمر: ر، ل
[٢٥٨] الوضعين] الموضعين: ب
[٢٥٩] أقله] أقل: ب = متغيّر من «أقل»: ك
[٢٦٠] التي] -ب
[٢٦١] الكواكب] الكوكب: ب
[٢٦٢] درجاتها] درجتها: ب
[٢٦٣] طوله] طلوعه: ب
[٢٦٤] في] من: ر، ك، ل
[٢٦٥] ثم عرض الأفق] متغيّر من «؟»: ك، ل

٢٦٦ تقدّم] مرّ: ك
٢٦٧ الكلي] -ر، -ك، -ل
٢٦٨ يظهر] يظهران: ر، ل
٢٦٩ هو] - ب
٢٧٠ يكون بحسبه] بحسبه يكون: ب، ر
٢٧١ قدّر] نقدّر: ب = متغيّر من «نقدّر»: ر
٢٧٢ واحدة] واحدا: ب
٢٧٣ فضل] هال
٢٧٤ لمعدّل النهار وإن كان] للمعدل وإن كانت: ك، ل
٢٧٥ المستضيء] متغيّر من «المضى»: ك، ل
٢٧٦ و] - ك، - ل
٢٧٧ إحديهما] احدبهما: ب = متغيّر من «إحدبهما»: ر، ك
٢٧٨ الشرق] المشرق: ب، ل
٢٧٩ يماسّ] بماسه: ك، ل
٢٨٠ المذكوران. ونهايتا هذين الخطّين هما مسقطا مجري الارتفاعين، أعني جيبيهما. والخطّ] هال
٢٨١ إذ لتساوي] ولتساوي: ل = متغيّر من «ولتساوي»: ر، ك
٢٨٢ متساويّي] متساوىى: ك
٢٨٣ لا] فال
٢٨٤ بينهما] متغيّر من «بينها»: ر، ك، ل
٢٨٥ كلّ من] هار، هاك = مضاف بعد التحرير: ل
٢٨٦ القوسين] متغيّر من «القوس»: ر، ك، ل
٢٨٧ نهايتيه] نهاتيه: ك = متغيّر من «نهايته»: ر، ل
٢٨٨ المسمّاة] هال
٢٨٩ ينحرف] + به: ك
٢٩٠ يكون] فال
٢٩١ وكلّ بلدة يكون طولها أكثر من طول مكّة فمكّة غربية عنها] هال
٢٩٢ من] اما: ب
٢٩٣ مختلفتين] مختلفين: ب، ك = متغيّر من «مختلفين»: ر، ل
٢٩٤ فتوجّه] فمواجه: ك = فمواجه: ل
٢٩٥ الطولين والعرضين] العرضين والطولين: ك، ل

Part III

English Translation of Book III of the *Nihāya*

BOOK III

On the Configuration of the Earth

and Its Division into Inhabited and Uninhabited

and the [Consequences] Accruing to It

Due to the Changing Positions of the Celestial Bodies.

and Related Matters

It is also thirteen chapters

[as in Book II]:

- Chapter one on a general summary of the configuration and circumstances of the Earth
- Chapter two on the characteristics of the equator
- Chapter three on the characteristics in general of locations having latitude, which are called the oblique horizons, and on ortive and occasive amplitude, and on the equation of daylight
- Chapter four on the characteristics of locations whose latitude does not exceed the complement of the obliquity
- Chapter five on the characteristics of locations whose latitude exceeds the complement of the obliquity but does not reach one-quarter revolution
- Chapter six on the characteristics of locations whose latitude is exactly one-quarter revolution
- Chapter seven on the co-ascensions of the zodiacal signs
- Chapter eight on the lengths of the nychthemerons
- Chapter nine on dawn and dusk
- Chapter ten on understanding the units of the day, namely hours, and what is composed of days, namely months and years, and what pertains to them, namely intercalation and the calendar
- Chapter eleven on the degrees of transit of the stars on the meridian and on their [degrees of] rising and setting
- Chapter twelve on understanding shadows and their circumstances
- Chapter thirteen on finding the meridian line, which is also called the noon line, and on the *qibla* direction

CHAPTER ONE
A General Summary of the Configuration and Circumstances of the Earth

[1] It was shown in the first part of Book II that the apparent surface of the Earth is spherical and **parallel to the concavity of the** [celestial] **orb**, and together with the apparent surface of the water are analogous to the surface of a sphere, and that for **someone standing upon it**, in any location it be, his head **will be toward the** [orb's] **circumference, which is up, while his feet will be toward the center, which is down. The direction of the head of someone traveling upon the Earth is necessarily at each instant [toward] another part of the** [**orb's**] circumference. **If it were possible to travel** upon **the entire** apparent surface of the **Earth** and water, **and then three individuals were assumed to become separated at some location, one of them traveling toward the west, the second traveling toward the east, and the third staying in place until the two travelers had circled** [the Earth] completely**—the traveler** toward the **west returning to him from the east and the traveler** toward the **east returning to him from the west**—**then the** western **[traveler] will have one fewer than the total [number] of days that have been generally counted** and **the** eastern [traveler] **will have one more,** because the length of the day and night for the western [traveler] is longer compared to its length for the staying [individual] proportional to his motion, and for the staying [individual] is longer compared to its length for the eastern [traveler] proportional to his motion. This is because the time between two noons for the western [traveler] is more than that time for the staying [individual] proportional to his motion, and for the staying [individual] is more compared to the eastern [traveler] proportional to his motion, and these increments in a revolution will be equal to the period of a nychthemeron distributed over the total of days [of their travel], and subtracts one day from the total of the western [traveler] and adds one day to that of the eastern [traveler]. **This is also something that is asked about**, and it is said: Is it possible that the number of days in a solar year be different with regard to three different people, being 365 days and one quarter day with regard to one of them, e.g. the staying individual, and 364 days and one quarter day with regard to the second person, e.g. the western [traveler], and 366 days and one quarter day with regard to the third one, e.g. the eastern [traveler]? Or is it possible that a certain day be Friday for someone, e.g. the staying [individual], Thursday for the other one, e.g. the western [traveler], and Saturday for the third one, e.g. the eastern [traveler]? Or is it possible that three different people count days from a designated initial point until a

designated final point, being four days for one, three for another one, and five for the third one? So they would be answered that it is possible, and would find [this answer] to be strange. It should be clear that in response to the first [question], it is necessary to assume the two travelers' motions in a way that they complete a full revolution in a solar year with respect to the staying [individual]. For the third [question, they should be assumed] such that they finish a revolution in four days. For the second [question] neither is necessary, and it works with both assumptions. Thus what is needed in general to respond to all [three questions] would be that the two [travelers] complete a revolution in an amount calculated by the staying [individual]. /After fully understanding what we have stated, it should [now] be clear that if the motion of the two [travelers] is assumed equal to the eastward motion, so that they finish a revolution in the period of a nychthemeron, the time for the staying [individual] between the separation and reuniting would be a nychthemeron; for the eastern [traveler] two days; and for the western traveler the [same] time as when the separation occurred. Even if it happened at sunrise, [the western traveler] would be in that time up until he reaches the staying [individual], since the Sun has not risen from his horizon, because in the [same] amount as the western traveler has moved toward the west, the Sun has moved toward it as well. For this reason their assumed situation with respect to each other would not change, and this will be the case for any other assumed situation between [the Sun and the western traveler]. This means the Sun being on the eastern horizon for an individual could be in the amount of a nychthemeron, or even a month or a year or forever, if he moves with this motion forever, which is also strange, or stranger than what was mentioned before, due to its implication that two days for the eastern [traveler] would be like an instant for the western [traveler]. This, is [now] clear./[*] [i]

[2] Now that you have learned about this, then know that the Earth is divided by the equator—*i.e.*, the great circle occurring on the surface of the Earth due to the imaginary intersection of the plane of the equinoctial with the World—into two halves, northern and southern. It is called the equator because of the equality of the [length of the] day and night for its inhabitants all the times. And [the Earth is divided] by another great circle on its surface that passes through the two poles of the first [great circle, *i.e.*, the equator], into two halves, /upper and lower./[†][ii] Therefore **the Earth will be divided by them into fourths. One of the two**

---

[i] After fully understanding… This, is clear] margins of **B** and **K.**
[ii] upper and lower] margins of **B**, **K** and **L.**

northern [fourths] is the populated quarter, and circumstances of **the others** are unknown; [it is] not [true] that [the other three-fourths] **are either submerged in the sea and not populated or their circumstances are unknown** since the division [into either submerged in the sea or unknown] is false. Nor [is it true] that they are submerged in water, as it is said. [Nor is it true], proceeding from [these premises], that the totality of the elements are inevitably balanced in their volumes and [that], if the water does not encompass the three other quarters [of the Earth], then it would be much less than the whole earth, since what we see from them in their exposition of these premises is an error, let alone a proof. Therefore, it is possible that in the other quarters there are many inhabited lands we are not aware of, since there are drowning seas and towering mountains between us and them. Then if a third great circle imagined on the surface of the Earth that passes through the poles of the two first [great circles], the populated quarter will be divided into eastern and western, and the crossing point between the third and first [great circles] /in the upper half/† [iii] is called the cupola of the Earth, the cupola of *Arīn*, and midpoint of the Earth. [The length] between the cupola and either of the crossing points of the second and first [great circles] is a quarter of a revolution. The third [great] circle is called the meridian of the cupola and the meridian of the midpoint of the Earth, and the second [great] circle is their horizon, not because they are really horizons, but because they are in the plane of horizon circles. The second is also called the horizon of the equator, and this, if true, is because it is in the plane of the equator's horizon, however it does not have the advantage of the two first [great circles], since the horizon of the equator is more general than the second [great circle], *i.e.*, the horizon is found without the second [great circle], contrary to the meridian of cupola and its horizon which are not found without the third and the second. **One should then conceive the division of the Earth's surface to be in longitude according to the division of the equinoctial and in latitude to the poles according to the divisions of the circles of declination. One should also conceive on the [surface] circles that are exactly aligned with the day-circles in order to allow one location to be differentiated from another. Distances and quantities are measured just as they are on the orb.**

[3] The inhabited region has been determined to be a quarter because observations of celestial phenomena, such as lunar eclipses, have been found [to occur] for those living in

[iii] in the upper half] margins of **B**, **K** and **L.**

the farthest eastern [regions] 12 hours ahead [of their occurrence] for those in the farthest western regions, not more than that. **From this** it is **discerned that the length of the populated area does not exceed one-half revolution of the orb,** I mean one-half revolution of the Earth which is 180 degrees, since every hour is 15 degrees. Indeed Ptolemy **determined** firstly **that [this] quarter is in the north because** he satisfied himself that **the shadows** of the gnomons **at noon for the equinoxes** all over the populated world are toward north, and not **any of them** are toward south. This was his opinion when he wrote the *Almagest*, since at that time he did not know the amount of the width of the inhabited region. Later, he became aware of the inhabited areas beyond the equator to the south up to the [latitude of] 16 degrees and a quarter and a sixth [of a degree]. Thus, in his book entitled *Geographia* he said that the initial latitude of the inhabited region from the south is where the altitude of the southern pole is 16 degrees and a quarter and a sixth [of a degree], these being **populated regions at the farthest reaches of *Zanj* region, Abyssinia [*al-Ḥabasha*], and some other [areas]** that **have been reported to be southerly**. The last [inhabited region] in the north is where the altitude of the northern pole is 66 degrees, and it is not possible to live in regions beyond it due to the severity of the inevitable cold due to the remoteness of the Sun from the zenith there. Therefore the width of the inhabited region is 82 degrees and a quarter and a sixth [of a degree], and its length as he also mentioned there [in the *Geographia*], is 177 degrees and a quarter [of a degree]. [Ptolemy] also said in [the *Geographia*] that [localities] below the equator has only been afforded mention, because the northern quarter contains the most well-known and most important populated regions; thus [the equator] became like an encirclement for the inhabited part of the Earth. And because what is between the two ends of the inhabited region, according to the general belief, is half a circle [*i.e.*, 180 degrees] whenever the Sun sets in the farthest part of the eastern inhabited lands, it rises in the farthest part of the western inhabited lands. This happens when the Sun passes through the meridian of the cupola above the Earth, and the opposite [Sun sets in western lands, rises in the eastern lands] happens when the Sun passes through [the meridian of the cupola] beneath [the Earth]. Therefore, the horizon of the cupola is their meridian [*i.e.*, for the two ends of the inhabited region] and vice versa [*i.e.*, their horizon is the meridian of the cupola]; however, for one of them, the visible half of the [heavenly] orb and also the meridian is hidden from the other, and vice versa. From this it becomes easy to imagine the difference of the counted days for the above mentioned individuals with regard to the curious inquiry. Also, it was due to what we mentioned that the feet of the inhabitants of one of the two sides [of the inhabited region] are standing against the feet of the inhabitants of the other side, and are at the two ends of one of the diameters of the World. This is when two individuals stand on the two ends [of the inhabited region], but if they stand anywhere on the circumference of a circle not containing the two ends, the two lines extending from the center of the World to their feet are like two sides of an obtuse-angled triangle, if the distance between them is more than a quarter of a circle, and a right-angled [triangle] if the distance is a quarter, and an acute-angled [triangle], if the distance is less than a [quarter]. From this, the conception of what we said at the beginning of this book, that the distance between the heads of individuals standing on the Earth is more than the distance between their feet, is proved to be true, although this is apparent in [the case of] two individuals very far apart, and not in the ones who are nearby.

[4] As for **the sea**, it **surrounds most sides of the aforementioned area of the Earth. This is well-established for the western side, the north, and most of the south, especially the eastern part of it. As for the southwest, it has been stated that persons traveling in the direction of the sources of Egypt's Nile have reached locations whose southern latitude exceeds a certain number in the range of 10° to 20°. They saw mountains at a distance to their south white with snow, which were named for the moon, from which [arise] the headwaters of the Nile. They did not reach a body of water.** Likewise **we do not have definitive knowledge about the sea in the northeast,** although they guessed that there is a sea in the south-west and also in the north-east. /For these reasons the [abovementioned] sea is called the Encompassing Ocean./† [iv]

[5a] You should know that **in the area that has been uncovered to allow for habitation, there are also numerous bodies of water some of which are connected to the Encompassing [Ocean]** and **some are unconnected** to it; among those connected are the Sea of Oman [*ʿUmān*], which is called the Sea of Persia, India and China [*Baḥr al-Fārs wa-al-Hind wa-al-Ṣīn*]; it is the largest of them all, beginning from the farthest [part] of the regions of China and India to the farthest [part] of the regions of Abyssinia and Barbary [*Barbar*], not/‡ [v] where western Sudan [region] is, /according to what is commonly thought. Indeed, it is not correct, because this

[iv] For these reasons the sea is called the Encompassing Ocean] margins of **B**, **K** and **L**.
[v] Abyssinia and Barbary not] added within the text: **K** and **L** = al-*Maghrib* and Barbary: **B**; effaced in **K** and **L**.

Barbary is not the Barbary that is in western *Ifrīqiyya* region. If that [Barbary] was meant, then the length of [Sea of Oman] would be greater than what is agreed upon,/‡ [vi] which is 2660 *farsakh*s. Its width is 900 *farsakh*s, of which 360 or 330 *farsakh*s, according to two different opinions, is north of the equator and the rest is south of it. The equator passes through most of this sea. This is **the southern sea, which is connected to the eastern** side of the Encompassing [Ocean], **from which extends four gulfs into the middle of the inhabited region.** The first is **the Gulf of Barbary [*al-Khalīj al-Barbarī*],** inasmuch as it borders Barbary [region], and this [gulf] **is the nearest of them to the *Maghrib***. Its length on the northern side is 160 *farsakh*s, and its width /at its base, and, as has been said, at its end/‡ [vii] is 35 *farsakh*s. The second gulf is **the Red Gulf*** [viii] **[*al-Khalīj al-Aḥmar*]**, whose length in the north is 460 *farsakh*s. Its width at its base is 200 *farsakh*s, and where it gets narrow, which is its end, is 60 *farsakh*s; there it is called the Sea of Clysma [*Qulzum*], because it is [the name of] a city at its narrow end and is also called *Lisān al-baḥr* [the tongue of the sea/ *Lingua Maris*]. On its eastern side lie the regions of Aden [*ʿAdan*] and Yemen [*Yaman*], and on the western [side] the Abyssinia region; /therefore, they call this gulf the Sea of Yemen and also the Sea of Abyssinia./‡ [ix] The third is **the Persian Gulf [*Khalīj Fārs*],** on whose extremity is Basra [*Baṣra*], and *Fārs* and *Kirmān* [provinces] are connected to it. Its length in the north is 460 *farsakh*s, and its width at the base is 180 *farsakh*s; its width at its end is 54 *farsakh*s. On its eastern coast lie the regions of *Tīz* and *Mukrān*, and on its western coast on the opposite side, the port of *ʿUmān*; /therefore, it is also called the Sea of Oman./‡ [x] Between this gulf and the Red Gulf, which is close to 500 *farsakh*s, in its entirety lie the Arab province [*wilāyat al-ʿArab*], the regions of Hijaz [*Ḥijāz*] and Yemen. The Euphrates [*Furāt*], whose source is from the mountains of Erzerum [*Arzan al-rūm*], connects to the Tigris [*Dijla*] near Basra, whose source is also from the same mountains or from the mountains of Anatolia [*al-Rūm*] and Syria [*al-Shām*] according to what is said, then discharges into this gulf near *Ābādān* [*ʿAbbādān*]. The boundary of this gulf is the Sind region, where many rivers, like the *Manṣūr* River flowing from India to Sind, discharge into it. There are many islands in this gulf. The fourth gulf is **the Green Gulf [*al-Khalīj al-Akhḍar*],** which is also called the Gulf of India, since it is in the region of India. It has been said that, in its farthest parts, its length in the

---

[vi] according to what is commonly thought… what is agreed upon] margins of **K** and **L** = its length: **B**.
[vii] at its base, and, as has been said, at its end] - **B**; margins of **K** and **L**.
[viii] the Red Gulf] + and it is close to the region of Ubulla: crossed out in **B** and **K**.
[ix] therefore…the Sea of Abyssinia] - **B**; margins of **K** and **L**.
[x] therefore, it is also called the Sea of Oman] - **B**; margins of **K** and **L**.

north is 500 *farsakh*s. There are 1370 islands, inhabited and non-inhabited, in it, /namely in the Sea of China and India./‡ [xi] One of them is a huge island in the farthest part of this gulf facing the region of India, belonging to the eastern region where the region of China is. /This [island] is not Sri Lanka [*Sarandīb*], according to what is said, and is encompassed/‡ [xii] by 1000 *farsakh*s; it contains imposing mountains and many rivers, and ruby and blue sapphire are extracted from it. There are 19 inhabited islands surrounding this island which contain many cities and villages, among them an island from which white lead is obtained and another island from which camphor is obtained.

[5b] Among those connected to the Encompassing [Ocean] from the west, there is a sea called the Sea of *Rūm*, Syria, Egypt and *Ifrīqiyya* [hereafter, Mediterranean Sea]. Its length from Andalusia [*Andalus*] toward the east is 1600 *farsakh*s, and [the distance] between its [eastern] edge and Sea of Clysma, by land, is three way stations. Its width where it connects to the Encompassing [Ocean] is three *farsakh*s, and as it gets farther from it to half its length, it[s width] becomes 200 *farsakh*s, and when it reaches the boundary of Syria, 260 *farsakh*s. Many rivers flow into it like the *Jayḥān* River and /*Sayḥān*/‡ [xiii] River and *Yazdān* River. These [river names] are the names of mountains within the boundaries of Anatolia. From this sea extends two gulfs toward the north. One of them, which is closer to the east, is the Gulf of Constantinople [*Qusṭanṭīniyya*] whose length is 160 *farsakh*s. It is not connected to the Encompassing [Ocean], as mentioned by the master Abū Rayḥān in his book, who said it is possible to reach Constantinople by land from [the regions of] Slavs and Russians. Masʿūdī said: "I have heard from those tradesmen on their sayings one can trust that 'we traveled from Russia to Constantinople by land.'" The second one, which is closer to the west, is /not/‡ [xiv] connected to the Encompassing [Ocean], /again, being accurate;/‡ [xv] its length /toward the north-west/‡ [xvi] is 70 *farsakh*s. The islands of the Greeks are in this sea. [Also,] the Nile of Egypt discharges into it, at its southern part. Of these two gulfs, Constantinople is closer to the eastern gulf.

[xi] namely in the Sea of China and India] - **B**; margins of **K** and **L**.
[xii] This is not Sarandīb, as has been mentioned, and is enclosed] added within the text in **K** and **L** = This is Sarandīb, enclosed: **B**.
[xiii] Sayḥān] Sinjār: **B** = has been changed from "Sinjār:" **K** and **L**.
[xiv] not] and: **B** = has been changed from "and:" **K** and **L**.
[xv] again, being accurate] - **B**; margins of **K** and **L**.
[xvi] toward north-west] added in the margin in **K** and within the text in **L** = toward it: **B** = effaced in **L**.

[5c] Also among those [connected to the Encompassing Ocean] is the Sea of *al-Maghrib*, which is known as the [Atlantic] Ocean [*Uqiyānūs*], and the Sea of India is connected to it. Nothing is known about it except for its western and northern parts alongside the regions of Russians and Slavs. It goes from the farthest part of the south alongside the Sudan region passing across the borders of the far Sus [*al-Sūs al-Aqsá*] and regions of Tangier [*Ṭanja*] and Andalusia, then commences from there, behind the impassable mountains and uninhabited lands towards the east. In this sea, I mean the Ocean, ships do not circulate, and only travel alongside its coast. There are six islands in it, facing the region of Abyssinia, called the Islands of the Eternals [*Jazāʾir al-Khālidāt*] and the Islands of the Fortunates [*Jazāʾir al-Suʿadāʾ*]. [There is] another island in it, called *Ghadīra*, that faces Andalusia at a gulf that extends from this sea whose width where it extends is 2 *farsakh*s and one *mīl*. This [gulf] is between Andalusia and Tangier and was known as the passage of Hercules [*maʿbarat Hiraqlis*] in olden times and is now known as *al-Zuqāq*. This gulf flows into the Mediterranean Sea, /so it is claimed, but in fact the water of the Mediterranean Sea discharges into this sea in *al-Zuqāq*, just as the water of the Gulf of Constantinople discharges into this sea, I mean the Mediterranean Sea; similarly, the water of the Sea of Trebizond [*Ṭarābizanda*] discharges into the Gulf of Constantinople, as is confirmed by the senses./‡ [xvii] In this sea [*i.e.*, the Ocean] in the north there are the Islands of Britannia [*Jazāʾir Birṭāniya*] consisting of twelve islands. Another gulf extends from [the Ocean] in the north of the region of Andalusia, which is also connected to the Mediterranean Sea /as it is claimed, but it being connected to the Mediterranean Sea is not correct/‡ [xviii]. The length of the Mediterranean Sea [starts] from this place called *al-Zuqāq*, and extends eastward to Syria; this length is 1300 *farsakh*s.

[5d] Among those connected to the Encompassing [Ocean] **in the northern region is the Baltic Sea [*Warank*]**, and [*Warank*s] are a people [who live] on its coast. This sea extends from the north of the region of the Slavs towards the region of the Bulgarians [*Bulghār*]. Its length from east to west is 100 *farsakh*s and its width 33 *farsakh*s. Among those connected to the Encompassing Ocean is the Black Sea [*Nīṭus*] which is called the Sea of Trebizond [*Ṭarābizun*], since it is a port on it[s shore]. This [sea] extends into the regions of the Russians and Slavs from above Constantinople. Its length is 4033 *farsakh*s. At the wall of Constantinople, a gulf surges

---

[xvii] so it is claimed… as is confirmed by the senses] - **B**; margins of **K** and **L**.
[xviii] so it is claimed… is not correct] - **B**; margins of **K** and **L**.

from the Black Sea, into which 100 rivers discharge, and [from there] into the Mediterranean Sea [*Baḥr Miṣr*]. The width of this gulf near Constantinople is one *farsakh*, and it keeps becoming narrower until it opens into the Mediterranean Sea [*Baḥr Miṣr wa-al-Shām*] to the south of which lie the regions of the *Maghrib* and *Ifrīqiyya* as far as Alexandria [*al-Iskandariyya*], and Egypt, and parallel to them in the north [lie] Andalusia, and the regions of Romans and Franks [*Firanja*] as far as Antioch [*Anṭākiya*]. Adjoining it are the region of Syria, /because Syria is between the southern and northern edges of the Mediterranean, where the sea ends at Syria and Palestine [*Filasṭīn*]/‡ [xix].

[5e] Among those [bodies of water] that are unconnected [to the Encompassing Ocean], the largest is the Caspian Sea [*baḥr al-Khazar*], nowadays called the Sea of *Ābiskūn*, since it is above the harbor [of *Ābiskūn*], and used to be called the Sea of *Jurjān* and the Sea of Bāb [*al-Abwāb* (?)] in olden times. Its length from east to west is 260 *farsakh*s, and its width is 200 *farsakh*s. It is not connected to any other sea, but extends from *Ābiskūn* towards *Ṭabaristān*, *Daylam*, *Shirwān*, *Bāb al-Abwāb*, then *Khaza*r on the mouth of Volga River [*Ātil/Itil*], then the region of *Ghuzz* [*Diyār al-Ghuziyya*], till it returns to *Ābiskūn*. This sea is called by the name of every locality that lies alongside it. Huge rivers discharge into it such as the *Aras* River, which comes from Armenia [*Armīniyya*]; the Volga which comes from Bulgaria, and is larger than the Oxus [*Jayḥūn*]; another river known as *Sipīdh-rūdh*; and other rivers among those whose sources are the mountains of Syria, or from the south of this sea, such as the ones whose sources are the mountains of *Gīlān*, *Daylamān* and *Ṭabaristān*.

[5f] These five are the largest seas; others are lakes, channels and basins, such as the Lake of Tiberias [*Ṭabariyya*] in the region of Syria, and the Aral Sea [*Khʷārazm*], the circumference of which is 100 *farsakh*s. The distance between the latter and the Caspian Sea is 20 days; the Oxus and Jaxartes [*Sayḥūn*] discharge into it. The Oxus River extends from the east of Balkh, where five large rivers come together, the largest of which comes from east of the region of Tibet [*Tubbut* (probably from Tüpüt; also read as Tubbat)]; another branch comes from the region of Kyrgyz/Qirghiz [*Khirkhīz*]; and the others are from the *Ṭukharistān* region. As for the Jaxartes River, or the river of *Farghāna*, its source is from the farthest regions of the east, and the region

[xix] because Syria… Palestine] margins of **K** and **L** = and Palestine: **B**.

of the Turks. This lake [*i.e.*, *Khʷārazm*] is like the Lake of Tiberias, or larger. In Armenia there is a lake near Manzikert [*Malāzjird*].

[5g] It is reported from Aristotle that the [Atlantic] Ocean surrounds the Earth like its crown. A gulf opens a gulf from it in the western region in a locality called the passage of Hercules, and penetrates into the inhabited region passing towards the east. This [gulf] is the Mediterranean Sea [*Baḥr Miṣr wa-al-Rūm wa-Ifrīqiyya wa-al-Shām*]. A gulf also opens from it in the eastern region and penetrates into the inhabited region passing towards the west. This [gulf] is the Sea of China, India, Persia, Clysma and Barbary. These were the examples of the situation of the seas based on the account given by Jayhānī, and other experts on the locations of the seas and their extensions. But there are many details, most of them mentioned in the books on roads and kingdoms [*al-masālik wa-al-mamālik*], so whoever wants a thorough examination should refer to those books. **In addition to the seas, there are numerous other obstacles to habitation such as** wastelands, **mountains, hills, sands, jungles, and** also deserts like the deserts of Arabia [*bādiyat al-ʿArab*], *Maʿbad* and *Khʷārazm*, of which the experts of roads [and kingdoms], travelers and others are aware. This is a general account of the inhabited quarter.

[6a] You should know that the reason for the northern region to be uncovered, after divine providence and heavenly causes, such as star conjunctions and similar astrological matters, is the attraction of most of the water to the southern region due to its being hotter than the northern region, together with heat's nature to absorb moisture, as can be seen in the lamp, and the fact that the more intense [the heat], the more absorbent it gets. The southern [region] is hotter, due to the nearness of the Sun to it, and its farness from the northern [region], since the Sun's perigee is in the southern zodiacal signs, and its apogee is in the northern ones; its being near [makes] its rays more intense than its being far, and the heat associated with the more intense ray is stronger and sharper than the one associated with the less intense. Based on this [explanation], the inhabited region would then move from north to south and vice versa due to the movement of the apogee from one [direction] to the other.[§] [xx] The statement of he who has claimed that **"the**

[xx] the other] + The inhabitation will always be where the apogee of the Sun is; otherwise the two proximities would combine in the summer, namely the proximity of the Sun to the zenith, and [its proximity] to the Earth, so that the heat reaches the threshold of discomfort and scorching. Nor [will habitation be] where [the Sun] is at the two farthest distances [namely the distance of the Sun from the zenith, and from the Earth] in the winter, so that the cold reaches the threshold of discomfort and bleakness. From this, it can be known that the heat of our summer, while the [solar] apogee in Cancer, is much less than the summer heat of the ancients when the [solar] apogee was in the tenth

existence of seas north of the inhabited region contradicts this judgment," is inadmissible inasmuch as the contradiction to the [aforementioned judgment] would be the existence of more seas in the north, not fewer, which is actually the case, and something the claimant has acknowledged. The reason for the southern [region] being hotter is not that the Sun is visually larger in size there on account of this region's proximity to the day circle of the Sun's perigee; according to what is claimed, the [visually] larger is more intense in terms of rays and illumination. This is incorrect but not because of what has been stated, namely that **"the difference between the smallest size of the Sun from its being at the apogee and its largest size from being at the perigee is imperceptible to the senses; thus it is far-fetched that its effect would reach an extent whereby one of two similarly positioned locations with respect to the heavens,** *i.e.*, the southern and northern hemispheres of the Earth, **would be populated, while the other would not be populated."** We accept this; however this reasoning, even though convincing with respect to habitation being exclusively in the northern hemisphere rather than the southern one, is not convincing with respect to being exclusively in one of the two northern quarters rather than the other. This is because we do not accept either the equivalence of the situation of Earth's southern and northern hemispheres with respect to the heavens, /as mentioned,/[*] [xxi] or the characterization of one of the two northern quarters as inhabited but not the other inasmuch as the other could possibly be populated but reports of them have not reached us, as discussed before. [We also do] not [accept] that the effect of the difference between the smallest size of the [Sun's] body and its largest, if it were perceptible to the senses, could reach the required extent, as the context indicates; this is because the influencing factor [*al-muʾaththir*] is size as the matter of truth [*nafs al-amr*], not according to the senses. Accordingly, the heat of a

---

of Gemini. That is why the most skilled physicians of ancient times, such as Hippocrates, Galen, and others, recommended that healthy people keep eating antidotes to hot, and cured hot diseases with honey; those two [Hippocrates and Galen] preferred honey to other [antidotes to hot]. However, if people of our time were to rely on this for curing hot diseases, they would get worse. One should not think that while their summer was hotter than ours, they were less tolerant of medicines for hot diseases compared to us, because, on the contrary, a thing gets affected by its opposite, not its like. That is why Indian people have persistently used the spices produced by their hands and count this as one of the reasons for their continued health. The people of Azerbaijan obtain nourishment from beef and watermelon during their winter. If one were to say that the distance between the Sun and the Earth, when the Sun is in its apogee, is not considerably different from the distance between them when [the Sun] has passed the apogee by about 20 degrees such that it could affect the summer of our predecessors and make it hotter than ours, we will say that this amount of distance from the apogee necessitates that the Sun be closer to the Earth in the summer of the abovementioned ancients by 3180 *farsakh*s compared to our summer, every *farsakh* being 12000 cubits. So is this amount of increase in the Sun's closeness something that in spite of its greatness, whose effect upon the heat [of summer] can be refuted by knowledgeable people?: margins of **B**, **K**, **L** and **R**.

[xxi] as mentioned] - **B**; margin of **K**.

fire would not be more intense, even though it looks bigger at night from afar than what it actually is. Indeed, that which is factual is size as the matter of truth, as we have stated. Now, it is clear that the reason for the lack of habitation in the southern region is also its being hotter according to the approach we have taken.

[6b] The statement of anyone who has asserted that **"if this were the reason, then regions beyond [this day-circle] in the south, whose latitude is greater than the obliquity, would be inhabited"** is within the realm of denial; the support [for this denial] is known to the clever after fully understanding what we mentioned /about the absorption of water to those regions, or their extreme heat./* [xxii] Indeed, were it to be said that the reason is what has been mentioned by the astrologers in their superstitions about that [region] being **beneath those southern day-circles occurring between the "falls" of the two luminaries,** *i.e.*, between 19 degrees of Libra and 3 degrees of Scorpion, then what he has stated would count against it. Despite what [astrologers] have said about **the regions not being populated beneath the** abovementioned **day-circles, which they call**, along with what is aligned with them on the celestial orb, **the combust way,** this is wrong based on what Ptolemy has said in the *Geographia*, and we have quoted from him. [However] this does not invalidate what we have stated, because when the Sun is in the solstice or close to it, the heat is more intense than if it were far from the solstice, based on the validation that is forthcoming—God the Almighty willing.

[6c] Al-Kharaqī said that "this location on the Earth," by which he meant the locations beneath the day-circle of the Sun's perigee and its vicinity, "is called the combust way, because if we imagine a line extending from the center of the world toward the Sun, it will cross the surface of the Earth at a point. If the Sun revolves and that line also revolves due to the [Sun's] revolution until it returns to its initial point, a circle will occur on the surface of the Earth. That circle is actually the combust way, and it is not a great circle; for the line that is drawing that circle on the surface of the Earth sweeps the surface of a cone that does not bisect the Earth into two halves." This is his wording in the *Muntahá al-idrāk*, but this is unresolved. Firstly, [this is] because the [definition of] combust way upon which there is a general agreement is the afore-mentioned one which is well-known, not the one he has mentioned. Secondly, what he has stated is not a good reason for calling them the combust way in spite of his clearly expressing it as

[xxii] about the absorption of water to those regions, or their extreme heat] - **B**; margin of **K**.

such. It seems as if he wants to say that “those locations on the Earth are called the combust way, because they are aligned with what is on the orb between the ‘falls’ of the two luminaries.” What is meant by “their being aligned” is not what comes to mind instinctively, namely that those locations are between two circles occurring on the surface of the Earth by imagining that day-circles of the ‘falls’ of the two luminaries are described on the Earth; this is because, not every day-circle is described on the Earth, even through imagination. Rather, “being aligned,” is meant that those locations are between two small circles occurring on the surface of the Earth by imagining two lines extending from the center of the world to the center of the Sun, one while the Sun is in its fall, which is 19 degrees of Libra, and the other when [the Sun] is in the fall of the moon, which is 3 degrees of Scorpion. The two lines revolve with Sun[’s revolution] until they return to their [initial] places. So they describe, as mentioned, two cones and two circles on the surface of the Earth, between which, is in fact the combust way. This [definition] is what is accepted by the reliable practitioners of the science. Clearly he wanted to convey it the same way, as well, but he failed in expressing it correctly, so he stumbled into what occurred. You should pay attention to what we have stated about the climes and inhibited regions that are beneath the day-circles, and should not pay attention to what comes to mind instinctively, which is useless.

[7a] You should know that the Greeks took the western side of the inhabited region as its initial limit with regard to longitude since this was the closest of the two fringes of the inhabited region to them, which, according to Ptolemy, was the islands named the Eternals in the western sea, called Oceanus, which were inhabited in ancient times but are currently uninhabited. According to others the [initial limit] was the shore of the western sea. Between the two is 10 degrees, which is almost 120 *farsakh*s. Some Indians took the eastern side of the inhabited region as its beginning—since it is nobler to be at the right side of the orb because they imagine the orb as a supine human, his head being the South Pole, and the rest is clear, according to what is well known—which, according to their scholars, is a place called *Kankdiz*, and [the Indians] believe it is the abode of the devils. Its longitude from the coast of the western sea is 170 degrees, and it has been reported that Indian scholars [made their] observation there. **The initial limit** of the inhabited region with regard to latitude **is the equator since it, rather than something else, is determined by nature**. Thus, any [part] of [the inhabited region] that is in the south, its latitude is expressed as southern, and that which is in the north, its latitude is northern.

[7b] You should know that the identification of localities is by longitude and latitude. The longitude of a locality is an arc from the equinoctial between the meridian of the initial limit of the inhabited region and the meridian of that locality. Since those who arrived at Alexandria from the west were more than those who arrived there from the east, for Ptolemy the western side was certainly at an advantage compared to the eastern side; thus, he made the western side the initial longitude **so that the longitude increases in magnitude in the direction of the sequence of the signs,** and the majority followed him in this. Yet Ptolemy and some scholars took the [Eternal] islands as the initial [longitude] while others [took] the coast, between which is 10 degrees, which is why one finds difference between the longitudes in [different] books. Among [other scholars], some made the eastern side the initial longitude so that the distance [increases] in the direction of the prime motion. You have learned that **what is on the equator between the two ends,** which **is at a distance of one-quarter revolution from the initial western limit,** is **named the cupola of the Earth. There will thus be a divergence attendant upon [its location] because of the difference concerning [the initial limit].** Some of the [scholars] believed that the cupola of the Earth is the midpoint of the inhabited region in terms of longitude and latitude, that is, a location whose longitude is a quarter revolution and whose latitude is 33 degrees and a fraction—[which is equal to] half of the overall width of inhabited world; appellations are incontestable. Since this location is the midpoint of the inhabited region, it has been made the origin. Thus it has been stated that any locality whose longitude is less than its longitude, *i.e.*, less than a quarter [of a revolution], is western; any [locality whose longitude] exceeds [a quarter], is eastern; any locality whose latitude is less than the latitude [of the cupola] is southern; and any [locality whose latitude] exceeds [the latitude of the cupola] is northern. Some [scholars] believe that any locality beneath the meridian of the cupola is at the cupola, because it is not a particular location; rather, any location with the longitude of 90 is the cupola. Some [others believed] that a locality being on the cupola means that its inhabitants are the inhabitants of the cupola, *i.e.*, what lays between the two extreme limits of the inhabited region along the equator. This is correct because, based on this [interpretation], the world ascendant will not change, while with the first [interpretation] there will be a different world ascendant for each locality beneath the meridian of the cupola. Now, the latitude of a locality is an arc along the meridian circle that passes through the zenith of [the inhabitants of] that locality, between the equinoctial and the zenith. The [latitude arc] is in alignment with an arc from a great circle on the

Earth, between the equator and the midpoint of that locality, which is equal to the altitude of the visible pole [of the equinoctial circle] and equal to the inclination of the equinoctial toward the direction of the invisible pole. Thus, if one knows the altitude of the equinoctial for a locality with an instrument which is appropriate for this purpose and subtracts that from ninety, the latitude of the locality will be obtained. This is a third§ [xxiii] method for calculating the latitude of the locality.

[7c] Now that you have learnt about the longitude and the latitude, you should know that the longitudinal difference is an arc on the equinoctial circle between the meridian circles of the two localities. /The difference between their horizons is equal to the amount [of that arc] such that if the ascendant is known for one of them, it is [also] known for the other./‡ [xxiv] The latitudinal difference is an arc along the meridian between the zenith of one of the two localities and the intersection of its meridian with a [small] circle drawn at the distance of the chord of the complement of the latitude of the other locality from the equinoctial visible pole. The distance between two localities is an arc along the altitude circle between the two zeniths. The equation of the longitude is an arc along a circle passing through the rising point of our equinox and their zenith. The equation of the latitude is an arc along the meridian circle between the equation of the longitude circle and the equinoctial. The adjusted latitude of a locality is an arc along the meridian circle between our zenith and the equation of the longitude circle.

[7d] Here, we should point out some rules concerning the fixed stars that, due to their dependence on knowledge of longitude and latitude, were not appropriate to be mentioned in the earlier parts. Thus, we say that when longitudes differ, but not latitudes, that is, all [localities] are beneath the same day-circle, stars will neither rise nor set together for [those localities] and the amount by which their rising occurs in advance for the easterners is the same amount by which their setting is in advance for them. When latitudes differ, but not longitudes, that is, all [localities] are beneath the same meridian, fixed stars whose day-circles lie between the greatest permanently visible [day-circle] and the equinoctial will stay above [the horizon of] the northerners longer than the southerners and, for the northerners, their setting will be later as much as their rising is earlier. This will be the other way around for [stars] whose day-circles lie

---

[xxiii] third] changed to “mentioned”: **K**, **L** and **R**.
[xxiv] The difference… known for the other] margins of **B**, **K** and **L**.

between the greatest permanently invisible [day-circle] and the equinoctial, that is, they will stay above [the horizon of] the southerners longer than the northerners, and for the southerners their setting will be later as much as their rising is earlier and stars that are on the equinoctial will rise and set together for them. [Finally, for the localities with] different longitudes and latitudes, fixed stars whose day-circles lie between the greatest permanently visible [day-circle] and the equinoctial, will stay above [the horizon of] the northerners longer. This will be the other way around for those whose day-circles lie between the equinoctial and the greatest permanent invisible [day-circle], that is, they will stay above [the horizon of] the southerners longer.

[7e] Now, you should know that **most of the inhabited region on the northern side falls between the [area] beyond 10 degrees in latitude up to 50 [degrees]. The practitioners of this science have divided** most of the prosperous part of the populated quarter **into seven** divisions **lengthwise so that each**[§ xxv] **clime is beneath a day-circle, the conditions of the places in it then being similar**—among [the scholars], some divided the [entire] inhabited [quarter] this way—and named each division a clime, which is a part of the [surface of the] Earth containing some localities, bounded by two parallel half-circles, /between which there is a distance that we will mention later,/[* xxvi] that are [also] parallel to the equator, /if [the equator] is not one of them./[* xxvii] **Thus each clime extends from east to west in longitude** in the shape of a half tambourine, one of its two sides more contracted than the other since climes are different in length. So the one at the equator is longer than the one next to it and the length of a singular clime is longer in its southern side than in its northern side, the shortest being the one next to the timpani-shaped uninhabited zone. /[This is] because the farther the circles that are parallel to the equinoctial, or rather to the equator, are from [the equator], the smaller they get./[*xxviii]. From this, it becomes clear that the length of a longitude degree decreases by getting farther from the equator. Therefore, the length of the one next to the equator is, in the unit of *mīl*, 10200 *mīl*s, and the [length of the] one next to the timpani-shaped [uninhabited zone] is 4080 *mīl*s, approximately. As for the quantity of a latitude degree, it is the same for all locations because all meridian circles are the same. The width of each clime, which is a small amount, is what **results in a difference of half an hour in lengths of longest daylight** at the middle [line] of the climes

[xxv] each] + division namely: margins of **L**, **K**, and **R**.
[xxvi] between which there is a distance that we will mention later] margins of **B** and **K**.
[xxvii] if it is not one of them] margins of **B** and **K**.
[xxviii] because the farther … the smaller they get] margins of **B** and **K**.

and [results in the interval of] a quarter of an hour between the initial limit and middle [line] and between the middle [line] and the final limit [of each clime], except the initial limit of the first clime and the final limit of the last clime [between each of] which [and their middle lines] is more than this amount due to the scattering of the inhabitation in them.

[8a] Now, **the initial limits and middle [lines] of the climes according to latitudes and the longest periods of daylight are as follows: the initial limit of the first** clime **is where the longest day is (12 + ½ + ¼) hours and its latitude is 12 2/3 degrees. Its middle [line] is where the day is 13** [hours] **and** the **latitude is (16 + ½ + 1/8) degrees.** /Lengthwise, it begins from the east and the region of China, passes across the bodies of water in China, which are the large rivers through which ships travel upstream/ascend from the sea to the harbor, then [passes] across the coast of the South [China] Sea. [It then passes] through some of the southern localities of India and the Sind region, then across the sea [it passes] by *Karak* Island—whose ruler, appointed by the King of Yemen, makes all the passing-by ships pay tithe—then across the Persian Gulf and the Arabian peninsula [*Jazīrat al-ʿArab*], then across the southern edge [of the Arab peninsula], through the *Ḥijāz* region and most towns of Yemen such as *al-Mīd*, *Madīnat al-Ṭīb*/*al-Ṭayb*, *Muʿallā*, *Ḥaḍramawt*, *Ṣanʿā*, *Mārā, Zabīd*, *Qalhāt*, *Ẓafār, Shihr*, and Aden. It then passes across the Red Gulf and the towns of Abyssinia, Sudan [*Sūdān*] and *al-Nūba* regions, such as *Jarmá*, the capital of Abyssinia, *Dunqula*, *madīnat al-Nūba*, *Ghāna* the gold mine of western Sudan region [*bilād Sūdān al-Maghrib*], then the Barbary region until it reaches the western Ocean./† [xxix]

[8b] **The initial limit of the second is where the day is 13 ¼** [hours], **and the latitude is (20 + ¼ + 1/5)** degrees, **its middle [line] is where the day is 13 ½ and the latitude is (24 + ½ + 1/6).** Lengthwise, it begins from China, then passes over most of India, then over the north of [some] well-known mountains of the region of [Indians], then the Sind region [until] it reaches the Oman [Sea] and passes across the Arabian Peninsula through *Najd* and *Tihāma* and passes *Ṭāʾif*, Mecca [*Makka*], Medina [*Madīna*] and *Yathrib*, then across the Red Sea [*Qulzum*], then reaches the *Ṣaʿīd* [region] of Egypt and passes across the Nile, then begins [its passage] through

[xxix] Lengthwise, it begins from the east… then the Barbary region until it reaches the Ocean] added in the margin in **K** and within the text and in the margin in **L** = Some of its regions are western Sudan and some provinces of Barbary and Yemen, and the regions of Abyssinia and *al-Zanj*, and Indian islands to the borders of China: **B** = crossed out in **K** = effaced in **L**.

the region of the *Maghrib* and passes through the middle parts of *Ifrīqiyya*, then the Barbary region, and [finally] reaches the Ocean.

[8c] **The initial limit of the third is where the day is (13 + ½ + ¼)** [hours] **and the latitude is 27 ½** degrees, **its middle [line] is where the day is 14 and the latitude is 30 2/3.** It begins from the east of China. Within this [clime] lies the capital [of China]; the middle part of the Indian kingdom; *Qandahār*, which is one of the largest cities of India; *Mūltān* in the land of Sind; *Zābul*; *Bust*; *Sīstān*; *Kirmān*; *Fārs*; *Iṣfahān*; *Ahwāz*; *ʿAskar*; *Kūfa*; *Baṣra*; *Wāsiṭ*; *Baghdād*; *Anbār*; and *Hīt*. When it goes past these towns, it passes through the towns of *Jazīra* and Syria, [such as] *Diyār Rabīʿa*, [*Diyār*] *Muḍar*, Damascus [*Dimashq*], Homs [*Ḥimṣ*], *Ṣūriyya*, Tiberias, *Qaysāriyya*, *Bayt al-Maqdis*, *ʿAsqalān*, and *Madyan*. It then passes across an area of Egypt within which are *Dimyāṭ*, *Fusṭāṭ*, and Alexandria, then passes through *Ifrīqiyya* within which are the towns of *Qayrawān* and *Sūs*, and then through the [region of] *Barbar* tribes in the *Maghrib*, and then through the Tangier region until it reaches the Ocean.

[8d] **The initial limit of the fourth is where the day is 14 ¼** [hours], **and the latitude is (33 + ½ + 1/8)** degrees. **Its middle [line]—**which is the middle of the climes, and the middle of the most populated part of the world, since the third, fourth and fifth are more populated than others**—is where the day is 14 ½** [hours] **and the latitude is (36 + 1/5 + 1/6)** degrees. It starts from the north of China, passes the regions of Tibet; Kyrgyz/Qirghiz; Qitāy [*Khiṭā*]; *Khutan*; the mountains of Kashmir [*Kashmīr*]; *Bulūr*; *Badhakhshān*; Kabul [*Kābul*]; and *Ghūr*. Then [it passes] through *Ṭukhāristān*; Balkh; Herat [*Harāt*]; *Marv-i Shāhjān*; *Marvarūdh*; *Sarakhs*; *Bāvard*; *Nisā*; *Ṭūs*; *Nīsābūr*; *Isfarāyīn*; *Quhistān*; *Qūmis*; *Daylam*; *Jurjān*; *Ṭabaristān*; *Qum*; *Hamadhān*; *Āzarbījān*; *Qazvīn*; *Nahāvand*; *Dīnavar*; *Ḥulwān*; *Shahrazūr*; Mosul [*Mawṣil*]; *Sāmira*; *Niṣībīn*; *Raʾs al-ʿAyn*; Erzerum [*Qālīqalā*]; *Sumaysāṭ*; *Malaṭiyya*; Aleppo [*Ḥalab*]; *Qinnasrīn*; Antioch; Tripoli [*Ṭarābulus*]; and *Ṭarsūs*. [It then passes] across the Mediterranean Sea [*Baḥr al-Shām*], through the islands of Cyprus [*Qubrus*] and Rhodes [*Rūdhus*], and through the western land across the region of the Franks [*Ifranja*] and Tangier, and finally reaches the Ocean through the [strait of] *Zuqāq* between Andalusia and the *Maghrib* region.

[8e] **The initial limit of the fifth is where the day is (14 + ½ + ¼)** [hours], **and the latitude is 39 less 1/10** degrees; **its middle [line] is where the day is 15 and the latitude is 41 ¼.** It starts from the farthest parts of the region of the Turks and passes through [the residences of

different] Turkic races known by their tribes, [goes] towards the border of *Kāshghar*, [then passes] through *Balāsāghūn*, *Farghāna*, Talas/Ulugh Talas [*Ṭarāz*], *Ispījāb*, Tashkent [*Chāch*], *Usrūshana*, Samarkand [*Samarqand*], Soghd [*Sughd*], Bukhara [*Bukhārā*], *Khʷārazam*, the Caspian Sea [*Baḥr Khazar*], Armenia region, *Bardaʿa*; *Mayyāfāriqīn*, and through narrow mountain-passes [*durūb*] toward the Roman region. Then it passes through the Mediterranean coast, the regions of Romans and Andalusia until it reaches the Ocean.

[8f] **The initial limit of the sixth is where the day is 15 ¼** [hours], **and the latitude is (43 + ¼ + 1/8)** degrees; **its middle [line] is where the day is 15 ½ and the latitude is (45 + ¼ + 1/10).** Among its localities are: most of the Roman region, [the region of] the Khazars, *Turkistān* [*lit.*, the land of the Turks], and the province [containing] their different races. This clime starts from the east, passes through the residences of eastern Turks and their tribes, across the middle of the Caspian Sea [*Baḥr Jurjān*], then passes through [the region of] the Khazars, *Mūqān*, [the region of] the Slavs, *Allān*; *Bāb al-Abwāb*, and [the region of] the Russians. Then [it passes] through the Roman towns, such as Constantinople, and the north of Andalusia until it reaches the Ocean.

[8g] **The initial limit of the seventh is where the day is (15 + ½ + ¼)** [hours], **and the latitude is 47 1/5** degrees, **its middle [line] is where the day is 16 and the latitude is (48 + ½ + ¼ + 1/8); its endpoint is where the day is 16 ¼ and the latitude is 50 1/3. The end of each clime other than the [last] is the beginning of the following one.** The seventh clime also starts from the east, passes through the terminations of [the region of] eastern Turks and their tribes, and through the north of the region of Gog and Magog, then through the jungles and mountains at which Turks seek shelter like uncivilized people. It then passes through [the region of] the Bulgarians, Russians and Slavs, and across the Sea of Germans and Slavs [*Baḥr Alamān wa-al-Ṣaqāliba*], and ends at the Ocean. Some of the inhabitants of these regions reside for six months in the bathhouses due to severe cold.

[8h] Whatever is beyond or below these localities, is not counted as climes except by **one group** who **has made the initial limit of the first clime the equator—**where the longest day is 12 hours, its middle [line], as it was, that is, where the longest day is 13 hours, and the latitude is (16 + ½ + 1/8) degrees—and [also made] **the end of the seventh the termination of the inhabited region.** It is permissible for what is between the initial limit of the first [clime] and its

middle [line] to be more than [what is between] its middle [line] and its final limit, due to the scattering of the inhabitation, as was stated. And therefore, it is also permissible for what is between the initial limit of the last [clime] and its middle [line] to be less than [what is between] its middle [line] and its final limit.

[8i] The equator begins from the east of China, passes through an island that the Indians call *Jamkūt*; then through the region of China that is toward the south and *Dizkank* which is /reckoned as [part of] China; then passes through the Java [*Zāwa*] islands, which is called the land of gold; and through the south of the Sri Lanka island, between the two islands of *Kalla* and *Sarbuza*; and through the middle of the *Dīwa* islands; and north of the Zanzibar islands [*Jazāʾir al-Zanj*] and north of most of the *Zanj* region. After passing through the [northern] limits of the *Zanj*, it passes through the steppes of Sudan [region] and its deserts, and then north of the Mountains of the Moon, and south of western Sudan until it reaches the Encompassing Ocean, also known as *Uqiyānūs*./[†] [xxx]

[8j] This was a reference to some of the localities of the climes to awaken the eagerness of the learners.

[9] You should know that **the longest [period] of daylight reaches 17 hours where the latitude is 54 degrees plus a fraction; it reaches 18 where the latitude is 58; it reaches 19 where the latitude is 61; it reaches 20 where the latitude is 63**—where there is an island, called Thule [*Tūlī*], whose inhabitants are said to be living in bathhouses due to its severe cold—**it reaches 21 where the latitude is 64 ½; it reaches 22 where the latitude is 65 plus a fraction; it reaches 23 where the latitude is 66; and it reaches 24 where the latitude is equal to the colatitude of the obliquity. It reaches 1 month where the latitude is 67 ¼, 2 months where the latitude is 70 less ¼, 3 months where the latitude is 73 ½, 4 months where the**

[xxx] reckoned as [part of] China… until it reaches the Encompassing Ocean, called *Uqiyānūs*] margin of **K** = added within the text in **L** = reckoned as [part of] it then [passes] across the coast of the South Sea, and the rivers into which ships travel upstream from the sea. It then passes through India, *Sarandīb* Island, and the Sind region, then across the sea passing by *Karak* Island whose governor is appointed by the King of Yemen, and makes all passing-by ships pay tithe, then across the sea towards the Arabian peninsula, and Yemen. All southern towns of Yemen such as *Ṣanʿā*, *Ẓafār*, *Ḥaḍramawt*, and *ʿAdan* are within it. It then passes across the gulf of the Green Sea, and through the regions of Abyssinia and Sudan in which there are the towns of *Nūba*, and *Usqūṭara*, then passes in the west through the Barbary region until it reaches the Encompassing Ocean: **B**, **K** (the phrase <reckoned as [part of] it> is crossed out in **K**) = effaced in **L**.

latitude is 78 ½, 5 months where the latitude is 84, and approximately **half a year where the latitude is a quarter revolution.**

[10] Let us now go into the characteristics of the localities lying beneath **the day-circles** and what is comparable to them, such as the equinoctial and the two poles—by the aid of God, and His divine grace.

CHAPTER TWO
On the Characteristics of the Equator

[1] The equinoctial passes through the zenith in **localities that are on the equator** and thus intersects their horizons at right angles, as mentioned earlier in [proposition] 5. The circle of the initial azimuth [prime vertical] is the same as the equinoctial with its two poles on the horizon's north and south points, as already mentioned in [proposition] 4. There are neither permanently visible nor permanently invisible stars there but all the stars rise and set, except those that are exactly on either pole, for which always one half, but not a specific one, is visible, and the other invisible. Since any surface that passes through the center of a circle bisects it and the **horizon circles of** those [localities that are on the equator] **pass through the poles of the equinoctial,** and or rather through the axis on which the centers of all day-circles lie, thus their horizons **bisect all the day-circles,** so that the visible part [of the day-circle] is always half [of the day-circle], which is the arc of daylight; likewise for the invisible [part of the day-circle], which is the arc of night. **Therefore day and night during the entire year are equal. Also the period of visibility of each point on the orb is equal to the period of its invisibility. If there is a difference, it is because of variability in speed in the two halves due to the second[ary] motion,** such as [the variability in] the speed of the Sun's motion between its stay above the Earth and its stay beneath the Earth; whenever it is faster above the Earth, it will stay there longer, and the day will be longer than the night; whenever it is faster beneath the Earth, it will stay there longer, and the night will be longer than the day; however, **this will not be perceptible. The Sun will in a year pass twice over their zenith, this being when it is at the point of the two equinoxes.** At noon, there will be no shadow, *i.e.*, the shadow that spreads over the surface of the horizon [*i.e.*, the second shadow]; this is what is intended and should be considered whenever we use the [word] shadow without qualification. In the two [equinox] days the azimuth of the Sun's altitude is zero. The Sun **moves away from their zeniths only to the extent of the zodiacal orb's maximum declination from the equinoctial; thus [the Sun's] maximum altitude is never less than the complement of the obliquity. The Sun is in each direction for** /almost/† [i] **half the year, the noon shadow being in the opposite direction.** The shadows at the beginning of summer and of winter are equal, and the maximum length of [the shadow] will be 26 ½ units, according to the gnomon being 60 units. **The zodiacal poles are at**

[i] almost] margins of **B**, **K** and **L**.

the horizon when one of the two equinox points are at the zenith; thereupon the intersection of the zodiacal orb **and the horizon is at right angles,** as mentioned earlier in [proposition] 4. At that time, the meridian bisects the visible half of the zodiacal orb, as already mentioned in [proposition] 8. Then if the vernal equinox is at the zenith, the northern of the two zodiacal poles will be about to set on the western horizon, and the other [pole] will be about to rise on the eastern horizon; and for the autumnal [equinox] it will be the opposite. Therefore, **during the passage of the northern half of the [zodiacal] equator across the meridian, the southern of the two zodiacal poles is visible; during the passage of the southern half, the northern is visible. The altitude [of each pole] does not exceed the magnitude of the obliquity,** neither does their depression. So, the maximum of their altitude and depression with respect to the horizon will be equal. The maximum altitude of the northern pole and the maximum depression of the southern [pole] will occur when the southern solstice is on the meridian. If the northern solstice is on the meridian, it will be the maximum depression of the northern [pole] and the maximum altitude of the southern [pole]. **Since the beginning of summer is the time in which the Sun is nearest the zenith and the beginning of winter is the time in which it is farthest from it, the time at which it is at the two points of the equinox is the beginning of their summer and the time at which it is at the solstitial points is the beginning of their winter. The beginnings of the other two seasons are [at] the midpoints of the quarter [divisions of the zodiacal equator].** Therefore, the beginning of the spring is the middle part of Leo and Aquarius, and the beginning of the autumn is the middle part of Taurus and Scorpius. **It follows from this that they have eight seasons in a year. The turning of the orb there is wheel-like because the planes of all the day-circles intersect the horizon plane at right angles,** as mentioned before in [proposition] 4. **Their horizons are therefore called the horizons of the right orb** and the horizons of the erect sphere. **And since the horizon circle** [at the equator] **is one of the circles of declination,** due to its passing through the poles of equinoctial, **the ortive amplitude of each point, which is the arc along the horizon between its rising place and the rising place of the equinoctial, is in the amount of its declination; the same [holds] for the occasive [setting] amplitude.**

[2a] There is a discussion here: There is general agreement on the fact **that the hottest localities in summer are** those beneath the day-circles of the two solstices, *i.e.*, **those whose latitudes are equal to the obliquity,** if terrestrial causes do not work against it by reducing the

temperature; but there is disagreement on where the most temperate locality is. **The Grand Master Abū ʿAlī ibn Sīnā** believed it to be the equator. The most eminent of the Moderns, the polymath **Imām Fakhr al-Dīn al-Rāzī**, believed it to be the fourth clime. Before delving into [the discussion] let us present an introduction [consisting of two propositions]: [(1)] The intensity of heat may be due to the power of the heat-maker and may also be due to the continuity of heating, even if [the heating] is weak; and [(2)] the effect of a weak influencing factor will be stronger if the duration [of its influence] is longer than the duration [of influence] of a strong factor, based on a *limmī/propter quid* proof [and five *innī/quia* proofs]. The *limmī* proof is that the influencing factor produces one effect in the first [interval of] time and another effect is added to it in the second [interval of] time; there is no doubt that the combination of the two effects is stronger than one single effect. [In other words,] the influencing factor produces an effect in the first [interval of] time, if it continues to the second [interval of] time, the propensity will be more intense and the effect stronger. The five *innī* proofs are: (1) The Sun's heat being greater when it is in Leo, in spite of its being afar from us, than [its heat] when it is in the [summer] solstice despite its being close to us; (2) The Sun's heat being greater when it is in Leo and Virgo than when it is in Taurus and Aries; (3) The Sun's heat being greater two hours after noon than its heat two hours before noon, even though its distance from us is the same in both states; (4) The heat of a body that has been in a weak fire for a while being greater than its heat when it was in a strong fire for a moment; (5) The cold in the early morning being greater than at midnight, even though the Sun is farther away at midnight. /This is the general belief; however, it is clear that the *limmī* proof only signifies that the intensity of heat is certainly due to the continuity of heating, even though the heat is weak. The first, fourth and fifth *innī* proofs [signify] that the effect of a weak influencing factor may become stronger if the duration [of its influence] is longer than the duration [of influence] of a strong factor. The second and third *innī* proofs do not convey any of the two [aforementioned] significations, although conventionally the six [*limmī* and *innī* proofs] are mentioned for the explanation of the second proposition, so be aware of this./† [ii]

[2b] Now that you have learned this, you should know that it has been generally justified that localities beneath the day-circles of the two solstices are the hottest localities **for** the reason

[ii] This is the general belief… for the explanation of the second proposition, so be aware of it] margins of **B**, **K** and **L**.

that **the Sun will be directly overhead and will linger near this alignment for nearly two months**—because of the decrease in the difference between the increments of the declinations, as already mentioned in [proposition] 12, which is why there is no visible change in the Sun's declination for a few days around the two solstices, as if the Sun stays over their zeniths during those days—and [for the reason] that **their** summer **days will be long and their nights short.** Due to both reasons, in those localities the intensity of the [Sun's] heating will be greater compared to other localities, since these two causes do not come together in other localities. The statement of anyone who holds the first [reason] contradicts the existence of reasons for coldness before this time of the year due to the Sun being far from their zeniths, together with the fact that heating a cold object is much less effective than heating a not-cold object. And the second [reason contradicts] the fact that the length of their winter nights causes increase in cold and the resulting opposition between [the heat and the cold] will be offset, as will become apparent in the course of what we will mention.

[2c] The Master justified his claim by [saying] that **"the Sun does not linger there long at the zenith, but rather it passes by it at the times of its crossing from one of the directions to the other and its motion in declination will there be at its fastest,"** as mentioned earlier in [proposition] 12; in fact, [the Sun] moves 25 minutes away from the equinoctial every day, **"thus the heat of their summer will therefore not be intense."** [This is] because the persistence of /what is practically the same as/[†] [iii] being directly overhead is more effective in producing heat than simply being directly overhead, as established in the introduction [above]. Whoever considers this [only] as a reason for the equator's not being hotter than the localities beneath the day-circles of the two solstices, not for its not being hotter than the fourth clime or other climes, which is desired, is wrong; [whoever also incorrectly says] that the equality of their [*i.e.*, the inhabitants of the equator] daylight and night necessitates permanent temperateness, due to the quick breaking of **the severity of each of the weather conditions arising from them**—contrary to other localities, because of the length of their days and shortness of their nights—and due to their [*i.e.*, the inhabitants of the equator] weather not having extreme perceptible changes because the Sun is not really directly overhead during the alignment and it gets very far after being almost aligned, thus it is as if they keep being transferred from one state to another similar

[iii] what is practically the same as] margins of **B**, **K** and **L**.

state, contrary to other [localities where] they swing from one opposite to another due to the Sun's extreme farness from them. Whoever said that the length of the day does not affect the increase of heat, since otherwise, the heat should be more where the length of the day is six months while in reality it is the opposite because the cold is reinforced there by the length of their winter night, so they are not affected by the length of their summer day [is also wrong]. Firstly, we do not accept that 'in reality it is the opposite,' because it is well-known that there is no inhabitation there, we admit it being unknown whether it be due to the severity of the cold or the severity of the heat; however, we do not accept the necessity of [those localities] being very hot. For the reason is not just the length of the day but is the Sun's nearness to the zenith, on account of the concentration of the rays§ [iv] due to their reflection at very acute angles that intensify the heating, based on what has been explained in natural philosophy. In latitude 90 [degrees], due to the extreme farness of the Sun from the zenith, its rays do not reflect at very acute angles but with obtuse angles; therefore, rays will not concentrate but will become scattered and diminished, thus weakening the heat production. /According to the natural and usual order [of propositions], this refutation, being the refutation of [false] correlation, should precede the first [refutation], which is the refutation of [the fallacy of] denying the consequent. However it happened as such, and there will be no difference after the explanation of the idea./‡ [v] Secondly, the disposition in which the cold has become ingrained, will be more influenced by the heat than the one in which it has not, let alone [the disposition] that is accustomed to the heat. That is why in winter someone who suddenly comes from outside into a house whose weather is temperate due to heating, feels hot, and someone who suddenly comes out of a hot house feels cold even though both of them were only acclimated to the weather for a short period of time; imagine if they were acclimated to it for a longer period of time.

[3] The polymath Imām Fakhr al-Dīn al-Rāzī rejected the Master's [first argument], saying: when the Sun is in maximum declination its heating in a locality whose latitude is twice the obliquity is the same as its heating at the equator. Still, its heating in the assumed locality is very intense, likewise for the equator but even more intense, because even though the **Sun lingers on the equator only briefly, it nonetheless is never too far from being directly**

[iv] the rays] + then: margins of **K**, **L** and **R**.

[v] According to the natural and usual order... after the explanation of the idea] - **B**; margins of **K** and **L**.

overhead, it is thus virtually overhead for the length of the year, unlike the assumed locality from which the Sun gets quite far. While this is the state of the heat at the equator in winter, imagine how their summer heat will be, thus it has been established that the heat there is very intense. Then, h**e judged the most temperate clime to be the fourth,** and [this statement] has been reasoned from the fact that **the profusion of habitations and the magnitude of propagation and reproduction in the seven climes, but not in the rest of the uncovered parts of the Earth, indicates that they are more temperate than other [places]. And what is nearer to the middle [of the climes] is most certainly nearer** to being temperate **than what is at their fringes; for becoming seared and** bleak**, which result from the two [extreme] weather conditions, are clearly evident at the two fringes.** The reply to the aforementioned Imām is that we do not accept that the heat at the assumed locality, while the Sun is in the solstice, is like the heat at the equator, but in fact the heat at the assumed locality is greater due to their long daylight and short nighttime. This is contrary to the dwellers at the equator; since someone accustomed [to heat] is not affected by it, perhaps, their disposition being accustomed to heat, they find the weather cold while the Sun is at the solstice, unlike the [dwellers of the] assumed locality because their disposition is not accustomed to heat. [The dwellers at the equator also] do not find the weather hot while [the Sun] is over their zenith because they are accustomed [to it], unlike the [dwellers of the] assumed locality, due to [their being] unaccustomed.

[4] The truth of the matter is that if one means by temperate a uniformity in the conditions, then there is no doubt that it is most so at the equator, as opposed to the fourth clime. **But if one means by it a balancing of the two [extreme] weather conditions, then there is no doubt that** it is more so in the fourth clime, as opposed to the equator; **this is indicated by the extreme blackness in color of its inhabitants among the peoples of *Zanj* and Abyssinia, the extreme frizziness of their hair, and other things that are brought about by the heat of the air. The opposite of this among the people of the fourth clime indicates that the state of its air is more temperate.**

CHAPTER THREE
On General **Characteristics of Locations Having Latitude Which Are Called the Oblique Horizons** and on Ortive and Occasive Amplitude, and on the Equation of Daylight

[1] **For every location that is** neither beneath the equinoctial nor beneath one of its poles, but is **beneath one of the day-circles between the equator and one of the poles of the [first] motion, the turning of the orb there is slanted** due to the inclination of the equinoctial from the horizon in the direction of the invisible pole, or [in other words due to] the inclination of the horizon from [the equinoctial] in the direction of the visible pole. That is why they are called oblique horizons, not because of the inclination of the equinoctial from the zenith as has been said, the latter clearly is not related to the former. These [oblique horizons] are [divided into] five divisions, since the latitude is either: [1] less than the obliquity; [2] or equal to it; [3] or greater than it, but less than its complement; [4] or equal to its complement; [5] or greater than [its complement] but less than one quarter [*i.e.*, 90 degrees]. For these divisions, **the altitude of the pole that is in the direction to which the location is inclined is in the amount of the local latitude; the distance from the equinoctial of the day-circles that are permanently visible or permanently invisible is greater than the local colatitude,** /except for **the distance of the largest of them, which touches the horizon,** and thus is equal to the colatitude./* [i] The maximum altitude of the permanently visible star is when it reaches the upper crossing point between its day-circle and the meridian, and the maximum depression is when it reaches the other crossing point.* [ii] **The remaining day-circles,** /whose distance [from the equinoctial] is smaller than the local colatitude,/* [iii] **are divided by the horizon into two unequal parts—the largest visible one being along** [the day-circle] **closest to the visible pole** /and in the same direction,/* [iv] **the [largest] invisible one being** along the closest to the invisible pole /and in the same direction,/* [v] not along the **farthest away** from the visible pole, as has been said, which is not correct, /unless it is qualified by what we have said./* [vi] **The two parts are conversely equal for any two day-circles equidistant from the equinoctial** in two [opposite] directions. For any

---

[i] except for the distance of the largest of them, which touches the horizon, and thus is equal to the colatitude] margins of **B** and **K**.
[ii] the other crossing point] + the distance of the largest of them which touches the horizon is equal to the colatitude: crossed out in **B** and **K**.
[iii] whose distance is smaller than the local colatitude] margins of **B** and **K**.
[iv] and in the same direction] margins of **B** and **K**.
[v] and in the same direction] margins of **B** and **K**.
[vi] unless it is qualified by what we have said] margins of **B** and **K**.

two day-circles in one direction [from the equinoctial], the visible part of the one closer to the equinoctial is smaller than /the visible part of/* [vii] the farther one, if they are in the direction of the visible pole. This will be the opposite if they are in the direction of the invisible pole; and [the relative proportion of] the invisible [parts] of [any] two [day-circles in one direction of the equinoctial] will be the opposite [of what was said for the visible parts]. That is why the farther the Sun gets from the equinoctial in the direction of the visible pole, the greater will be the excess of daylight over nighttime. This will be the opposite in the direction of the invisible pole, inasmuch as the daylight keeps getting shorter than night. The shortest daylight for the half [of the Sun's path] at the midpoint of which is the solstice that is adjacent to the visible pole is longer than the longest night of [the days of] that [half], and the longest daylight of the other half is shorter than the shortest night. The greater the latitude of the locality, the greater the difference between the daylight and night because of the increase in the altitude of the visible pole, and because of the day-circles adjacent to it, and [because of] the increase in the excess of their visible arcs over their invisible arcs, and because of the increase in the depression of the invisible pole, and because of the day-circles adjacent to it, in which the excess of the invisible arcs over the visible ones increase. **There is an increase in daylight** and decrease in night **up to the apex of the solstice that is adjacent to the visible pole, and a decrease in** daylight and an increase in night **until the apex of the other solstice**. The daylight of every point [on the zodiacal equator] is equal to the night of the point diametrically opposite, and vice versa, *e.g.* the daylight of the beginning of Cancer [is equal] to the night of the beginning of Capricornus, /and vice versa./‡ [viii] For any two points equidistant from the equinoctial in the same direction, *e.g.* the beginnings of Taurus and Virgo, there will be equal daylight and night. **Daylight will only be equal to night when the Sun is at the equinox points,** while it rises or sets. For when the Sun rises, /while/* [ix] on the equinoctial moving away, for example, from the summer solstice point, the night of that rise will be equal to its daylight; and if it sets, /while/* [x] on the equinoctial, the day[light] of the sunset will be equal to its night. If one day it rises and sets while its distance from one of the two solstice points at both times is equal, it will be in the [same] solstice point at noon; and if its distance at both times is not equal, it will not get to the solstice [point] at noon.

[vii] the visible part of] margins of **B** and **K**.
[viii] and vice versa] - **B**; - **K**; margin of **L**.
[ix] while] margin of **B**; above the line in **K**.
[x] while] margin of **B**; above the line in **K**.

The circles passing through the poles of the Universe will be perpendicular to the horizon twice in every revolution, and likewise the zodiacal equator to the meridian. [The zodiacal equator] will not be perpendicular to the horizon if the pole of the horizon is between the visible pole and the day-circle of the solstice point that is adjacent to [the visible pole]; it will be perpendicular once in every revolution if its pole is on one of the two solstices' day-circles; and twice if the pole is between them. From the equator to the latitude that is equal to the obliquity, there will be two shadows, that is to say, the noon shadow will be cast northward at times and southward at other times. /At this latitude [=obliquity] there will be no noon shadow/‡ [xi] and from this latitude to latitude 90 there will be one shadow, which is towards the direction of the visible pole.

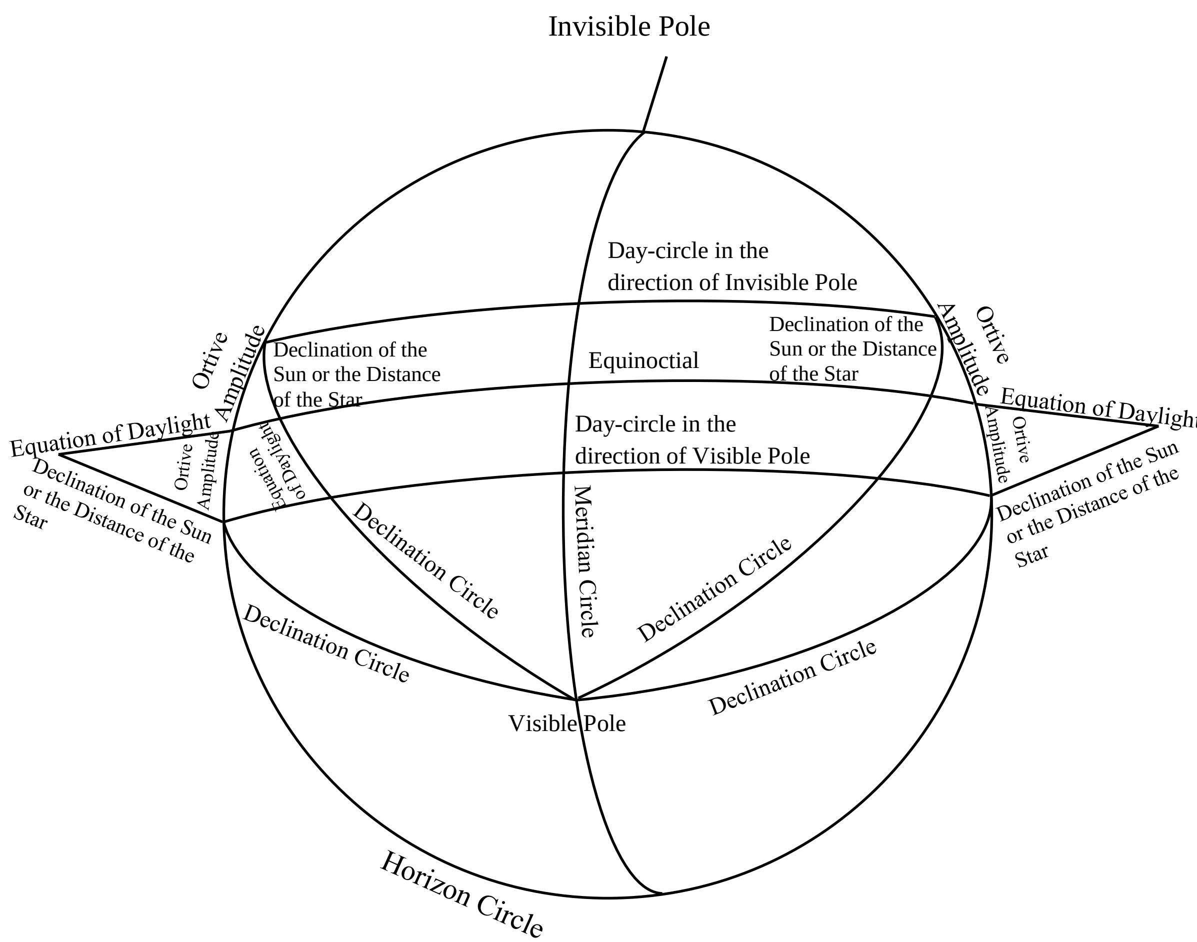
[2] **Every day-circle whose elongation from the equinoctial is equal to the local latitude,** if it is **in the direction of the visible pole, will pass through the zenith and be tangent to the prime vertical circle above the Earth;** if it is in the direction of the invisible pole, it will pass through the nadir and be tangent to [the prime vertical] as well. **Every [day-circle] whose elongation is greater than that will not meet the prime vertical circle** but **will pass beyond the zenith in the direction of the visible pole,** or beyond the nadir in the direction of the invisible pole. **And every one whose elongation is less than that will intersect the prime vertical at two points, one of which is easterly and the other westerly. The star, as long as it is** along an arc of its day-circle that falls between **the prime vertical** and equinoctial, is **in the direction of the invisible pole** with respect to the prime vertical, if the day-circle is in the direction of the visible pole; and is in the direction of the visible pole with respect to the prime vertical, if the day-circle is in the direction of the invisible pole. From this, it is clear that the statement of whoever asserts that **"the star, as long as it is between the two points, is in the direction of the invisible pole with respect to the prime vertical circle,"** is wrong.

[3] If two circles of declination are assumed to pass through the two points at which the day-circle of the Sun or of some star and the horizon intersect, there will occur two triangles between two circles, the horizon, and the equinoctial; one is easterly and the other westerly. One of the sides of each [triangle] is the declination of the Sun or the distance of the star from the equinoctial, which is along the declination circle; the second of them is the ortive amplitude of the Sun or of the star, which is along the horizon circle; and the third

---

[xi] At this latitude there will be no noon shadow] - **B**; - **K**; margin of **L**.

[of the sides] is the equation of daylight of the Sun or of the star, which is along the equinoctial. [When] the two **triangle**s are **in the direction of the visible pole,** they are **below the Earth [*i.e.*, the horizon], while in the direction of the invisible pole,** they are **above it.** This is its illustration:

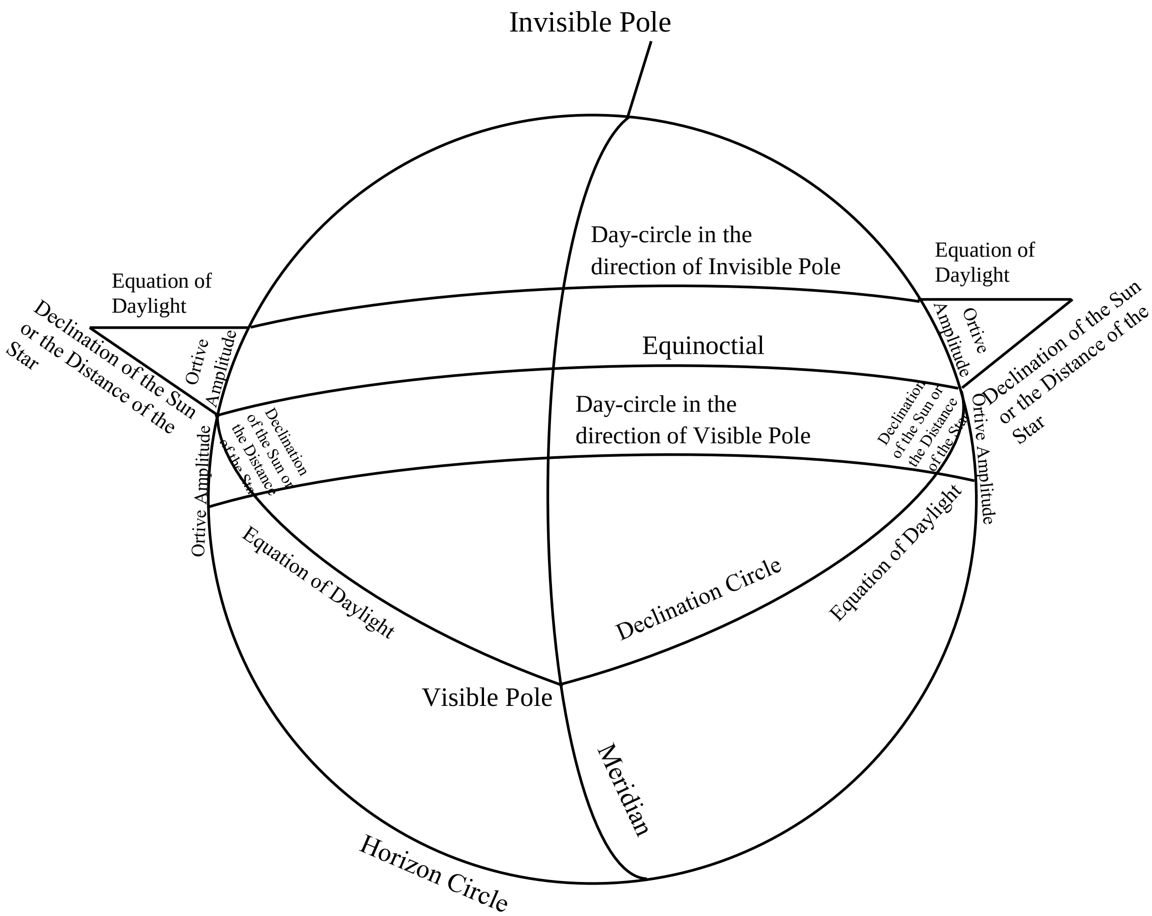


[Figure 1]

[4] [However,] some assume one circle of declination that passes through the rising place of the equinox and its setting place. Thus, two triangles will occur from that [circle] and the horizon and each day-circle; one is easterly and the other westerly. The two [triangles] are above the horizon, [when they are] in the direction of the visible pole, and below it [when] in the other direction. The ortive amplitude and the declination remain unchanged, but the equation of daylight, /based on this assumption,/[†] [xii] is along the day-circle, while /it was/[†] [xiii] along the

[xii] based on this assumption] margins of **B**, **K** and **L**.

equinoctial in the first assumption. Based on the first assumption, all sides of the triangle are [arcs] of great circles; [but] based on the second [assumption] the equation of daylight is [an arc] from a small circle, and the rest are from the great circles. [However,] the rule remains unchanged, because this arc from the small circle is similar to that arc from the equinoctial, due to their being between two circles of declination, one passing through the rising and setting points of the equinox, the other through the rising or setting point of the day-circle. This is its illustration:



[Figure 2]

[5] From what we have mentioned, it becomes clear that the ortive amplitude of a planet or the part on the zodiacal orb is an arc along the horizon [circle] between the day-circle of the planet or the part and the rising place of the equinox; and that the occasive amplitude is an arc

[xiii] it was] - **B**; - **K**; above the line in **L**.

along the horizon [circle] between the day-circle and the setting place of the equinox; [the amplitudes] will be northerly if the star or the part is northerly, and southerly if it is southerly. Since the day-circles are parallel to the equinoctial, the ortive amplitude of each planet is equal to its occasive amplitude, not strictly but roughly speaking, because of the planets' motion. The faster its motion is, the greater the difference between ortive and occasive amplitudes, like for the moon; [but] if the motion is slower, it is smaller, like for the Sun; one may analogize these two cases for the other planets. From the aforementioned, you have learnt that on the equator the ortive amplitude of each point is equal to its declination; thus the Sun's maximum ortive amplitude [at the equator] equals the obliquity. But in other localities [the ortive amplitude] increases with the increase of local latitude, until the latitude equals the complement of the obliquity where the ortive amplitude at the beginning of the summer becomes a quarter of a revolution, as will be discussed—God willing. The Sun's maximum ortive amplitude in the north is equal to the ortive amplitude of the head of Cancer, while in the south it is equal to the ortive amplitude of the head of Capricornus; likewise for its occasive amplitude. The ortive amplitude of each quarter of the orb equals the other quarter's ortive amplitude, one in the sequence of [the zodiacal signs] and the other in the counter-sequence; and the ortive amplitude of the two northern quarters is the same as the other two quarters; and the ortive amplitude of each part is the same as the occasive amplitude of its diametrically opposite part. In sum, any two equidistant parts from the equinoctial, whether it be in one direction or in two directions, have the same ortive and occasive amplitudes.

[6] It also has become clear that the equation of daylight of a planet or a [zodiacal] part is [either] an arc along the equinoctial between its rising or setting places and the declination circle that passes through the intersection point of the horizon and the day-circle of the planet or the part; or an arc along the day-circle of the planet or the part between the horizon circle and the declination circle that passes through the rising and setting places of the equinox. Based on the first consideration, [the equation of daylight] can also be defined as an arc along the equinoctial between the two circles passing through the planet or the part, one from the pole of the prime vertical and the other from the pole of the equinoctial, that is, the horizon and declination circles; and the equation of daylight for a part is defined as the excess of its co-ascension at the equator over its co-ascension at a locality. The co-ascension of a point is understood as an arc along the equinoctial between the head of Aries and the point that rises from [the equinoctial] with that

point. Let us take an example for this, thus we say: when the head of Gemini is adjacent to the east [point] in a locality other than the equator, and we assume one of the declination circles passes through it and intersects the equinoctial, a triangle will occur. One of its sides is the declination of the head of Gemini. The other two sides are two arcs between the declination circle and the vernal equinox point: one [arc] is along the zodiacal orb, which is called the equal degrees, the other [arc] is along the equinoctial, which is the co-ascension of the head of Gemini at the equator. The horizon of the locality divides this triangle into two triangles. One of them is beneath the Earth, enclosed by the ortive amplitude, the declination of the head of Gemini, and an arc along the equinoctial, which is the equation of daylight for the head of Gemini at that locality and is [equal to] the excess of its co-ascension at the equator over its co-ascension at the locality, and is [also equal to] the arc along the equinoctial above the Earth [from the horizon] to the equinox point. Since the sectioning of such a triangle by the horizon will differ with the varying latitudes of localities, it necessarily follows that the co-ascension will vary with different latitudes. The discussion of this will come later—God willing.

[7] After understanding what we mentioned, it should be clear that the equation of daylight is half of the excess of the daylight of the Sun—or the planet—in a locality over the daylight at the equator—or the daylight of the equinox point, that is, the average daylight—because the daylight arc of every part at the equator is like the daylight arc of the equinox point. /Therefore,/†[xiv] in the oblique horizons the daylight arc of the part /will be greater/† [xv] than the daylight arc of the equinox point by twice the equation of daylight, if the part is in the direction of the visible pole; and will be less than [the equinox daylight] by twice [the equation of daylight], if the part is in the direction of the invisible pole. Thus, in order to obtain half of the daylight arc [for the part] in the direction of the visible pole, the equation of daylight will be added to a quarter of a revolution and will be subtracted from it to obtain the same arc [for the part] in the direction of the invisible pole. From this, it becomes clear that calling this arc the equation of daylight is metaphorical because it is an equation for half of the arc of daylight, not all of it. The half of the arc of daylight for a planet or for a [zodiacal] part is an arc along the equinoctial that rises in half the visibility time of that planet or point; it is [also] half of the visible part of its day-circle. And half of the arc of night is the complement of this

[xiv] Therefore] As for: **B** = “As for” has been changed to “Therefore” in **K** and **L**.
[xv] will be greater] thus will be greater: B, K = “thus will be greater” has been changed to “will be greater” in **L**.

[aforementioned] arc to half of a revolution. The definition of arcs of daylight and night should be clear from the definition of their halves. This is well-known, and will be discussed later in its place—God willing.

CHAPTER FOUR
On the Characteristics of Locations Whose Latitudes Do Not Exceed the Complement of the Obliquity

[1] They are divided into four divisions, according to what you have learnt:

[2] The first is that whose latitude is less than the obliquity. In those locations the Sun will pass over the zenith at two points whose declination is equal to the local latitude in the direction of the visible pole. /At that time **objects will not have shadows at noon.** When one of the two [aforementioned] points passes over the zenith, /* [i] **the zodiacal equator will be perpendicular to the horizon and its poles will be on the horizon.** Thus, at that time [the zodiacal equator] is the altitude circle of the Sun and the planets that are on [the zodiacal equator] are above the Earth, /if the Sun and the planet are not on one of the two points./* [ii] As the latitude of the locality increases, one of the two points draws nearer to the other one, the arc between them becoming smaller. The two zodiacal poles rise and set [in these localities]. **As long as the Sun is on the arc between the two points in the direction of the visible [equinoctial] pole, the [noon] shadow will fall toward the invisible pole.** /At that time,/† [iii] **the visible one of the zodiacal orb's poles will be that which is adjacent to the invisible pole of the equinoctial, and the invisible will be that which is adjacent to the visible pole. As long as the Sun is on the other arc, that is, the one between the two points in the direction of the invisible [equinoctial] pole, the [noon] shadow will fall toward the visible pole.** /At that time,/† [iv] **the visible one of the zodiacal orb's poles will be that which is adjacent to the visible pole of the equinoctial, and the invisible will be that which is adjacent to the invisible.** For the Sun, there will be two altitude extremities as its altitude is decreasing: one which is larger, in the direction of the visible pole, and the other which is smaller, in the direction of the invisible pole. The amount of the[se] two extremities, the amount of the maximum altitude of the two zodiacal poles, and their maximum depressions should be clear after thoroughly comprehending what has preceded. **The seasons of the year in those regions [*lit.*, horizons] are not equal** because their summer is longer than other seasons, due to the Sun reaching the zenith twice. In mid[-summer] there will be a reduction in the heat because of the

[i] At that time… passes over the zenith] margins of **B** and **K**.
[ii] if the Sun and the planet are not on one of the two points] margins of **B** and **K** = + objects will not have shadows at noon: crossed out in **B**, **K**.
[iii] At that time] above the line in **B**; - **K**; margin of **L**.
[iv] At that time] above the line in **B**; - **K**; - **L**.

distance of the Sun from the zenith in accordance with the amount of the distance. However, **if** [the number of the seasons] **were increased beyond the four, they would still not be uniform,** due to the lack of order in them—/because of the difference between the two maximum distances of the Sun from the zenith in each directions—in contrast to the equator where there are two extremities in [the Sun's] being close [to the zenith] which is in contrast to [localities] whose latitude is equal to or greater than the obliquity./† [v]

[3] The second division is that whose latitude is equal to the obliquity. In those locations the Sun will pass once a year over the zenith. The [noon] shadow during the equinox in those [locations] will be /equivalent/† [vi] /to the [noon] shadow/† [vii] during the solstices at the equator, with regard to the amount [of the length]; /and [equivalent] to the [noon] shadow/† [viii] during one of the two [solstices] which is in the counter-direction of the latitude of the locality, with regard to the direction as well. **One of the zodiacal orb's poles will become permanently visible; while the second [will become] permanently invisible. In their revolution, they will touch the horizon once, this being when the solstice point that is in the direction of the visible [equinoctial] pole reaches the zenith. At that time, only the zodiacal equator will be perpendicular to the horizon.** At that moment, the zodiacal equator will be the circle of the prime vertical. The Sun will be permanently in the direction of the invisible pole, and **the shadows will be toward the visible pole throughout the year** except for one day when the Sun reaches the solstice /that is in the direction of the visible pole./‡ [ix] Thus at noon of that day, there will be no shadow /nor will the Sun be in the direction of the invisible pole but it will be overhead./* [x] The maximum altitude of the visible zodiacal pole and the maximum depression of the invisible zodiacal pole are twice the amount of the obliquity; they then decrease until they vanish. **The altitude of the Sun increases from one of the solstices to the other; it then returns, [the altitude] decreasing until [the Sun] comes back to [the original solstice]. The seasons of the year will be four—no more, no less.** These characteristics and also other characteristics are common for the northern and southern populated regions. The summer and

---

[v] because of the difference… or greater than the obliquity] margins of **B**, **K** and **L**.
[vi] equivalent] under the line in **B**; - **K**; under the line in **L**.
[vii] to the shadow] "like the shadow" has been changed to "to the shadow" in **B** = like the shadow: **K**.
[viii] and to the shadow] "and like the shadow" has been changed to "and to the shadow" in **B** = and like the shadow: **K**.
[ix] that is in the direction of the visible pole] visible: **B**; margin of **L**.
[x] nor will the Sun be in the direction of the invisible pole but it will be overhead] margins of **B** and **K**.

winter of these two regions alternate, that is, when it is summer in the north, it is winter in the south and vice versa. The other two seasons are also like this. Localities in the south whose latitude is equal to the obliquity are hotter than the ones with the same latitude in the north, due to the place of the apogee and perigee, as has been mentioned earlier. In this division, and the previous one, there is for the Sun an altitude that has no azimuth, which occurs when the Sun reaches the circle of the prime vertical above the Earth. /This will be the case for any locality wherein the Sun reaches the circle of the prime vertical above its horizon./‡ [xi]

[4] The third division is that whose latitude is greater than the obliquity and less than its complement. There the Sun will not reach the zenith; it will have a highest altitude, which is equal to the sum of the obliquity and the local colatitude, and a lowest, which is equal to the excess of the local colatitude over the obliquity. The two poles of the zodiacal [orb] neither rise nor set, and neither touch the horizon. There will be two altitudes for the visible pole: one higher [which happens] when the solstice [that is in the direction] of the invisible pole reaches [the meridian] and another lower which happens when the other solstice reaches the meridian. There will be two depressions for the invisible pole in the same manner. The shadows will be in the direction of the visible pole throughout the year and **the remaining conditions,** such as the length of the daylight or its shortness, etc. **are as we have [already] explained.** One of the astrologers believed that no prophet would emerge from any locality whose latitude is greater than 33 [degrees] since no planet would pass over their zeniths. He thought that at a latitude of 33 [degrees] some of the planets like Venus would pass above the zenith, proceeding to this conclusion from the fact that one of Venus' two latitudes is 2 degrees and a half, and the other is about 7 [degrees] and these two [amounts] together with the obliquity add up to more than 33 [degrees]; therefore Venus passes above their zenith. He forgot that Venus' two latitudes alternate; thus, they are not additive, as he thought would be correct. So it is more appropriate to say that any locality where /the excess of/† [xii] the latitude over the obliquity does not go /beyond/† [xiii] the amount of **the latitudes of the other wandering [planets], those whose latitude is greater than the excess of the local latitude over the obliquity, will pass over the zenith twice, while those whose latitude is equal to the excess [will pass over] once.** In this statement

[xi] This will be the case for any locality wherein the Sun reaches the circle of the prime vertical above its horizon] -**B**; margins of **K** and **L**.
[xii] the excess of] above the line in **B**; margin of **L**.
[xiii] beyond] has been changed from "by the amount of" in **B** and **L**.

it is necessary to assert as a condition that the [longitudinal] degree of the planet that has latitude be [equal to the longitude of] the solstice point that is in the direction of the latitude of the locality; /again, not in the first /* [xiv] [statement] as was conditioned by one of [the astrologers] /because it negates what is desired./* [xv] **In these latitudes, the equation of daylight and the ortive and occasive amplitudes increase with increasing latitude,** as with its increase the magnitude of permanently visible and invisible day-circles, and the depression of the Sun's day-circle with respect to the zenith in the direction of the invisible pole will increase, and the rising place of Cancer will move away from the rising place of the equinox. [So,] the excess of the [Cancer] daylight over the equinox daylight will increase. Thus the ortive amplitude and the equation of the daylight will increase until the greatest permanently visible day-circle becomes the day-circle of the solstice that is in the direction of the visible pole.

[5] The fourth division is that whose latitude is equal to the complement of the obliquity. The day-circle of the solstice that is in the direction of the visible pole becomes /the greatest permanently/‡ [xvi] **visible** [day-circle] **there, while the day-circle of the other solstice is** /the greatest permanently/‡ [xvii] **invisible** [day-circle]. **The day-circle of the visible pole of the zodiacal orb passes over the zenith, and the day-circle of the other pole over the nadir [*lit.,* that opposite it]. Then when the visible solstice comes to touch the horizon, it will do so at the point of the pole of the prime vertical that is in the direction of the visible pole, while the invisible solstice will touch it at the other pole; the two zodiacal poles will thereupon be at the zenith and the nadir [*lit.,* that opposite it], and the zodiacal equator will coincide with the horizon.** Then when the visible pole is northerly, the beginning of Aries will be in the east, the beginning of Libra in the west, the beginning of Cancer in the north point, and the beginning of Capricornus in the south point. The point on the equinoctial corresponding to Capricornus will be on the meridian, toward the south, above the Earth; and the point on the equinoctial corresponding to Cancer will be on [the meridian], [toward] the north, below [the Earth]. From this one can find the relative position of the two equators and the horizon when the visible pole is southerly. **Then when the pole departs from the zenith** towards the west **and the visible solstice rises from [the horizon], the eastern half of the [zodiacal] equator rises in**

[xiv] again, not in the first] margins of **B** and **K**.
[xv] because it negates what is desired] margins of **B** and **K**.
[xvi] the greatest permanently] permanently: **B** = added within the text and the margin in **K** and **L** .
[xvii] the greatest permanently] permanently: **B** = added within the text and the margin in **K** and **L**.

one stroke from the horizon and, likewise, the other half drops below it [in one stroke]. [At this time,] the zodiacal and horizon circles intersect at two points near solstices, /and near/[*][xviii] the north and south [points]. Because if one of these four were the tangency point, it could not be the crossing point, and this, though clear, is critical. **The point subsequent to the invisible solstice will then be** /close to/[*][xix] **the pole of the prime vertical, being about to set, and the point subsequent to the visible solstice will be** /close to/[*][xx] **its other pole, being about to rise. The visible half is what is between them, that is, the half that the vernal equinox is in the middle of if the visible pole is northerly, or the autumnal if it is southerly; the invisible half is the other half. Then the invisible half will rise point by point in all parts of the eastern half of the horizon.** Then Cancer, Leo, and Virgo will rise from the north-eastern quarter, and Libra, Scorpius and Sagittarius from the south-eastern quarter, if the visible pole is northerly, and one should draw an analogous conclusion from this if it is southerly. **The visible half will similarly set point by point,** that is, in all parts of the western half of the horizon. Thus, Capricornus, Aquarius, and Pisces will set in the south-western quarter, and Aries, Taurus and Gemini in the north-western quarter if the visible pole is as we mentioned, and the rule is clear when the visible is the other pole. This will be completed **during the period of a nychthemeron [*lit.*, the day with its night]** and then **the position of the orb returns to its original condition. Each of the ortive amplitude and the equation of daylight** /in its totality/[‡][xxi] **will there be a quarter revolution;** as for the first, this is because between the rising place of the visible solstice and the rising place of the equinox lies a quarter of the horizon, and the second is because half of the excess of its longest daylight, which is 24 hours, over the equinox daylight, which is 12 hours, is 6 hours which is the amount of one-quarter of a revolution, since every hour is 15 degrees. Points whose distance from the equinoctial is less than the obliquity rise and set, though other celestial points neither rise nor set. **Daylight will increase until the measure of the nychthemeron becomes entirely daylight;** this is the time when the Sun reaches the visible solstice, if the beginning of the day is considered to be the Sun's center reaching the horizon. If its beginning is considered to be the appearance of light and disappearance of the fixed stars, the daytime will be one month as justified by Theodosius in his *On Habitations* [*Masākin*]. **Night will thereafter**

[xviii] and near] margin of **K** = and: **B**.
[xix] close to] margin of **B**; above the line in **K**.
[xx] close to] margin of **B**; above the line in **K**.
[xxi] in its totality] - **B**; -**K**; margin of **L**.

occur, increasing until the measure of the nychthemeron becomes entirely night. The altitude of the Sun increases until it reaches twice the obliquity; it will then begin to decrease, decreasing until it becomes zero [whereupon] the Sun will touch the horizon. The shadows of gnomons will be circular around [the gnomons], because if the Sun while it is in the visible solstice, rises over the pole of [the circle of] the prime vertical, it starts to rise in the eastern direction until it reaches alignment with the east-west line; then it comes to be in the other direction, and reaches its maximum altitude at the time it reaches the meridian; then its altitude decreases until it touches the horizon at the pole of [the circle of] the prime vertical. Then [the Sun] makes another revolution, as we have said, until it reaches the horizon before its arrival at the pole of [the circle of] the prime vertical; then its center, not its whole body, sets. Then it makes another revolution or two, until its whole body sets, and the night occurs. It is clear that the shadow at the rising time is towards the invisible pole, then to the west, then towards the visible pole, and thus always in the opposite direction of the Sun. The arc of the night then increases gradually until [the Sun] reaches the equinox point; thus the night will be equal to the daylight and then the nighttime will increase. This will be the opposite when the Sun reaches the invisible solstice because /[the Sun's] center, or rather the day-circle of [the Sun's center,]/* [xxii] in the first revolution touches the horizon below the Earth; in the second [revolution, the Sun] reaches the horizon before its arrival at the pole of [the circle of] the prime vertical; thus its center, not its whole body, rises; in the third or fourth revolution its whole body appears, and sets quickly, and then rises little by little, and the arc of the daylight increases gradually until [the Sun] reaches the equinox point; thus the night equals daylight. Then the daylight increases as we have said. Here, also **the rising of a half revolution of the zodiacal** orb **occurs with a revolution of the equinoctial; the rising of the other half of the zodiacal equator does not [require] time.** This locality is the end of the inhabited region in the north and inhabitation beyond it is impossible due to the severe cold, as has been mentioned earlier.

[xxii] [the Sun's] center, or rather the day-circle of [the Sun's center]] margins of **B** and **K**.

CHAPTER FIVE
On the Characteristics of Locations Whose Latitude Exceeds the Complement of the Obliquity But Does Not Reach One-Quarter Revolution

[1] In these locations, /the day-circle of/[*] [i] the zodiacal pole is inclined away from the zenith /toward the direction of the invisible pole/[*] [ii] in the amount of the excess of the latitude over the complement of obliquity. Therefore those parts [of the zodiacal orb] whose declination is more than the colatitude /or equal to it/[*] [iii] will neither rise nor set. The permanently visible [day-]circle will be greater than the day-circles of the two solstices. Thus, **the largest permanently visible [day-circle] will** inevitably **intersect the zodiacal equator at two points whose declinations in the direction of the visible pole are equal. The largest permanently invisible day-circle will intersect it at two points opposite these two in the direction of the invisible pole.** /The declination of /all of/[†] [iv] the four [points] is equal to the local colatitude./[*] [v] **The zodiacal equator is divided into four arcs: one of them is permanently visible at the middle of which is the solstice that is in the direction of the visible pole,** and, therefore, the length of one of their summer days will be equal to the time during which the Sun has been along that arc; **the second is permanently invisible at the middle of which is the other solstice,** and, therefore, the length of one of their winter nights will be equal to the time during which the Sun has been along that arc. **The endpoints of the first arc** in each revolution by the motion of the Universe **touch the horizon** at the pole of [the circle of] the prime vertical that is in the direction of the visible pole **but do not disappear; and the endpoints of the second arc touch it** at the other pole **but do not rise. As for the two remaining arcs, the one at the middle of which is the first of Aries rises in reverse order,** that is, its end rises before its beginning, **and sets in regular order,** that is, its beginning sets before its end, **if the visible pole is northerly; and if the visible pole is southerly it rises in regular order,** that is, its beginning rises before its end, **and sets in reverse order,** that is, its end sets before its beginning. **The arc at the middle of which is the first of Libra is the opposite of this:** what rises in reverse order sets in regular order, and vice versa. Since the setting [part] is diametrically opposite to the rising [part],

---

[i] the day-circle of] margins of **B** and **K**.
[ii] toward the direction of the invisible pole] margins of **B** and **K**.
[iii] or equal to it] margins of **B** and **K**.
[iv] all of] margins of **B**, **K** and **L**.
[v] The declination of the four is equal to the local colatitude] margins of **B** and **K**.

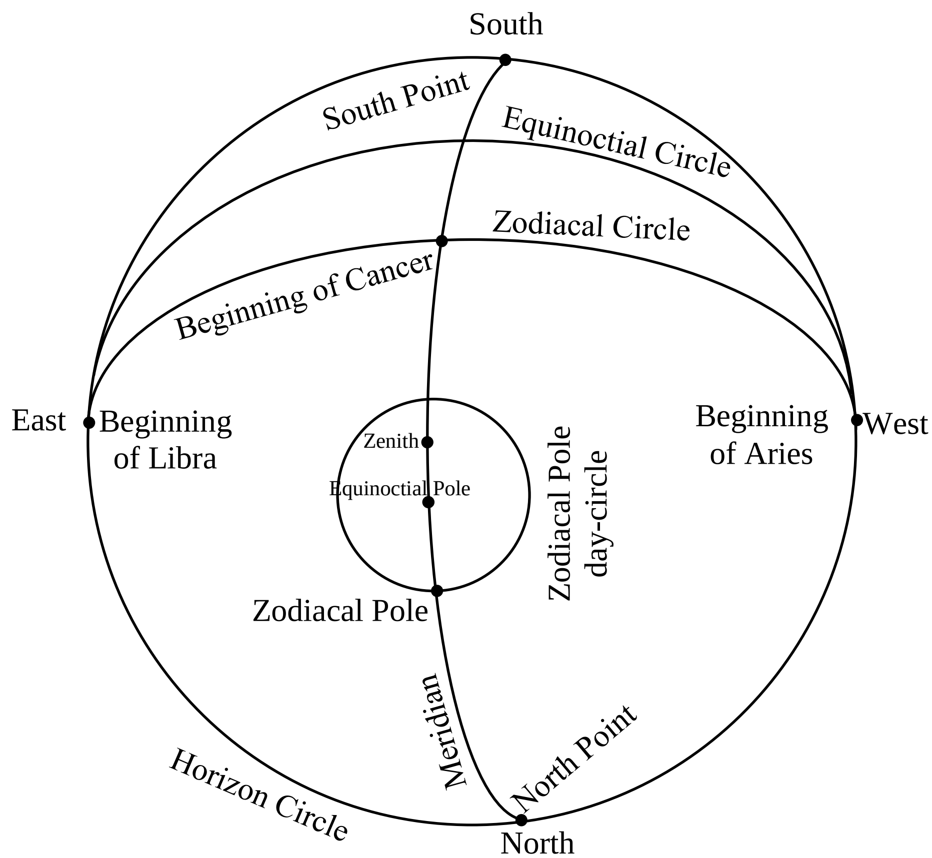
whatever rises in reverse order, like for example the end of Virgo,[§ vi] its diametrically opposite [part], like [in this example] the end of Pisces,[§ vii] sets in reverse order, and vice versa. Therefore, rising in one of the two [zodiacal] segments will be the same as setting in the second one, in being or not being in regular order, but will be the opposite of rising in the second one, in being in regular order. Hence, it follows that the rising of each segment will be the opposite of its setting, and what rises in reverse order sets in regular order, and vice versa. **The visible solstice has** two altitudes: one of them is the **highest [altitude], which is equal to the sum of the obliquity and the local colatitude along the meridian circle in the direction of the invisible pole;** the other is the **lowest [altitude], which is equal to the excess of the local latitude over the complement of the obliquity along the meridian circle in the direction of the visible pole. The** [visible] **pole of the zodiacal orb also has two altitudes: a highest [altitude], which is equal to the sum of the local colatitude and the complement of the obliquity,** and this is in the direction of the invisible pole; **and a lowest [altitude], which is equal to the excess of the local latitude over the obliquity,** and this is in the direction of the visible pole. [At these altitudes,] **the pole will be simultaneously with the solstice on the meridian, but [they are] in opposite directions from the zenith and their altitudes are at opposite [extremes]. One may draw analogous conclusions from this for the situation of the invisible solstice and the invisible pole.** In these horizons, dawn and dusk linger due to what is going to appear in the course of their description—God the Almighty willing—and the shadow will cast in all directions, although for a longer period in the direction of the invisible pole.

[2] In order to conceive positions in these latitudes, we shall take an example. Let the latitude in the north be 70: the arc that is permanently visible will be Gemini and Cancer, and the arc that is permanently invisible will be Sagittarius and Capricornus; the arc that rises in reverse order and sets in regular order is from the first of Aquarius to the end of Taurus, and that which rises in regular order and sets in reverse order is from the first of Leo to the end of Scorpius. Then when the first of Cancer is at the meridian on the southern side, its altitude being at its maximum [value], namely (43 + 1/3 + ¼), the visible pole of the zodiacal orb is on the northern side on the meridian as well and its altitude is at its minimum [value], which is (46 + ¼ + 1/6). At the rising place of the equinox is the first of

---

[vi] Virgo] has been changed to “Pisces” within the text in **K**, **L** and **R**.
[vii] Pisces] has been changed to “Virgo” within the text in **K**, **L** and **R**.

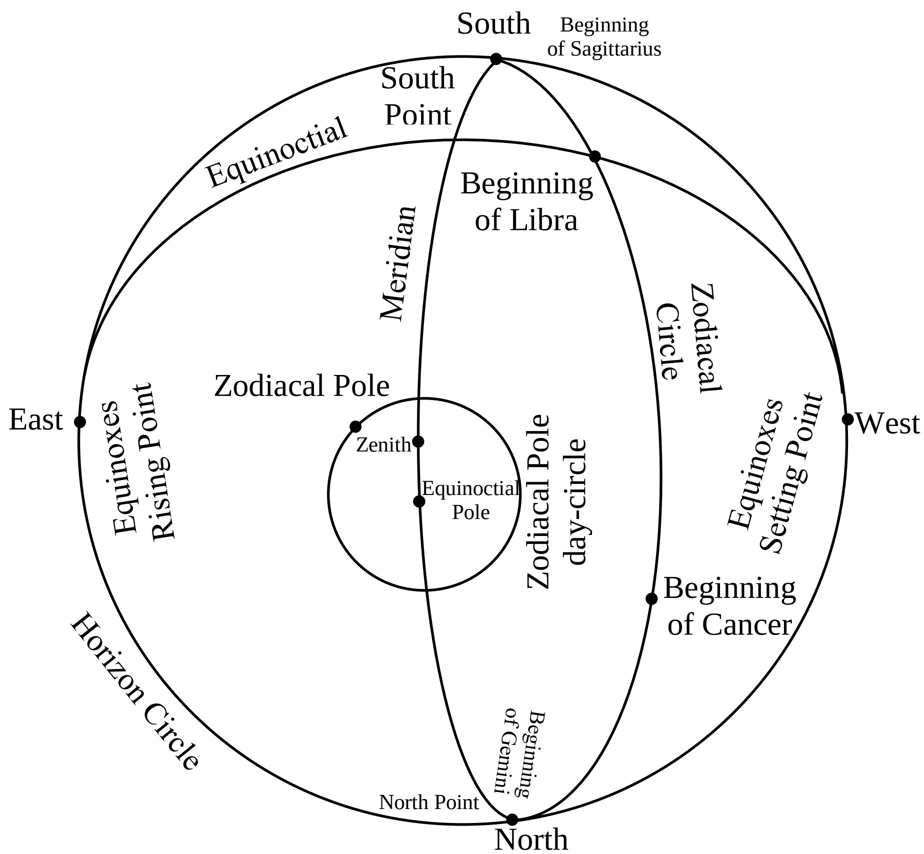
Libra, which is on the verge of rising, and at its setting place is the first of Aries, which is on the verge of setting. The visible half of the zodiacal orb [extends] from west to east in the south, and **this** is its **illustration:**



[Figure 3]

[3] Then let the orb move with the first motion so that the first of Cancer will begin its depression toward the west and the pole of the zodiacal orb its ascent toward the east; the vernal equinox sets and the autumnal rises, and so do the two [zodiacal] arcs connected to them. The distance of the rising place of each part and the setting place of its diametrically opposite part from the rising and setting place of the equinox increases, until the shift ends at the two parts, one of which touches the horizon but does not set and the other touches it but does not rise. Hence, **Libra and Scorpius** have risen **in regular order, and their ortive amplitude** spans **the southeastern quarter [of the horizon]. Aries and Taurus** have set **likewise in regular order, and their occasive amplitude** spans **the northwestern quarter [of the horizon]. The first of Sagittarius** touches **the horizon at the south point and the first of Gemini** touches it **at the**

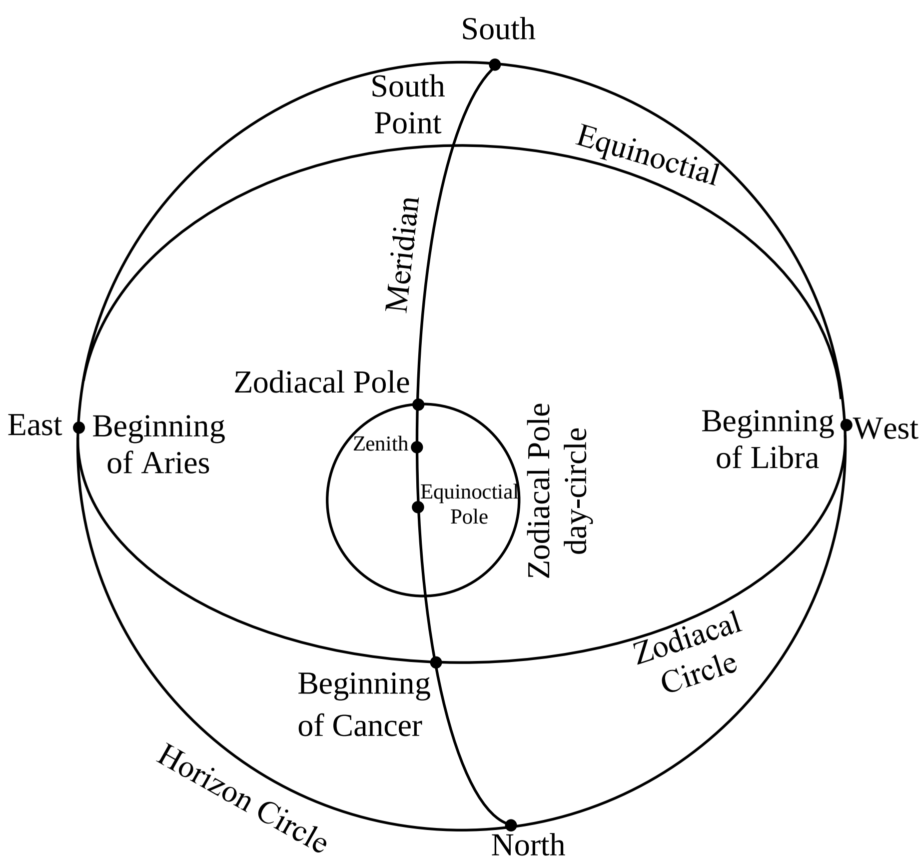
north point. The visible pole of the zodiacal orb is in the eastern direction between its highest and lowest altitude on the circle of the prime vertical, and the diametrically opposite pole [*i.e.*, the invisible pole] is in the opposite position. **The visible half of the zodiacal equator comes to be on the western side [extending] from south to north** and the invisible [half] is in opposition to [the visible half]; hence the zodiacal [equator] and the horizon intersect at the north and south points, and **this** is its **illustration:**



[Figure 4]

[4] Then let the orb move so that the first of Gemini begins its rise toward the east, and the end of Taurus, which is contiguous with it, rises little by little such that the rising place of each part becomes closer to the rising place of the equinox than to the rising place of the part that precedes it in rising, **until Taurus has risen. Then Aries rises from its end to its first. The ortive amplitude of these two signs spans the northeastern quarter [of the horizon], and the first of Aries reaches its rising place. Directly opposite this, the first of Sagittarius begins its depression below the horizon, and the end of Scorpius, which is contiguous with**

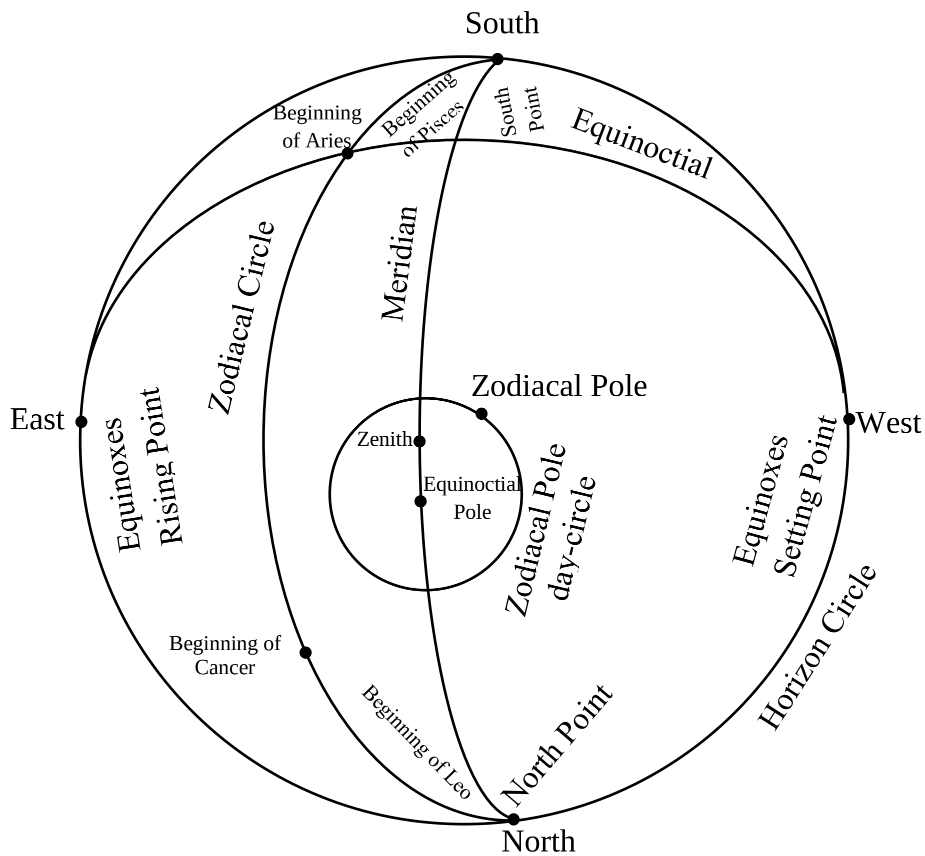
it, sets little by little until Scorpius has disappeared; then Libra sets from its end to its first. Their occasive amplitude spans the southwestern quarter [of the horizon], and the first of Libra reaches its setting place. Thus, the shift in rising and setting in reverse order has reached the two equinoxes, and **the first of Cancer** has reached **the meridian circle on the northern side** while **it is at its lowest altitude, which is (3 + 1/3 + ¼) degrees,** and **the pole of the zodiacal orb** is at **its highest altitude [on the meridian] on the southern side, and this is (86 + ¼ + 1/6) degrees. The visible half of the zodiacal orb is on the northern side between the rising and setting places of the equinox, the directional sequence [of the signs here being] opposite the conventional one,** and the invisible half is in the opposite direction. The intersection of the zodiacal [orb] and the horizon is at the east and west points, **as in this illustration:**



[Figure 5]

[5] Then let the orb move so that Pisces rises from its end to its first, then Aquarius from its end to its first. Their ortive amplitude spans the southeastern quarter [of the

horizon]. Directly opposite them, Virgo disappears from its end to its first, then Leo from its end to its first. Their occasive amplitude spans the northwestern quarter [of the horizon]. The first of Aquarius comes to touch the horizon at the south point, and the first of Leo comes to touch the horizon at the north point; the visible half of the zodiacal circle is in between them in the eastern direction. The first of Cancer has risen higher on the eastern side, and the pole has begun its depression on the western side, and has reached the circle of the prime vertical in the direction of the west, **as in this illustration:**



[Figure 6]

[6a] Then let the orb move and let **the first of Leo** rise **from the horizon, moving toward the eastern half: the points of Leo will then rise sequentially until its end, then the points of Virgo** in the same way**. Their ortive amplitude spans the northeastern quarter [of the horizon]. Directly opposite this, the first of Aquarius will drop below the horizon to beneath the Earth. Then Aquarius will set followed by Pisces sequentially. Their occasive amplitude spans the southwestern quarter [of the horizon]. The [action of] rising will have**

reached the first of Libra and that of setting the first of Aries, because the rising and setting place of the [zodiacal] parts becomes closer to the rising and setting place of the equinox. **At that time the first of Cancer will have come to be at the meridian circle at its highest altitude, and the visible pole of the zodiacal orb will be at its lowest altitude on the meridian. The visible half of the zodiacal orb comes to be on the southern side, and the situation returns to what we assumed originally. So the revolution is completed and what we have [earlier] described should become clear.**

[6b] The general rule is that we look at eastern zodiacal signs beneath the horizon; if their end parts are closer to the horizon than their first parts, their rise will be in reverse order; if their first parts are closer to the horizon than their end parts, they will rise in regular order. We look at western zodiacal signs above the Earth; if their end parts are closer to the horizon than their first parts, they will set in reverse order; if their first parts are closer to it, they will set in regular order, based on what has been explained in the examples. Or we say: if the visible pole is northerly, whatever is connected to the permanently visible part next to the vernal equinox rises in reverse order and whatever is connected to the permanently invisible [part] next to the autumnal equinox sets in reverse order; otherwise this would be the opposite. It should be clear that when the Sun reaches the two equinoxes, the daylight and nighttime will be equal; when it passes from Aries in northern localities and from Libra in southern [localities], the daylight increases and the nighttime decreases, until the night is effaced, and it all becomes day. It remains like this when the Sun is along the permanently visible arc; then the nighttime starts and increases until [the Sun] reaches the other equinox, so they become equal again. Then the night exceeds the daylight until the day is effaced and it all becomes night. It stays the same during the time when the Sun is along the permanently invisible arc; then the daylight begins and increases until the two [day and night] become equal.

[7] In these regions [*lit.*, horizons] when the local latitude approaches the extreme and the altitude of the equinoctial from the horizon is small, then a planet whose day-circle is getting extremely close to **the horizon** may shift **to another day-circle by [means of] its secondary motion; thus it might disappear while in the eastern half after having been visible, or it might become visible while in the western half after having been invisible. So it**

would then have set in the east or risen in the west. And this too is one of the things asked about that is found to be strange.

CHAPTER SIX
On the Characteristics of Locations Whose Latitude Is Exactly One-Quarter Revolution

[1] This does not occur on the Earth except at two points at which one of the poles of the equinoctial is there at the zenith. The equinoctial circle becomes coincident with the horizon, and the orb turns with the first motion with **a spinning** rotation**; there is no longer on the horizon** a distinguishable **east or west,** but there may be rising or setting in any direction. Similarly, there is no meridian, but the Sun and other planets may reach their maximum altitude in any direction. The maximum altitude of the Sun is equal to the obliquity, as is its maximum descent. The shadows of the gnomons form approximately parallel complete circles, one within the other, about one center, which is the base of the gnomon; the smallest is when the Sun is in the solstice that is in the direction of the visible pole, and the greatest being when [the Sun] gets closer to the horizon when it is in the vicinity of one of the two equinoxes. **The half of the orb that is in the direction of the visible pole from the equinoctial is permanently visible, and the other half is permanently invisible.**

[2] As long as the Sun is in the visible half of the zodiacal orb, it will be daytime; and as long as it is in the invisible half of it, it will be night. Thus, [at these locations,] the **entire year will be a** day and a night, **with one [*i.e.*, daytime or night] exceeding the other due to the variability in speed [lit., the slowness and fastness] of the [Sun's] motion. Beneath the northern pole at the present time, their daytime is greater than their night by seven of our nychthemerons. This is because the apogee of the Sun is at the end part of Gemini and its perigee is at the end part of Sagittarius.** This is [the case] if the beginning of the day is considered to be the time when the center of the Sun reaches the horizon, but if it is considered to be the appearance of the light and the disappearance of the stars, /and its end [is considered to] be the disappearance of the light and the appearance of the stars,/* [i] their daylight would be longer than seven months /by the seven [nychthemerons]/‡ [ii] and their night around five months, based on what Theodosius has verified in his *On Habitations*. /If you say that/* [iii] since **the period for the setting of dusk or the rising of dawn occurs for them in 50 of our days as will be explained when describing these two [terms] later on**—May God the Almighty be

[i] and its end be the disappearance of the light and appearance of the stars] margins of **B** and **K**.
[ii] by the seven nychthemerons] - **B**; - **K**; margin of **L**.
[iii] If you say that] above the line in **B**; margin of **K**.

willing—*[iv] it becomes necessary that the difference between [the daylight and nighttime] be more than what [Theodosius] has verified because, based on this [length of dusk and dawn, the daylight] will be seven§ [v] months and forty§ [vi] of our days. I say: this would be necessary if the disappearance of the stars were to occur with the rising of dawn but this is not so and it is [in fact] later, there being a period of around twenty days§ [vii] between them. /Likewise for the appearance of the stars that precede the setting of dusk by the same amount./* [viii] None of the orb's parts rises nor sets due to the prime motion, and **neither the rising nor the setting of the Sun and planets that is due to the secondary motion will occur at** a fixed **place on the horizon.** Any star with no latitude will stay 12,000 years above the Earth, and the same amount of time below it.

[3] Stars whose latitude is less than the obliquity will have a rising and a setting; the periods of visibility and invisibility will vary depending on how far or how near their latitudinal circuits **are from the zodiacal orb. [Stars] whose latitude is equal to the obliquity will touch the horizon once during one revolution of the second motion; neither they nor those [stars] whose latitude exceeds the obliquity will have a rising or a setting, but instead they will be either permanently visible or invisible. Let it be recalled what we said regarding the positions of the orb due to the first two motions, and let [the situation] be determined here on that basis.**

[4] This is the last of the characteristics **of the localities** aligned with **the day-circles and what is comparable to them**—God knows what is correct.

[iv] May God the Almighty be willing] + if you say that: crossed out in **B** and **K**.
[v] seven] has been changed into "nine" in **K**, **L** and **R**.
[vi] forty] has been changed into "seventeen" in **K**, **L** and **R**.
[vii] twenty days] has been changed into "one month and eight days" in **K** and **R** = has been changed to "thirty five" in **L** = + days if between disappearance and rising of the Sun is fifteen days based as well on what he has verified: margin of **L**.
[viii] Likewise for the appearance of the stars that precede the setting of dusk by the same amount] margins of **B** and **K**.

CHAPTER SEVEN
On the Co-ascensions of the Zodiacal Signs

[1] The co-ascension is the parts of the equinoctial that rise with a given part of the zodiacal orb, and this is called the equal degrees. The co-ascension at the equator is most certainly bounded between two declination circles because its horizon is also a declination circle. That is to say, what is on the equinoctial between two declination circles is the co-ascension of what is between them on the zodiacal orb, and is called the co-ascension of the right orb, or co-ascension of the erect sphere or co-ascension of the equator. In oblique horizons, [the co-ascension is] / bounded between the two circles extending from the pole of [the circle of] the prime vertical, passing through the two endpoints of that arc along the zodiacal [equator],/† [i] /not/† [ii] between the circles of the horizon and declination /such that/‡ [iii] what is between them on the equinoctial will be the co-ascension of the arc on the zodiacal [equator] whose initial point is on the declination circle and whose termination is on the horizon, /according to what is found in some works, for this is not correct. The secret behind this is that the co-ascension and the equal degrees will not be bounded and their occurrence will not be conceived properly, except if a circle is assumed that intersects with the horizon at the two poles of the prime vertical and, if it is assumed to be below the horizon, it passes through the end of that arc along the zodiacal [equator]; if it is assumed to be above the horizon, [it passes] through the beginning [of the arc along the zodiacal equator], such that when this circle moves by the daily motion, the terminations of the co-ascension and the equal degrees arcs reach the horizon in one stroke. Therefore, what is between [the two circles] along the equinoctial is the co-ascension of what is between them along the zodiacal [equator]. It is impossible for what is between the horizon and declination [circles] along the equinoctial at oblique horizons to be the co-ascension of what is between them on the zodiacal [equator], except when the declination circle is the meridian [circle], then what is between them [along the equinoctial] will be the co-ascension of what is between them [along the zodiacal equator], based on the aforementioned secret, that is, the intersection of [the meridian] with the horizon is at the two poles of the prime vertical, so be aware of this./† [iv] [This co-ascension] is called the co-ascension of the oblique horizons or the co-

[i] bounded between the two circles… that arc along the zodiacal] margins of **B**, **K** and **L**.
[ii] not] above the line in **B**; added later in **K** and **L**.
[iii] such that] I mean: **B**, **K** = "I mean" has been changed to "so that" in **L**.
[iv] according to what is found in some works… so be aware of this] margins of **B**, **K** and **L**.

ascension of the oblique orbs, since oblique horizons are [also] called oblique orbs, like the right orbs which are called right horizons.

[2a] Since the demarcation of the zodiacal orb is not based on the poles of the equinoctial, and the [zodiacal orb's] rotation is from east to west around the [equinoctial] poles, it is impossible that all the equal parts of the zodiacal orb in both right and oblique orbs pass in equal periods of time; rather, [they pass in] different [periods]. That is why the co-ascensions of some zodiacal signs differ from those of other signs. Furthermore, co-ascensions, in addition to being unequal in themselves, change by the change of horizons due to the difference in the intersection of horizons with the triangle mentioned in what preceded. The initial point of the co-ascensions is taken from the vernal equinox; some took the initial point from the winter solstice for a purpose arising from practical [calculations]. If this is established, we say that **at the [Earth's] equator, each quarter that is bounded by two of the four points,** [*i.e.*,] the two equinoxes and the two solstices, **will rise with a quarter because when the equinox point, which is simultaneously one of the two boundaries for two quarters for [each of] the two equators, reaches the zenith, the solstitial colure will coincide with the horizon; thus the two other boundaries of the two quarters,** which are the summer solstice point and its corresponding point on the equinoctial, **will both be on the horizon;** and the two equators will cross the horizon at right angles. **One should draw analogous conclusions from this for the remaining quarters. But 30 time units, *i.e.*, (1/2 of 1/6) of the equinoctial, will not rise with a zodiacal sign that adjoins one of the four [cardinal] points, which is (1/2 of 1/6) of the zodiacal equator. This is so because, if the zodiacal sign is one that adjoins the equinox point, then one of the boundaries, namely this point, is common to both [the sign and its co-ascension]. When the zodiacal sign's other boundary reaches the horizon, there occurs a triangle [formed] from the sign, the arc that rises with it along the equinoctial, *i.e.*, the co-ascension, and what is between them along the horizon; its angle that is bounded by the equinoctial and the horizon is right, and the remaining two are acute. Since the sign is the subtense of a right [angle], and its co-ascension is the subtense of an acute angle, the sign is larger than its co-ascension,** based on what was explained by Menelaus in his *Sphaerica* [*Kuriyyātihi*]. **The same will hold for two signs that adjoin the equinox point and their co-ascensions.** From this it is possible to construct a proof to deny [the existence of] the [indivisible minimal] part (*i.e.* the

atom) by saying that if /the [indivisible minimal] part were real, then/† [v] the equinoctial /and similarly the zodiacal equator/†[vi] would be composed of indivisible [minimal] parts. /Based on this,/† [vii] when, except for one of the above-mentioned [indivisible minimal] parts, a quarter of the equinoctial rises, the beginning of which is the vernal equinox, then what rises with it from the zodiacal [equator] will be more than that, because the equal degrees are more than the co-ascension, and less than a quarter, because the quarter rises with the quarter. Therefore, it follows that the [indivisible minimal] part next to the first of Cancer will be divided, while its indivisibility† [viii] was assumed, and this is a contradiction. This is a point which, although it does not fit into our discussion with respect to form, it suits it with respect to the matter. Because of this, and also because of its peculiarity, I mentioned it here.

[2b] Now, if the zodiacal sign is one that adjoins the solstitial point, its co-ascension will be larger than [30 degrees]. This is because what remains from a full quarter, [after taking] the co-ascension of the [above] two signs, which is less than 1/6 of a revolution, will be greater than (1/2 of 1/6) of a revolution, and [this remainder] will rise with the remaining sign. The increase of this will be like the decrease of that. Then, with equal arcs of the zodiacal [equator], unequal arcs of the equinoctial will rise in the same way as in the first quarter, except that co-ascensions of the parts of Cancer sequentially are like co-ascensions of the parts of Gemini counter-sequentially, until the next quarter rises and the autumnal equinox reaches the horizon. One should draw analogous conclusions from this for the two other quarters. **It is apparent from** what we have mentioned about the excess and deficiency of the co-ascension and the equality of these amounts of excess and deficiency **that for any two equal arcs that are equidistant from one of the four [cardinal] points, their co-ascensions at the equator will be equal.** Or, in other words, the equality of co-ascensions [of zodiacal arcs] that are equidistant from the two equinoxes is due to the equality of the four triangles occurring on both sides [of the two equinoxes] because in any two right triangles with two equal non-right angles and with two hypotenuses that are also equal, the other two sides and the remaining angle will be correspondingly equal, as explained by Menelaus in *Sphaerica* [*al-Ashkāl al-kuriyya*]. Now, [for equidistance from] the two solstices, this is because if one subtracts from two equal

---

[v] the [indivisible minimal] part were real, then] margins of **B**, **K** and **L**.
[vi] and similarly the zodiacal equator] margins of **B** and **K**; added later in **L**.
[vii] Based on this] margin of **B**; above the line in **L**.
[viii] its indivisibility] + also: **B**; crossed out in **K** and **L**.

[amounts]—which are [in this case] two quarters from the equinoctial—two [other] equal amounts—which are [in this case] co-ascensions of two arcs that adjoin the two equinoxes along one side of the equinoctial—two equal [amounts] will remain, which are co ascensions of the two arcs on the two sides of the two solstices. **The zodiacal equator may be divided into four segments whose initial [points] are at the midparts of the quarters [of the zodiacal orb]. Each segment at the midpart of which falls one of the equinoxes will be greater than its co-ascension; each segment at the midpart of which falls one of the solstices is smaller than its co-ascension.** The maximum difference between the rising [time] of the quarters is 10 degrees, because it is known inductively that the maximum difference in each one-eighth [of the zodiacal equator] is 2 ½ degrees. This is because 45 degrees of the zodiacal orb, beginning from the equinox point, rise with 42 ½ degrees of the equinoctial, that is, 3 hours minus 1/6 [of an hour]. Also, 45 degrees [of the zodiacal orb] ending at the solstice, rise with 47 ½ [equinoctial] degrees, that is, 3 1/6 hours. Thus, a complete quarter will have risen with a complete quarter, that is, 6 hours [which fit] in a quarter of a nychthemeron. This [aforementioned] order will be the opposite for the other quarter whose initial point is the solstice. This is because the first one-eighth, which is 45 degrees of the zodiacal equator, rises with 47 ½ [equinoctial] degrees. The other one-eighth, whose termination is the other equinox, rises with 42 ½ [equinoctial] degrees. One should draw analogous conclusion from this for the state of the two other quarters. Therefore, each quarter at the midpart of which falls one of the equinoxes will rise with 85 degrees of the equinoctial and each quarter at the midpart of which falls one of the solstices will rise with 95 degrees. Thus, the difference between them is 10 degrees, as we said.

[3] The passage of the equinoctial and the zodiacal equator across the meridian circles in all localities is as their rising for the equator since each one of [these meridian circles] is one of the horizons for the equator, due to their passage through the two poles of the universe; **the same statement holds for all the declination circles. The co-descensions are as the co-ascensions for these horizons.** This is because [in those horizons,] the co-ascension of every zodiacal sign is like the co-ascension of the diametrically opposite sign, according to what has been explained [earlier]. And in all horizons, the co-ascension of the diametrically opposite sign is like the co-descension of the [given] sign, because the rising of any part of the zodiacal orb in the east happens with the setting of the diametrically opposite part in the west. Thus, [in those horizons,] the co-descension of every zodiacal sign is like its co-ascension. It is now clear, after understanding what we mentioned, that if the co-ascension of a quarter is known [for those horizons], the co-ascensions of other quarters will also be known. In other words, if the co-ascension of Aries, for example, is known, the co-ascension of Pisces will be known due to the equality of their distance from the first of Aries; and the co-ascension of Virgo [will also be known] due to the equality of their [*i.e.*, Aries and Virgo] distances from the first of Cancer. The co-ascension of Libra [will also be known], either through the co-ascension of Aries, because it is diametrically opposite, or through the co-ascension of Virgo, due to the equality of their distances from the first of Libra. From the co-ascension of Taurus, the co-ascensions of four§ [ix] other [signs] will be known, and from the co-ascension of Gemini, the co-ascensions of the remaining four§ [x] [signs will be known].

[4] As for the oblique horizons, a half will rise with a half when they are bounded by the two equinox points, and **a quarter will not rise with a quarter since the plane of the equinoctial is not perpendicular to the plane of the horizon** in order to render this necessary, as is the case at the equator. But, **when** a quarter **adjoining the equinox point that is away from the equinoctial in the direction of the visible pole rises, it will be larger than its co-ascension because in the above-mentioned triangle, [the zodiacal arc] will be the subtense of an obtuse [angle] and its co-ascension will be the subtense of an acute [angle]. And if it is away from the equinoctial in the direction of the invisible pole, then its co-ascension is greater than [the** quarter**] because the statement becomes the opposite of what it was [before]**. The maximum difference in each quarter is equal to the equation of daylight of solstices, which is called the total equation of daylight. So, each quarter, beginning from the vernal equinox, rises with an arc from the equinoctial that is less than one-quarter [of the equinoctial] by the amount of the equation of daylight. The other quarter that ends at the other equinox rises with an arc from the equinoctial that is greater than one-quarter [of the equinoctial] by the aforementioned amount. Therefore,§ [xi] the half at the midpart of which falls the vernal equinox will be less than§ [xii] the other half by four times the equation of daylight. Considering this, the zodiacal orb **may be divided into two segments: one of them is bisected by that equinox which is such that a star, when crossing it, comes to be in the direction of the**

[ix] four] has been changed to "three" in **R**.
[x] four] has been changed to "three" in **R**.
[xi] Therefore] + the co-ascension of: **R**; margins of **K** and **L**.
[xii] than] + the co-ascension of: margins of **K**, **L** and **R**.

visible pole; the other is that bisected by the other equinox. The first is larger than its co-ascension, while the other is smaller, according to what we have mentioned. This is the rule for the halves bounded by the solstices. Now, the rule for the halves bounded by the equinoxes is the same, except that for one half it is in the sequence [of the zodiacal signs], and for the other in counter-sequence. That is why equal arcs that are equidistant from one of the equinoxes have equal co-ascensions, whether [they are] greater than their co-ascensions in the right [orb] or less than them, as you have learnt. However it is different for the solstices: for the segment that adjoins Aries, its co-ascension in the oblique orb is less than its co-ascension in the right orb, and vice versa for the segment that adjoins Libra. The increase of this one is like the decrease of that. That is why for any two zodiacal signs that are equidistant from the two sides of one of the solstices, like Aries and Virgo, if their co-ascensions at a [given] locality are summed up, [the sum] will be equal to the [sum of] their co-ascensions at the equator. From this, it follows that the co-ascensions of any two diametrically opposite zodiacal signs like Aries and Libra, are likewise, because for any two signs that are equidistant from one of the solstices, the distance of the sign that diametrically faces one of them from one of the equinoxes is like the distance of the other sign from it; [hence] their co-ascensions are equal. It then follows that [the sum of] the co-ascensions of Aries and Libra in the oblique orb are equal to [the sum of] their co-ascensions in the right orb, which are equal there. Therefore, [the sum of] the co-ascensions of two diametrically opposite [signs] in the oblique [orb] is twice [the sum of] the co-ascensions of one of them in the right orb, and it will be so for the co-ascensions of signs that are equidistant from one of the solstices, according to what we have mentioned. It also follows that [the sum of] the co-ascension of, let's say, Aries and its co-descension in the oblique [horizon] is twice its co-ascension in the right [orb], because the co-descension of Aries is like the co-ascension of the diametrically opposite sign, according to what you have learnt, namely that in all horizons the co-ascension of any zodiacal sign is like the co-descension of the diametrically opposite sign and vice versa. Since, in the oblique horizons, the co-ascension of any zodiacal sign differs from the co-ascension of the diametrically opposite sign which is equal to the co-descension of that [given] sign, [in those horizons,] the co-ascension of any zodiacal sign differs from its co-descension. The co-ascension /of any zodiacal sign/† [xiii] in the southern horizons is like the co-

[xiii] of any zodiacal sign] margins of **B**, **K** and **L**.

descension /of that zodiacal sign/† [xiv] in the northern ones, /and vice versa/† [xv] when the latitudes of the two horizons are equal. Thus, **the co-ascensions of northern arcs for northern horizons are equal to the co-ascensions of the corresponding [equivalent arcs] opposite to them in the south for the [equivalent] southern horizons.** /It will be the same in the southern/† [xvi] [horizons] on the aforementioned condition. After thoroughly comprehending what we have mentioned, it should be clear that if we know the co-ascension of one-quarter of the zodiacal [equator], the co-ascensions of the rest can be obtained; because if we know the co-ascension of Aries for a [given] locality, we will know the co-ascension of Pisces for [that locality] since they are equivalent [to each other]; and if we subtract the co-ascension of Aries from the sum of its co-ascension and the co-ascension of Virgo in the right orb, the remaining is the co-ascension of Virgo for that locality, which is equal to the co-ascension of Libra for [that locality]. Using the same strategy, from the co-ascension of Taurus, the co-ascension of Aquarius, Leo and Scorpius can be obtained, and from the co-ascension of Gemini, the co-ascension of Capricornus, Cancer and Sagittarius.

[5] As for those horizons in which the day-circles of the two solstice points are the largest of the permanently visible and invisible day-circles, it has been mentioned **that a half of the zodiacal orb rises with the entire equinoctial and the other half** appears **without [requiring] time; in setting, the two halves exchange [properties].**

[6a] As for the horizons in which there are arcs of the zodiacal orb that are permanently visible and invisible, the equinoctial will be divided into two divisions: one rises with zodiacal signs that rise in reverse order and the other with the ones that rise in regular order. Those arcs that neither rise nor set will have neither co-ascension nor co-descension at all. **Let the example be the one in the northern region we have [previously] used, namely the region whose latitude is 70 where Gemini and Cancer are permanently visible, and Sagittarius and Capricornus are permanently invisible. When the vernal equinox point rises, Pisces will rise after it in reverse order from end to first; then Aquarius in reverse order from end to first; then will begin the rising of Leo from its first in regular order, then Virgo, then Libra, then Scorpius, likewise [in regular order]. Now when the first of Sagittarius is**

[xiv] of that zodiacal sign] margins of **B** and **K**; above the line in **L**.
[xv] and vice versa] under the line in **B**, **K**; margin of **L**.
[xvi] It will be the same in the southern] margins of **B**, **K** and **L**.

reached, the end of Taurus will begin to rise reversed, and Taurus and Aries will rise in reverse order. Thereupon, the vernal equinox point will return to the horizon. One should draw analogous conclusions from this for the remaining horizons, and from rising for setting. At latitude 90, there is neither co-ascension nor co-descension for zodiacal signs /for they neither rise nor set./† [xvii]

[6b] Now, if you have learnt what you should have learnt, you should know that the equation of the co-ascension is what is added to or subtracted from the co-ascension of the right horizon so that the co-ascension of a given locality is obtained; and this is the equation of the daytime as you have learnt. The co-descension of an arc is like its co-ascension for [that horizon]. [Also,] the equation of [the co-descension] is equal to the equation of the co-ascension, except that if it is added to the co-ascension of the right horizon, it will be subtracted from its co-descension, and if it is subtracted from its co-ascension, it will be added to its co-descension. The co-ascension of the azimuth is an arc along the equinoctial that falls between the horizon and the altitude circle passing through some assumed part. The [arc of] the revolution of daylight [*al-dāʾir*] is the segment of the arc of daylight between the Sun's altitude circle and the eastern part of the horizon circle. What is [along the arc of daylight] between [the altitude circle] and the meridian circle is the excess of the revolution of daylight. One may say that [the revolution of the daylight] is an arc from the Sun's day-circle that falls between the Sun's part [on the zodiacal equator] and the eastern horizon during the day; it is [also] what falls between the directly opposite part and the eastern horizon during the night along the day-circle of the directly opposite part. The amount of each of the two [*i.e.*, the revolution of daylight and the excess of the revolution of daylight] is equal to the corresponding arc from the equinoctial. The ascendant is the part of the zodiacal orb appearing on the eastern horizon. The descendant is the directly opposite part on the western horizon. The part that is on the meridian above the Earth is the tenth [upper culmination/ *Medium Coeli*] and is called the mid-heaven part. The part that is on the meridian below the Earth is the fourth [part] and is called *Imum Coeli* [*watad al-arḍ, lit.* pivot/peg/stake of the Earth]. These four points are called the quadruple cardines [cardinal points/ *quatuor coeli cardines*]—and God knows best.

[xvii] as they neither rise nor set] margins of **B**, **K** and **L**.

CHAPTER EIGHT
On the Lengths of the Nychthemerons

[1a] The nychthemeron [*lit.*, a day with its night] is the time that elapses from a sunrise, a sunset, /or the Sun's passage through the meridian/† [i] until another* [ii] sunrise, sunset, /or Sun's passage./† [iii] It is not, as is generally understood, **the time that falls from either the Sun's occurrence on the horizon—whether rising or setting—or else [from its occurrence] on the meridian until its return there after one complete revolution by the first motion; and that its length is one revolution of the equinoctial increased by the amount of it that rises with the arc traversed by the Sun during that nychthemeron.** [This definition is not correct] because it is not inclusive, since the qualifier "one [*wāḥida*]" excludes the nychthemeron of latitude 90 and what is close to it, because [in those localities] the return of the Sun to the assumed initial point will be after two revolutions or more. [Also,] because the qualifier "complete [*tāmma*]" and the determination of the length of a nychthemeron [exclude] some of the nychthemerons where the signs rise in reverse order, and its vicinity. Because [in those localities] the return [of the Sun]—according to what will be clear after the perception of those situations—is less than a revolution by an amount /that is necessitated by the Sun's motion. The point of the equinoctial that is on the horizon with the Sun—let it be in the tenth§ [iv] as an example—will not return with it to the horizon—due to the Sun's transmission to the eleventh and its rising before the tenth; rather, another point [on the equinoctial] will reach the horizon with the eleventh. Thus, what is between the two points along the equinoctial is what is subtracted from its [complete] revolution. If§ [v] it were possible to join the arc that rises in reverse order to the one that rises in regular order and the Sun were assumed during a certain day to traverse one day the degree that is on the common part of the two arcs, the returns of the Sun and [the point of] the equinoctial would be [at] the same [time].§ [vi] /This is because,/§ [vii] even though the [Sun's] motion along what rises in regular order necessitates an excess over the revolution of the equinoctial, its [motion] along what rises in reverse order necessitates a deficiency from one revolution by the amount of that excess; thus they cancel each other and the return [of the Sun]

---

[i] or the Sun's passage through the meridian] - **B**; margins of **K** and **L**.
[ii] another] + resulted from the daily motion: **B**; crossed out in **K**.
[iii] or the Sun's passage] - **B**; margins of **K** and **L**.
[iv] the tenth] + of Aries: margins of **K**, **L** and **R**.
[v] If] Not if: added in the margin in **K** and within the text in **L** and **R**.
[vi] the equinoctial] + according to: margins of **K**, **L** and **R**.
[vii] This is because] the fact that: added in the margin in **K** and within the text in **L** and **R**.

will happen/[*] [viii] only in one revolution, which is the departure of a point of the equinoctial from its alignment with a [certain] point and its return to [that point]. The time elapsed from the departure until the return is the period of one complete revolution of the outermost orb.[§] [ix] [The definition] that we have mentioned is inclusive and exclusive. When they say "the day" in an unrestricted sense, they mean "the nychthemeron"; likewise for "the days."

[1b] Now that you have learnt this, you should know that the nychthemeron /in the inhabited region/[*] [x] is subdivided into a true [nychthemeron] and a mean [nychthemeron], /which is also called the mean day./[†] [xi] The true [nychthemeron] is the time between the departure of the Sun from half a great circle, conceived to be fixed, and the Sun's return to it, which is a complete revolution of the equinoctial plus the amount that exceeds that semicircle with the arc that the Sun traverses by its proper motion during the time it returns to that semicircle. We have said "half a great circle" in order to include the eastern horizon semicircle, if the initial point is taken to be the sunrise; the western [horizon semicircle] if it is taken to be the sunset; and the meridian [semicircle], if the initial point is taken to be the passage [of the Sun] through it. We have [also] said, "the amount that exceeds it" instead of "the amount that rises from it," as is usually said, so as to include the sunrise, sunset and passage [of the Sun] through the meridian. Indeed, the period [of a true nychthemeron] will be more than the period of a revolution, because if the Sun were still and motionless, the period of its return to a given point that was taken as the initial point of its motion[§] [xii] would be equal to the period of the return of the equinoctial, but [the Sun] moves in the opposite direction of the motion of the Universe. So, if we assume the Sun to be on the meridian circle, there will be a certain point of the equinoctial with the Sun on it. Then, when the orb moves till it brings that point back to the meridian, the Sun will not return with the point to [the meridian] because it has traveled with its proper movement along an arc on the zodiacal orb. Therefore, when the orb moves until the Sun returns to the meridian, another point of the equinoctial will have reached it. Thus, what is between the two points, is the excess over the revolution of the equinoctial. The mean day is the period of one revolution of the equinoctial

---

[viii] that is necessitated by the Sun's motion… and the return will happen] margins of **B** and **K**.

[ix] the highest orb] + Because this difference actually appears in the nychthemeron not in some of it. Yes, if it were possible, the two returns of the Sun in two consecutive days would be the same as the two returns of the equinoctial, as it is clear: margins of **K**, **L** and **R**.

[x] in the inhabited region] margins of **B** and **K**.

[xi] which is also called the mean day] and other than them: **B** = added in the margin and within the text of **K** and **L**.

[xii] its motion] has been changed to "the nychthemeron" in **K**, **L** and **R**.

plus an arc along it, equal to the Sun's mean motion which is 0; 59,8,20. This [mean] day is the one by which the planets' mean motions and other motions that do not vary are defined in the *zīj*es; because if they were defined using the true [day], the arrangement of the tables would be difficult or impractical due to the variation of the true [nychthemeron].

[1c] The first [subdivision] is called "true," due to the consideration of the Sun's true movement, which is its movement with respect to the center of the Universe; and the second [subdivision] is called "mean," due to the consideration of the Sun's mean motion, not for the reason mentioned by Kharaqī, which is: "The return of the Sun to the same point of the zodiacal orb in one year will add one return to the equinoctial's returns. [This is] because of the daily excess of the Sun's return over that of the equinoctial by [the amount of] a small arc. If those [small] arcs are put together during one year, it will equal one return. If this extra return is divided over the days of a solar year, each day will get 0;59,8,20. Therefore, the amount of the mean nychthemeron will be 360;59,8,20." This is because this [explanation] is not appropriate for causal inference; for a proper appraisal, it is [the number of] the equinoctial returns that exceeds the Sun's returns, not the contrary, as was mentioned. Because if every return of the Sun to the meridian, for example, takes longer than the return of the equinoctial to it, then [the number] of the equinoctial returns should be more than [that of] the Sun's returns in one year by the amount of one equinoctial return. Do you not notice that if the Sun traverses with its proper motion, for example, a quarter of the zodiacal [equator] in one day, its return to the exact point on the zodiacal [equator] will take four returns to the meridian, which is equal to five equinoctial returns? [This is] because the Sun's return, based on this assumption, takes longer than the equinoctial return by the amount of its quarter.

[1d] These two [kinds of] days are used by the practitioners of the science [of astronomy]; as for other kinds, such as the nychthemerons at latitudes where no habitation exists, they do not take these into account.

[2] Now, the reason for the variation of the true [nychthemeron] is two: first, the variation of **what is traversed by the Sun** with its proper motion, **for [the Sun] will traverse in the far half smaller arcs, while in the near half larger arcs;** second, the variation of **[those arcs] that rise along the equinoctial with the arcs from the ecliptic orb, [the former] being sometimes smaller, sometimes larger than [the latter].** This is not because of the variation in its

movement, /for it has been included in the first [cause],/† [xiii] because even if it traversed equal arcs in [different] days, this [variation] would still persist since it does not pass over the circles in equal times: it passes over the eastern horizon through the co-ascension of the locality and over the western [horizon] through the co-ascension of [the point] /directly opposite to [the locality]/*[xiv] and over the meridian through the co-ascensions of the right orb, and these co-ascensions are different depending on where they are taken from. It is due to these two [reasons] that the length of one revolution of the orb is increased by time [intervals]; **indeed, the amount [of a nychthemeron] is variable but this variation is imperceptible in one or two days due to the smallness of the difference; one does perceive it over many days. The calculators,** as we have mentioned, **being obliged to use nychthemerons of equal size in order to find the mean motions and other [things], have taken the above increase to be** along the equinoctial **in the amount of the mean motion of the Sun during a nychthemeron,** for what has been mentioned as the cause. These two days may be either equal or different because the co-ascension is either equal to the equal degrees, *i.e.* the true position, or greater or less than it. In any case, the true position is either equal to the mean [position] or greater than it or less than it. Thus, there will be only nine divisions. Due to the first, the true [nychthemeron] will be equal to the mean [nychthemeron]; greater than it, due to the second; and less than it, due to the third. In the same way, the true [nychthemeron] will be greater than the mean [nychthemeron] due to the fourth, fifth and sixth, if the excess of the co-ascension over the true position is greater than the excess of the mean [position] over it; or less than it if the contrary; or equal to it, if they [*i.e.*, the co-ascension and the true position] are equal. Similarly, the true [nychthemeron] will be less than the mean [nychthemeron] due to the seventh and eighth, if the deficiency of the co-ascension with respect to the true position is more than the deficiency of the mean [position] with respect to it; and greater than it, if the contrary; and equal to it if they are equal. The same will happen due to the ninth, which is clear from an entirely theoretical point of view and from considering the truth of the matter [*nafs al-amr*]. But **for the true state of affairs, one needs to find out all about each of the two differences.**

[xiii] for it has been included in the first] margins of **B**, **K** and **L**.
[xiv] directly opposite to [the locality]] 'the locality' was referred to by the masculine pronoun (-*hu*) in **B**, which has been changed to the feminine pronoun (-*hā*) in **K**.

[3] As for the difference that is due to the Sun's variable speed: in the period that the Sun moves from the apogee to the mean distance that follows it, the increase of the Sun's mean over its true position will be in the amount of the maximum anomaly, which is two degrees; **in the period that it moves from the other mean distance to the apogee, it will be the same as this.** If one says that this [statement] indicates that the mean position will be greater than the true position when [the Sun] ascends from the mean distance to the apogee; and that your statement in the [section on the] configuration of the Sun's orbs **that the equation will be added to the mean as long as [the Sun] is ascending**, indicates that the true position is greater than the mean position there, which is contradictory, we will say that there is no contradiction in it, since there is no incompatibility between the arc of the true position being greater than the arc of the mean position, as we have mentioned there, and the true motion being less than that of the mean motion, as we have said here. **Thus the increase of the mean over the true position in the far segment from the Earth of the Sun's orb is in the amount of twice the anomaly; in the near segment, the increase of the true position over the mean is the same as this as well. The difference between the two segments is four times the anomaly.**

[4a] As for the difference due to the co-ascension: if the beginning of the day is made to be when the Sun reaches the horizon, this difference will vary according to the changing horizons, and it will not be the exact same thing for all localities. If the beginning of [the day] is [upon the Sun's] reaching the eastern horizon, that [difference] will be due to the difference between the equal degrees and their co-ascension in that locality, and then the difference [that is due to] the Sun's speed and the difference [that is due to] the local co-ascension come together in the required horizon. The difference [that is due to] the Sun's speed in the apogee half or the perigee half plus the middle half is four parts. The difference [that is due to] the co-ascension in the Arietic half or the Libran half plus the middle half is twice the total equation of daylight. Since the apogee is close to the summer solstice, in the vernal quarter the true [day] will be less than the mean by the amount of the sum of one single anomaly and one equation of daylight; in the summer quarter it will be more by the amount of the excess of an equation of daylight over an anomaly; in the autumnal quarter, it will be more by [the amount of] the sum of an anomaly and an equation of daylight; and in the winter quarter, it will be less by [the amount of] the excess of an equation of daylight over an anomaly. Due to the variation of the amounts of the equation of daylight according to the localities, this procedure is avoided. If the initial point is taken to be the western horizon, the difference [that is due to] the equations of the daylight for the Arietic and Libran halves will be opposite to that in the eastern horizon with respect to being additive or subtractive, /according to what has been mentioned earlier about the co-descension of an arc being like the co-ascension of the directly opposite arc, and because the co-ascension of the directly opposite arc differs in [being] additive or subtractive. And likewise, it, that is, the difference [due to] the equation of daylight, the beginning of which is taken to be the western horizon in the northern regions, will be equal to the one in the southern regions where the beginning of their day is taken to be the eastern horizon, if their latitudes are equal, according to what has already been mentioned, [namely] that the co-descension of an arc in the northern [regions] is like its co-ascension in the southern [regions] based on the mentioned condition, and vice versa./[*] [xv] One should draw analogous conclusions from what we have mentioned for the combinations.

[4b] But if the beginning of the day is made to be upon its reaching the meridian, the difference agrees for all horizons, and that is according to the co-ascension for the equator. [The calculators] thus chose this rather than the first alternative. You should know that for those who take the beginning of their day from the meridian [till the Sun's return] to it, there will be no variation at all in [the beginning of the day] in localities of equal longitude. Now, the difference in the beginning [of the day] for only longitudinally different, or both longitudinally and latitudinally different localities, will be only in the amount of the difference between the longitudes. Therefore, the true and mean days, the beginning of which are taken to be the meridian, will only differ by the same amount that the co-ascension of [the arc of] the Sun's true motion at the equator /differs/[*] [xvi] from its mean motion, and its maximum is (½ + ½ of 1/9) of an equal hour. The difference in the beginning of the days whose beginning is taken to be either the eastern or the western horizon, for localities of equal latitude, will be by the amount of the difference between the longitudes; for those with /only/[*] [xvii] different latitudes, the difference will be likewise in the beginnings /in the same amount that the difference of the latitudes

[xv] according to what has been mentioned earlier about the co-descension of an arc … is like its co-ascension in the southern [regions] based on the mentioned condition, and vice versa] margins of **B** and **K** = + is like the ones in the southern regions: crossed out in **B** and **K**.
[xvi] differs] margins of **B** and **K**.
[xvii] only] margin of **B**; above the line in **K**.

necessitates;/* [xviii] thus, at [two localities] of equal longitude, the Sun rises earlier for the one that is more inclined toward the north, than the one with less inclination, /if [the Sun] is to the north of the intersection of the two [local] horizons, as has been mentioned at the beginning of the book,/* [xix] and [there will be a difference] also in the amount due to the difference in the co-ascension of the Sun's movement. In longitudinally and latitudinally different [localities], it will be a combination of the three /aforementioned/* [xx] differences.

[5] It has been mentioned above that the zodiacal orb may be divided into four segments. The two that are bisected by the equinoxes are greater than their co-ascensions, and they are from the middle part of Aquarius to the middle part of Taurus, and from the middle part of Leo to the middle part of Scorpius. The amount of excess of each one of them over its co-ascension at the equator is five degrees. The other two segments, which are bisected by the solstices, are less than their co-ascensions, and they are from the middle part of Taurus to the middle part of Leo and from the middle part of Scorpius to the middle part of Aquarius. The amount of deficiency of each one of them from its co-ascension at the equator is likewise five degrees.

[6] When one additively combines the two differences when they are both additive, or both subtractive, or takes the difference when they differ, there results the total amount of difference between the mean days and the true days during the year. This difference is called the equation of the nychthemerons. Its maximum is nine degrees, because the difference between the apogee or perigee halves and the middle half is twice the [solar] equation, which is four degrees; and [the difference] between the quarters of equinoxes or solstices and the middle quarter is five degrees. Therefore, the maximum difference between the subtractive [true] and mean days or [between] the additive [true] and mean caused by both differences is nine degrees. The difference between the subtractive and additive /true/* [xxi] days is 18 degrees. When the Sun reaches its initial position with its proper motion, and a revolution is completed, this difference will be gone and this consideration will be cancelled; and the sum of the mean will

---

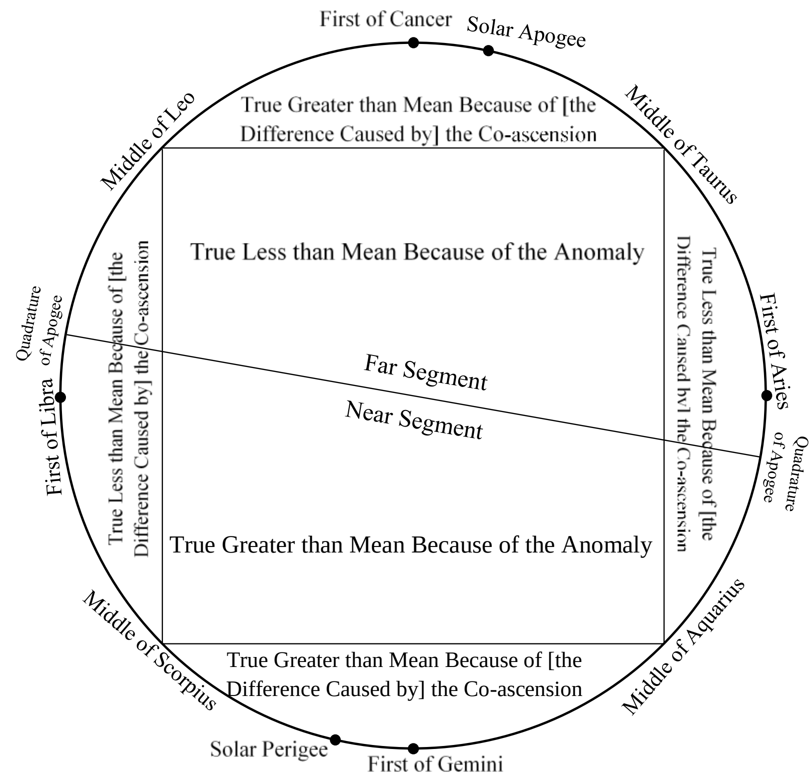
[xviii] by the same amount that the difference of the latitudes necessitates] margins of **B** and **K**.
[xix] if it is to the north of the intersection of the two horizons, as has been mentioned at the beginning of the book] margins of **B** and **K**.
[xx] aforementioned] margins of **B** and **K**.
[xxi] true] margins of **B** and **K**.

approximately be equal to the sum of the true, except for the amount that is caused by the motion of the Sun's apogee.

[7] One day must necessarily be taken as the initial one from which the other days are measured. Noon of that day is then the initial [time] for both mean and true days. For any day of the year that is taken to be the initial one, the difference between the mean and true days elapsed from that day is sometimes additive and sometimes subtractive, except for [initial days at] the end part of Aquarius and the beginning part of Scorpius; for if the initial [point] is made the end part of Aquarius, the true days will always be shorter than the mean ones, due to the combination of the two additions there, **and if it is made the beginning part of Scorpius, the true days will always be longer than the mean ones.** Its detailed explanation is that since the apogee is at Gemini, the deficiency of the apparent from the mean, according to the first difference, will [occur] in the half that is from Pisces to Virgo, and its excess over it will [occur] in the other half. If the two differences are combined, the two deficiencies that are due to the two [differences] will come together in what is between the beginning part of Pisces and the middle part of Taurus. From there to /the middle part of/† [xxii] Leo, the excess that is due to the co-ascension will reach the amount that the deficiency, which was also due to [the co-ascension], has reached in the previous quarter. The accumulated deficiency that is due to the first difference remains as it was before. Then, the two deficiencies will come together until the beginning part of Virgo. The Sun's anomaly keeps growing while the co-ascension is subtractive, until they counterbalance each other at the end of Libra. Then, the addition takes over and the two additions will come together in what is between the middle part of Scorpius and the middle part of Aquarius. Then, the deficiency that is due to the co-ascension occurs. Thus, based on this concurrence, the zodiacal equator divides into [two divisions]: one division in which only deficiency appears, and it is between the middle part of Aquarius and the end part of Libra; and [another] division in which only addition appears, and it is between the first of Scorpius and the middle of Aquarius. From this, what we have mentioned becomes clear, except that **the practitioners of the profession have agreed on making [the initial point] the end part of Aquarius.** Because of this, the true days are always less than the mean. /The excess of the true day over the mean while the Sun is in the smaller segment, like the

[xxii] the middle part of] the middle of: **B** = "the middle of" has been changed to "the middle part of" in **K** and **L**.

tenth of Capricornus for example, does not contradict the fact that the elapsed true days from the end part of Aquarius to the tenth of Capricornus are less than the mean days that are between them. This is because the deficiencies that obtain in the greater segment will not be compensated except if the Sun traverses the smaller [segment] and reaches the initial point, *i.e.*, the end part of Aquarius./[*xxiii] **This is an illustration of the segments, the apogee being in the end of Gemini:**



[Figure 7]

The difference of the anomaly changes due to the motion of the apogee, but over a long period.

[**8] This then is the explanation of the difference in the lengths of the days. Finding the [actual] amounts for all times pertains to the practical handbooks,** and it is more appropriate to leave its explanation to those [handbooks]—God knows best.

[xxiii] The excess of the true day over the mean… the initial point, i.e. the end part of Aquarius] margins of **B** and **K**.

CHAPTER NINE
On Dawn and Dusk

[1a] Dawn and dusk are illuminations in the vapor sphere due to the Sun's approaching the eastern horizon or its receding from the western [horizon]. They are similar in type, /but opposite in position,/* i since the state of /the beginning of/* ii the rising of dawn is like /the end of/* iii the setting of dusk. They are different in color, due to the difference of /the quality of the air/* iv in the horizon where they appear. The difference in the color of the Sun during sunrise and sunset, and also [the color of] its rays and whatever in the atmosphere is illuminated by its light, is due to the vapor's different colors in each of the two directions. The color of the vapor in the east is nearer to clearness and whiteness due to the humidity attained from the nighttime cold, while in the west it is more yellowish due to the dominance of the smoky part attained from the heat of the daytime. Furthermore, the whiter and clearer the§ v body is, /the brighter it is, and also/* vi the more intense the light reflected from it than the light reflected from other [bodies]. For this reason, among the objects of equal size and distance, one sees the white ones before the red and yellow ones, and the latter before the dark and dust-colored ones.

[1b] As for the vapor sphere, it designates the air thickened by ascending particles from the earth and water spheres due to the Sun and other things vaporizing them. The shape of this air is like a sphere encompassing the Earth around its center; since its surface is parallel to the Earth's surface and its maximum height from the center of the Earth is everywhere equal, this necessitates its being spherical. However, its consistency is different, since its parts which are closer of it to the Earth are thicker than the distant parts—since the thinner ascends and becomes farther in distance than the thicker, which is clear—but [the air] never reaches an extent of thickness such that it would conceal what is /beyond it./†vii The altitude of [the vapor sphere] reaches a limit, which is 51 *mīl*s and a fraction from the surface of the Earth, and does not exceed it, as will be explained in [book IV on] the sizes and distances—God the Almighty willing. The vapor sphere is also called the world of the wind, *i.e.*, the place from which the winds blow,

---

i but opposite in position] margins of **B** and **K**.
ii the beginning of] above the line in **B** and **K**.
iii the end of] added later within the text in **B** and **K**.
iv the quality of the air] margins of **B** and **K**.
v the] + thick: margins of **B**, **K**, **L** and **R**.
vi the brighter it is, and also] has changed from "is" within the text and in the margins of **B** and **K**.
vii beyond it] behind it: **B** = has been changed from "behind it" in **K** and **L**.

since the air above it, which is clear from dust particles, vapors and smoke, is still and undisturbed. /Some call it the sphere of day and night, as it is susceptible to light and darkness—unlike the clear air that is beyond it—and blueness appears in it, which seems to people as the color of the sky. Because the particles that are close to the surface of the vapor sphere are less susceptible to light due to their greater distance and fineness compared to those close to the Earth, they seem dark compared to these [latter] particles. When the light of vision extends from the particles illuminated by the stellar rays towards those particles that seem dark, the observer sees the dark atmosphere above himself as a combination of the terrestrial light and the stellar light, in a color between darkness and brightness, which is the color azure. Similarly, when one looks at a green body through, for example, a red transparent body, it appears to him as a color combined from redness and greenness./[‡] [viii]

[1c] Because the beginning of dawn and the end of dusk only occurs when the Sun's depression from the horizon is 18 or 19 degrees and [because] no light is visible in [the horizon] when [the Sun's] distance from the horizon is greater than that [amount], it was then ascertained that the light is due to the Sun. If not, why would its closeness or farness affect [the light]? However, [that light] is not due to the sunlight falling on the apparent surface of the Earth—/because it is considered dark [at dawn and at dusk]/[*] [ix] since, on this account, the Sun is beneath the visible horizon /by far, and it being so, its rays do not fall on the apparent surface of [the Earth], neither directly nor through reflection, and because/[*] [x] the eye only perceives what is above [the horizon]—rather [that light] is the sunlight falling on /the rough and thick part of/[*] [xi] the surface of the Earth's shadow cone, called night. This is because the rays of the Sun surround the cone and are scattered in all the orbs, except what is enclosed by the Earth's shadow cone due to its thick body, which is an insignificant amount of the orbs of the moon and Mercury. The rest of the [celestial] orb is illuminated by the light of the Sun.[§] [xii] Since the orb is extremely transparent, the light passes through it and does not reflect from it. That is why [the celestial orb] does not seem illuminated to us and neither does the air surrounding the vapor sphere which is

---

[viii] Some calls it the sphere of day and night … it will appear to him as a color combined from redness and greenness] - **B**; margins of **K** and **L**.
[ix] because it is considered dark] margins of **B** and **K**.
[x] by far, and it being so, its rays do not fall on the apparent surface of the Earth, neither directly nor through reflection, and because] margins of **B** and **K**.
[xi] the rough and thick part of] margins of **B** and **K**.
[xii] the Sun] + *i.e.*, its rays reach them: margins of **K**, **L** and **R**.

free from particles. Now [that part of the air that is] mixed with the particles, /which is the rough and thick part of the surface of the Earth's shadow cone,/* [xiii] can thus be seen due to the existence of terrestrial particles in [the air] illuminated by the sunlight, as can be observed when the light beam enters from the small window of a house into the relative darkness of [the house].

[1d] In fact, the situation of dawn and dusk are similar, except that dawn begins with a weak light which is a thin elongated whiteness, then [it becomes] a wide expanding whiteness, and then redness; and dusk is the opposite of this, since it is red after sunset, then [it becomes] an expanding wide whiteness, and then thin elongated whiteness until it disappears. However, the disappearance of this whiteness is barely perceived due to its being at the time of sleep and people being free to rest at their shelters, unlike the first thin whiteness since it is at the time of completion of rest and preparation for one's affairs, during which people wait for the beginning of the day at the rise of dawn in order to start dispersing for their needs. Thus, due to the similarity of their situations, if we make the case of one of them clear, it would be enough for the other; and since the dawn is more desirable, and of higher concern, we commence with it. Thus we say **when the Sun approaches the eastern horizon, the Earth's shadow cone inclines toward the west. Then of the rays surrounding it,** /*i.e.*, the thicker parts of [the cone]/* [xiv] **what is visible first is that which is nearest the eye,** which is what is above the horizon, not what is on it close to the Earth; because **the nearest of the sides of the cone to the eye is the side that is toward the Sun,** due to the cone's inclination to the west, and "the nearest [part] of this side to the eye" is what we mentioned.

[1e] In order to explain this, let one conceive a **plane** passing **through the centers of the Sun and Earth and through the axis of the cone, and let there occur in it a triangle whose angles are acute, whose base is on the horizon, and whose two sides are on the surface of the cone.** It is clear **that the [point] that is nearest the observer on the side [of the triangle] toward the Sun is the spot on which the perpendicular extending from the eye falls on that side, not the place of intersection of the side with the horizon,** because the latter is longer than the perpendicular due to its being the subtense of a right [angle] and the perpendicular being the subtense of an acute [angle]. Certainly, the perpendicular does not fall on the intersection point,

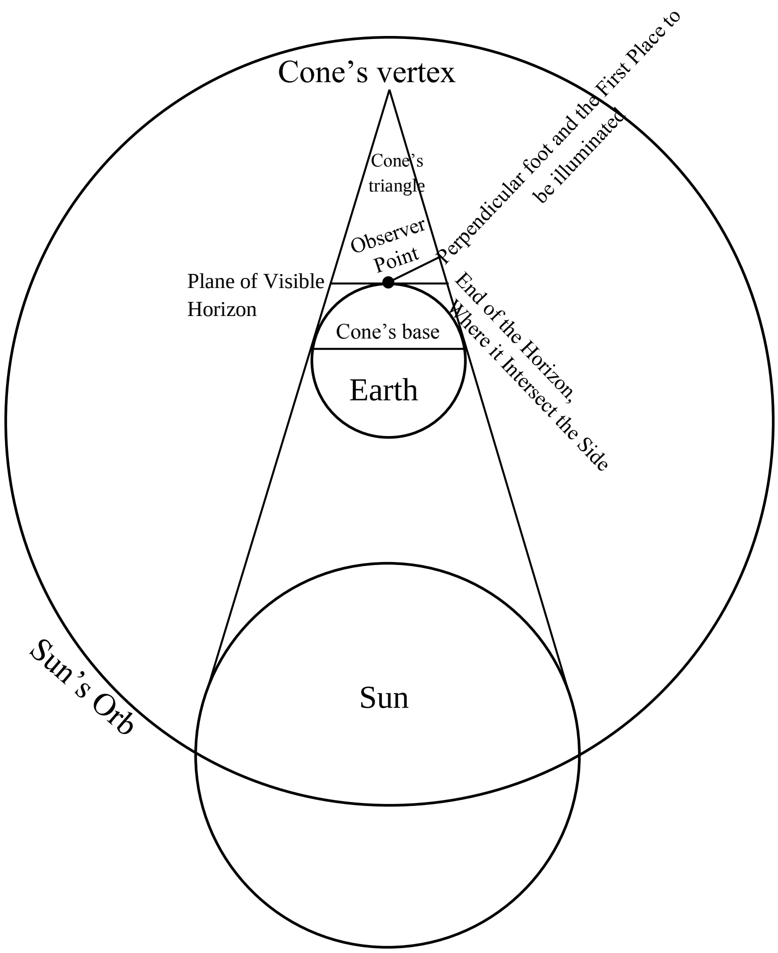
---

[xiii] which is the rough and thick part of the surface of the Earth's shadow cone] margins of **B** and **K**.
[xiv] *i.e.*, the thicker parts of [the cone]] margins of **B** and **K**.

because that angle is acute /and it is equal to its equivalent when the Sun is in the *Imum Coeli* [*watad al-arḍ*]. After the Sun's transit from there, the eastern [angle] will be more acute, and the western wider, and they are not always equal according to what comes quickly to mind. It would only be so if the triangle's base, *i.e.*, the diameter of the visible horizon, were moved by the motion of the triangle, which is not the case. Thus, because of that, *i.e.*, the acuteness of the eastern [angle], the perpendicular does not fall on the intersection point/[* xv] nor beneath the horizon on the above-mentioned side /either;/[* xvi] otherwise it would necessitate a right angle in the triangle, occurring from the perpendicular, and an obtuse [one] beneath the horizon, occurring from the intersection of the visible horizon's diameter and the above-mentioned side, because the upper angle [occurring] from their intersection is acute. So, necessarily, the perpendicular to the mentioned side falls above the horizon. **Therefore the first observed light of the Sun is seen above the horizon as a straight line that lies on the above-mentioned side, but what is near** the Earth **is still dark. For this reason that light is called first dawn,** as it is the first light that appears; [it is also called] the wolf's tail, due to its thinness and length, as a simile to it; **and [it is called] false dawn, due to the horizon being dark; in other words, for it to be believed that it is truly the light of the Sun, then [one would expect that] what is illuminated should be** near **the Sun** not **farther away from it.**[§ xvii]

[2a] Then when the Sun comes quite near, the light will spread; the horizon will then become lighted,[§ xviii] having a wide whiteness, **and the dawn will be true;** because its light is more reliable than the first light, not because it is not followed by a darkness, unlike the false [dawn] that is followed by a darkness disproving it, as some believe. Actually, /as we will clarify later,/[* xix] the correct [explanation] is that the first [dawn] is still there, but it only becomes hidden due to the superiority of the intense light that has suddenly started to be added to it, just as the Sun's light makes the lights of the torches, fires, and stars hidden. When the light of the Sun reaches a surface adjacent to the horizon, the redness will appear. **Dusk will be the reverse of dawn,** as we have mentioned. **This is an illustration of the horizon, the triangle, the perpendicular, the Sun, and the Earth:**

[xv] or equal to its equivalent… the perpendicular does not fall on the intersection point] margins of **B** and **K**.
[xvi] either] above the line in **B**; margin of **K**.
[xvii] from it (*min-hu*)] masculine "it" has been changed to feminine "it" (*min-hā*): **L**.
[xviii] lighted (*munīran*)] has been changed to *al-munīr* in **L**.
[xix] as we will clarify later] margins of **B** and **K**.



[Figure 8]

This is what is generally understood by the majority [of the scholars] on this topic.

[2b] Some people say that the reason for both the first dawn and the last dusk being elongated is the falling of the Sun's rays at that time over the sea from [either] east or west. Then the rays are reflected from the surface of the water to us, and the illumination occurs. Then the rays connected to the Sun's falling on the sea are cut off, and they fall over the expanse of the Earth. Thus, they cannot be reflected [from the sea] and reach us in the period between the two dawns. Then the Sun's rays appear at the sides of the horizon, and it becomes illuminated for the first reason. Similarly, the setting of dusk is in this manner. This, and its like, are inexact and imprecise, and there is no verification for them.

[2c] We ourselves say: since the base of the Earth's shadow cone is a circle on [the Earth] which is almost a great circle, but not [exactly] a great circle, as was mentioned earlier in [proposition] 29, the Earth is divided by it in two parts; one bigger, which is illuminated; and one smaller, which is dark, in the opposite side of the illuminated. These two accidents, *i.e.*, light and darkness, move on the surface of the Earth, [making] one revolution in a nychthemeron. The motion of the light is from east to west; the motion of the darkness is from west to east. Since the shadow cone intersects the vapor sphere, and [the cone's] axis is perpendicular to /the center of its base,/*[xx] their /common/*[xxi] part is a circle parallel to the base of the cone that moves by the Sun's daily motion due to the motion of [the circle's] axis, as any line perpendicular to the center of a circle is called its axis. Let us call it the cone circle: it separates the air that, due to its extreme transparency, will not be illuminated by the light of the Sun, and it is beyond [the cone circle's] circumference, and the air that receives the light, which is below it, *i.e.*, the air from the vapor sphere between [the cone circle] and the Sun, /not the air from [the vapor sphere] that is above [the cone circle], due to its being permanently inside the shadow cone./* [xxii] Therefore, the segment surrounding the cone that is separated by it from the vapor sphere between the surface of this circle and the cone's base, is illuminated by the light of the Sun, due to its being filled with terrestrial particles. If the surface of the visible horizon is imagined to intersect the vapor sphere, a fixed circle would occur on the horizon's surface, [which would be fixed] in the sense that [the circle] and the horizon's surface do not part; the axis of [the circle] would be the line passing through the zenith. Let us call this circle the vapor circle; it separates the part of the vapor sphere that can be seen, which is above the circle, and the part of it that cannot be seen, which is below the circle.

[2d] Since the vapor circle is smaller than the cone circle, for the reason we will explain, the vapor circle is above the cone circle [throughout] most of the nighttime. Therefore, no part of the illuminated segment of the vapor sphere surrounding the cone goes above the vapor circle, and no part of the illuminated air can be seen. Let us take an example to [understand] this: in a [given] locality whose latitude is not greater than the obliquity, let the azimuth circle in that locality at the time of the passage of the zodiacal circle through the zenith be the zodiacal circle,

---

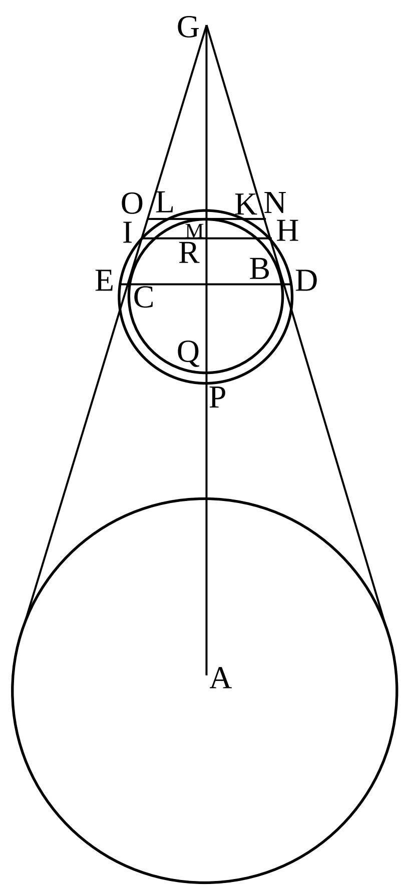
[xx] the center of its base] its center: **B** = has been changed from "its center" in **K**.
[xxi] common] - **B**; margin of **K**.
[xxii] not the air from [the vapor sphere] that is above [the cone circle], due to its being permanently inside the shadow cone] - **B**; margin of **K**.

so that conceiving what we say will be easier. Let the time be midnight; we imagine the azimuth circle, *i.e.*, the zodiacal circle, intersecting the Earth sphere at the circle *BC*; the sphere of the Sun at the circle *A*; the vapor sphere at the circle *DE*; and the shadow cone at the triangle *GBC*. Let the common part between the azimuth circle and the cone circle be the line *HI*, /which is always parallel to line *BC*, the diameter of the cone's base, because the cone's axis is always perpendicular to them and because of their motion with its motion;/* [xxiii] and [the common part] between the azimuth circle and the vapor circle is the line *KL*. It is clear that *HI* and *KL* are the diameters of the cone circle and vapor circle because the azimuth circle passes through their centers; and [it is also clear] that the illuminated [parts] of the vapor sphere are: [1] the illuminated [spherical] segment surrounding the cone, which is [shown in the figure by the sections] *BDH*, *CEI*, and [2] [the spherical segment] between the two [sections] in the direction of the Sun, /which is the segment *DPECQB*./* [xxiv] And the center of the horizon is *M*, which is the location of the [observer's] eye. The eye does not see any of the surface extending from the eye, passing through the points *N* and *O*, illuminated because these two [points] are in the transparent air. When the Sun moves toward the east, the cone inclines toward the west, and the eastern side of the cone circle is elevated until the point *H* reaches the point *K*, and thus *K* becomes the common [part] between the circumferences of the cone circle and the vapor [circle]. Therefore, the dawn breaks thin and dim due to the tangency of the two circles at one point. Then, one of them cuts from the other a small part. Thus, its light [*i.e.*, the light of dawn] extends along the shadow cone at the common part between the light surrounding the cone and the darkness that is inside it. As the inclination of the cone increases, the altitude of the eastern side of its [cone] circle increases. Thus, the part of the segment *BDH* above the vapor circle becomes greater than before. Therefore, the light widens in the east and extends horizontally, becoming a clearly apparent [light], which is the true dawn. Then, the illuminated segment surrounding the cone will be elevated little by little, until all of it goes above the vapor circle, and the light intensifies, and increases until the time of sunrise. When the time of sunrise is close, the cone circle becomes perpendicular to the vapor circle, with less than half of [the cone circle] above [the vapor circle] and the rest of it beneath it, because its center, /which is *R*,/* [xxv] is below the

---

[xxiii] which is always parallel to line *BC*, diameter of the cone's base, because the cone's axis is always perpendicular to them, and because of their motion with its motion] - **B**; margin of **K**.
[xxiv] which is the segment *DPECQB*] - **B**; margin of **K**.
[xxv] which is *R*] - **B**; margin of **K**.

center of the vapor circle, /which is *M*./* [xxvi] Then, its side descends toward west as the Sun gets altitude from the horizon, until the time it reaches the western horizon, [when] its situation will be like what it was at sunrise. Then, [the cone circle] inclines toward the west until the Sun's depression is 19 degrees, and the cone circle touches the vapor circle at one point in the western direction. Then, [the cone circle] gradually goes below [the vapor circle] until the cone circle is entirely beneath the vapor circle. Thus, the light disappears until [the cone circle] touches the eastern side of [the vapor circle] shortly before dawn, and everything starts all over again.



[Figure 9]

[2e] As for the fact that the cone circle is greater than the vapor circle, /this is because/‡ [xxvii] if it were equal to it, it would coincide with it when it touched it; since, for any two equal circles in a sphere, if, after being separated, one touches the other, it will coincide with it. Hence, when

---

[xxvi] which is *M*] - **B**; margin of **K**.
[xxvii] this is because (*fa-li-annahā*)] it is because (*li-annahā*): **B**, **K** = has been changed from "it is because (*li-annahā*):" **L**.

the distance of the Sun from the horizon is 19 degrees, the horizon will be illuminated from all directions and the dusk will only set when the dawn has just risen. If [the cone circle] were smaller, then most of the time the horizons would be illuminated like the morning light, but the reality is contrary to this. Thus, the cone circle is greater than the vapor circle. That is why [the cone circle] is always entirely or mostly beneath the vapor circle and no segment of it coincides with nor goes above [the vapor circle] at all, except a segment [which is] less than half of it, according to what has been mentioned. This is the true reason for the rise of dawn and setting of dusk, and for the increase of the first light and for the decrease of the second one and this is why it is not visible before the limited time [of its visibility].

[2f] Now that you have learnt this, you should know that **it has become known by trial and error that the depression of the Sun below the horizon at the first rising of dawn and the final setting of dusk is 18** degrees of the altitude circle which passes through the center of the Sun. However, due to the difference in the co-ascension of the depression arc, the dawn and dusk hours differ, *i.e.*, the hours between the rise of dawn and sunrise and [the hours] between sunset and setting of dusk. Now, at the equator, when the Sun is in one of the equinox points, this 18-degree depression will be traversed by the same amount of the equinoctial motion, due to the unity of the altitude circle and equinoctial at that time. Then, the dawn and dusk hours will be 1 hour and 1/5 of an hour, as this is the measure of 18 degrees. The dawn and dusk time will not be less than this [amount] anywhere on the surface of the Earth. If, [at the equator], the Sun is at [any point] other than the equinoxes, the altitude circle will be different from the solar day-circle; thus the dawn and dusk hours increase, as we have said, by the amount of the difference between this 18-degree and what rises with it from the equinoctial. This differs as the day-circles change. /This is because the altitude circle of the Sun and its day-circle, intersecting at the center of the Sun while it is below the horizon and [the horizon circle], form a triangle whose two angles at the horizon are right angles, and so their subtenses are equal; however, [the side of the triangle] that is along the altitude circle is 18 degrees of [the altitude circle], thus the [side] along the day-circle is more than 18 degrees of it, because it is a small circle, whereas the altitude [circle] is a great circle. Therefore, when the Sun is at [any point] other than the equinoxes, [an arc along] the equinoctial that is greater than 18 degrees rises with the depression arc, since the rules for the rising and setting in the day-circle and the equinoctial are the same. Since the day-circles become smaller as they get farther from the equinoctial, the maximum of this difference will occur at the time when the Sun is at one of the solstices. So, learn this, as it is one of the subtleties./* [xxviii] It is clear that every two parts with equal distances from one of the equinoxes have equal dawn and dusk hours. This is also one of the characteristics of the equator that cannot be found in any other place.

[2g] As for the oblique horizons, the greater the altitude of the visible pole of the zodiacal orb and the more acute the angle occurring from the intersection of the horizon and the zodiacal [equator], the greater the dawn and dusk hours; and the less /its altitude,/* [xxix] /the fewer/* [xxx] [the hours]. This is because the more acute the angle is, the greater what falls along the zodiacal circle between the center of the Sun and the horizon, compared to when it is less acute, due to the equality of the depression arc in them. The greater the arc along the zodiacal [equator], the greater its co-ascensions and, thus, the hours; and the less it is, the fewer [the hours]. Because of this—and also because the depression of any degree below the Earth is like the altitude of its directly opposite degree above [the Earth]—in the oblique horizons, the period of dawn and dusk for the half of the zodiacal [equator] whose declination is in the direction of the latitude is greater than the period in the other half. Do you not see that the period of dawn and dusk in the fourth clime when the Sun is in the beginning of Cancer is two hours, and in the beginning of Capricornus, an hour and a third?

[2h] **In the lands whose latitude is 48 ½, dusk will be continuous with dawn when the Sun is at the summer solstice.**§ [xxxi] There will be no nighttime darkness when the Sun reaches the meridian below the Earth, because at the time, when [the Sun is at the summer solstice], its depression arc on the meridian circle will be 18 degrees [of the meridian]. Thus, the moment when the setting of dusk ends will be exactly the beginning of the rise of dawn. **In the [regions] whose latitudes exceed that amount, this**, *i.e.*, the continuity of dawn and dusk, **will occur for a longer period in accordance with the decrease in the above value for the Sun's depression below the horizon,** because in this situation the rise of dawn will occur before the end of setting of dusk, contrary to the first situation. Thus, [the continuity of dawn and dusk] will be a certain

[xxviii] This is because the altitude circle of the Sun… So, learn this, as it is one of the subtleties] - **B**; margin of **K**.
[xxix] its altitude] altitude: **B**.
[xxx] the fewer] margin of **K** = the fewer the hours: **B**.
[xxxi] the summer solstice] has been changed to "the solstice which is:" **L** = + in the direction of the latitude: margin of **L**.

period of dusk hours and also dawn hours at the same time, and [the period of this continuity] increases according to what we have already mentioned.

[2i] In the localities whose latitudes are equal to the complement of the obliquity, when the Sun touches the horizon at the beginning of Capricornus§ [xxxii] but does not rise, the dawn hours will be 5 hours and 1/3; and the dusk hours will be the same; and the rest of the 24 hours will be the dark hours. /This is because when the Sun along the winter solstice day-circle reaches the alignment with the rising place of the equinox, its distance from the horizon will be equal to total obliquity; and when it passes nearly 10 degrees away from its alignment, its distance from the horizon will be 18 degrees. Thus, the dawn appears and stays until the Sun touches the horizon, which is equal to the amount [of time] it takes to traverse the rest of its day-circle until the [point of] tangency, which is 80 degrees, *i.e.*, 5 hours and 1/3, since from the alignment [point] to the [point of] tangency is 90 degrees. One should draw analogous conclusion from this for dusk hours./* [xxxiii]

[2j] In the localities whose latitude exceeds the complement of the obliquity until where the latitude is 84½ degrees, [the depression] will be the sum of the complement of the obliquity and the 18 degrees. /When the Sun is on a permanently invisible arc, the light will/* [xxxiv] appear during the period of each nychthemeron, /*i.e.*, during a revolution of the greatest orb./* [xxxv] [The light]* [xxxvi] appears from the south-east side, passes over the south, and disappears on the western side. [This is] /because, during that period in those latitudes, the distance of the Sun from the horizon as it moves along its day-circle when it reaches close to the southern side of the meridian below the Earth is less than 18 degrees, as is clear; except for the final latitude [*i.e.*, 84½ degrees], in which case the Sun's distance from [the horizon] when it reaches the meridian is 18 [degrees]; it is greater [than 18] for all other situations [*i.e.*, when the Sun is not at the meridian]. It is clear that the duration of the appearance of light differs due to the difference of the permanent invisible day-circles, and not [due to] the fact that the greater the day-circle, the greater the duration. [This is] because the greater [day-circle] is closer to the horizon and the

---

[xxxii] the beginning of Capricornus] has been changed to "the solstice which is in:" **L** = + in the opposite direction of the latitude: margin of **L**.
[xxxiii] This is because when the Sun along the winter solstice day-circle… One should draw analogous conclusion from this for dusk hours] - **B**; margin of **K**.
[xxxiv] When the Sun is on a permanently invisible arc, the light will] - **B**; margin of **K**.
[xxxv] *i.e.*, during a revolution of the greatest orb] - **B**; margin of **K**.
[xxxvi] [The light]] The light: **B**; crossed out in **K**.

appearance of light in it lasts longer than in the smaller [day-circle] and the disappearance time will be opposite for them—except that the hours remaining from 24 after the subtraction of the hours of illumination are the hours of darkness./* [xxxvii] This dawn and dusk will be continuous with one another, because it is considered dawn while in the eastern side and dusk while in the western side.

[2k] Then, when the latitude increases, as we have said, that light will not appear during the time the Sun is close to the winter solstice but will appear before and after that time, /because the distance of [the winter solstice] and whatever is close to it from the horizon is greater than 18 degrees, as is clear from what was previously determined above./* [xxxviii] Where the latitude is 90 and the pole is at the zenith, the period of dawn and dusk will be 50 nychthemerons each, since the altitude circle there is the same as the declination circle. Thus, when the Sun is at the part [of the zodiacal equator] whose inclination is 18 degrees, it will be the beginning of dawn and end of dusk; and that part is 50 degrees away from either of the two equinoxes in either direction; therefore, the period [of dawn and dusk] will be what we mentioned /as we had promised its explanation./* [xxxix] In the period of every nychthemeron, the light revolves around on the horizon; for a period of 12 hours, the light of dawn will be on the assumed eastern half of the horizon; for a period of 12 hours, on the assumed western half of the horizon; and the dusk will be analogous to this. This is one of the strange points of this /science./* [xl] The dawn and dusk [time] will not be greater than this [amount] anywhere on the surface of the Earth. Here, the discussion of dawn and dusk and their circumstances ends—and He is thanked for His blessings.

[xxxvii] because, during that period in those latitudes… are the hours of darkness] - **B**; margin of **K**.
[xxxviii] because the distance of [the winter solstice] and whatever is close to it from the horizon is greater than 18 degrees, as is clear from what was previously determined above] - **B**; margin of **K**.
[xxxix] as we had promised its explanation] - **B**; margin of **K**.
[xl] science] - **B**; margin of **K**.

CHAPTER TEN
On Understanding the Units of the Day, Namely Hours, and What Is Composed of Days, Namely Months and Years,
and What Pertains to Them, Namely Intercalation and the Calendar

[1a] The hours are two types: equal [*mustawiyya*], which is also called equalized [*muʿtadila*], equatorial [*istiwāʾiyya*], or equinoctial [*iʿtidāliyya*]; and seasonal [*zamāniyya*; *lit.* temporal], which is also called unequal [*muʿawwaja*; *lit.* distorted] or gnomonic [*qiyāsiyya*]. The equal [hour] is one part of 24 parts of the period of a nychthemeron. Therefore, the number of diurnal or nocturnal equal hours will increase according to the length of day and night, and decrease according to their shortness. [Therefore,] the parts of [an equal hour] are invariable, as each is equal to 15 equinoctial temporal units obtained from the division of a revolution [of the equinoctial, *i.e.*, 360 degrees] over 24. This is in general terms; however, in actuality the parts of an equal hour are greater than that since it is equal to one fourth of one sixth of the period of a nychthemeron, which is greater than an equinoctial revolution, be it the mean [nychthemeron], which is a revolution plus an arc from the equinoctial equivalent to the Sun's mean [motion], and as such, the unit of one equal hour will be approximately 15 degrees and two and a half minutes; or be it the true [nychthemeron], which is a revolution plus the co-ascension of the true Sun at that day, and as such, the unit of the hour cannot be determined because, as we already mentioned, it will increase if the true [motion] becomes greater than the mean, and vice versa if the opposite happens. However, this excess is disregarded in the division of the hours, either due to its insignificant amount or due to this and its lack of determinability. So, it has been said loosely that an equal hour is always 15 equinoctial temporal units and, because of this, it is called equal and equalized. However, its being called equatorial or equinoctial is either because of the equality of [its] parts or because of its connection with the localities at the equator where the parts and the numbers of the hours do not change; it has [also] been said that this is because unequal hours cease to exist when day and night are equal and [only] equal hours remain. Astronomers divide every equal hour into 60 divisions, each called a minute, then [they divide every] minute into 60, analogous to what is in the degrees.

[1b] A seasonal hour is one part of 12 parts of the arc of daylight or night; therefore, the number of them will not increase according to the length of day and night, and will not decrease [according to their shortness]; but in fact, their parts change, [*i.e.*,] become greater or smaller according to the length and shortness of day and night; therefore, they are called unequal. Their

being called seasonal [*lit.* temporal] is because a seasonal hour is half of one sixth of the period of daylight or night and, by [this type of hour], proportions of [daylight and night] become known. [Their being called] gnomonic is due to their being drawn on the gnomonic instruments. In the same manner that, in the division of the equal hours, the excess over the revolution of the equinoctial is disregarded, it is also disregarded in the division of the seasonal hours. That is why **the arc of daylight is** known to be **half a revolution,** if there is no equation of daylight; or half a revolution **plus** or minus **twice the equation of daylight,** when there is [an equation of daylight]. Because, in fact, **the arc of daylight is that which turns along the equinoctial from the time half the solar body rises on the horizon until half of it sets on** it. **It will be greater than the** accepted [amount] **by the amount of the co-ascension of [the arc] upon which the Sun has moved** by the true motion **during that day for a [given] locality. The arc of night is in accordance with the above.** Since the parts of the equal [hour] and the number of unequal [hours] are invariable, it has been said that **the difference between them is that the length and shortness of the days and of the nights is [measured] by the number of equal hours [or else] by the** parts **of the unequal [hours].** The equalized [hours] are known as those whose number changes but not their units, contrary to unequal hours. It has been determined that [the sum of] every two seasonal hours, one diurnal and one nocturnal, is equal to two equal hours since, by the amount one of the two seasonal hours exceeds the equal hour, the other [seasonal hour] is less than the equal hour. Therefore, if the arc of night is divided by 15 [degrees], that is, it is split into 15-degree divisions, the result will be the number of the equal hours of that night. The complement [of those equal hours] up to 24 [hours] is the diurnal equal hours. If [the arc of night] is divided by 12, that is, it is split into 12 equal divisions, the result, that is, the parts of each division, will be [the number of] the temporal units of the seasonal hours of that night and is called the temporal units of hours. Its complement up to 30 temporal units is [the number of] the temporal units of the diurnal seasonal hour. At the equator, and [in general] when day and night are equal, there is no difference between the two [types of the] hours because each one of the arcs of daylight and night are roughly 180. Therefore, when they are divided into 12, each division will be 15 temporal units. Therefore, parts of the equal and unequal [hours] will be equal and there will be no difference between them.

[1c] The beginning of the day according to the convention of the astronomers, Persians and Romans is the sunrise, which is the natural convention; and according to the convention of the

jurists, it is the rise of the true dawn. Therefore, the period of daylight, according to this [latter convention], is greater than [the period of daylight] according to the former by a known amount of the period of nighttime with a confined beginning, which is equal to [the period] between the rise of dawn and sunrise. The beginning of the night according to the convention of the first group is the sunset; and according to the convention of the jurists, is the passage of the Sun from the western horizon such that the darkness appears in the eastern side [of the horizon] and the coming down of the red light, as will be discussed at the end of the chapter on shadows. From what we have mentioned, the amounts of the periods of daylight and nighttime according to both groups become clear. Those who rely on the calculation take the beginning of the nychthemeron to be from the Sun reaching the meridian circle, not the horizon; because otherwise the difference of the co-ascensions will be added to the equation of time, as has been already discussed thoroughly; not because of the fact that all parts of the celestial orb do not return to the horizon, since this is not appropriate for reasoning. The westerners and the people of these [western] localities [take the beginning of the nychthemeron] to be from noon, and the easterners from midnight. However, those who do not rely on calculation take the beginning [of the nychthemeron] to be the Sun's reaching the horizon, or its departure from it. The Arabs and most jurists [take the beginning of the nychthemeron] to be the beginning of the night, because the beginning of their months is based on the visibility of the crescent which occurs mostly after sunset. It has been said that since, with regard to order, darkness is the original [quality], and that light over takes it, so it is better to take the original as the beginning. However, all others [take the beginning of the nychthemeron to be] the beginning of the day. It has been said that [the reason for this is] because their months are based on calculation, [the beginning of] which is from the beginning of the daylight; [however,] it is more appropriate [to say that this is] because the light is existential and the darkness is non-existential, and beginning from the existential is more suitable.

[2a] Now that you have learnt this, you should know that since the most known of the celestial bodies are the two luminaries, most of the nations considered the revolution of one or both of them in their convention of months and years. Also, because **the month is derived from the illuminated shapes of the moon** and its cycle is completed in almost 30 days and since, during its 12 revolutions, the year—which **is derived from the return of the Sun to its location on the zodiacal orb that results in a return of the [same] yearly condition determined by the**

seasons—is almost complete, the course/cycle of the year was based on 12 months and the course/cycle of the month was based on 30 days approximately. The year is either solar or lunar, and each one is either true [*ḥaqīqiyya*], which is called natural [*ṭabīʿiyya*], or conventional [*iṣṭilāḥiyya*], which is called customary [*waḍʿiyya*]. The month is similarly either true natural or conventional customary. The year will be a true solar year if the revolution of the Sun and its return to its [primary] position on the zodiacal orb is taken into account, not the number of days and months. Such revolution **is completed in 365 ¼** days minus 1/300 of a day, which is 1 1/5 parts of the 360 parts of a day. Since 60 is 1/5 of 300, one part of 300 is greater than one part of 360 by the amount of 1/5. This is according to Ptolemy, but there is disagreement among other masters of observation regarding the fraction added to the complete days, which is less than ¼ and is called the excess of the revolution, as has been mentioned in their books. The solar [year] is conventional if it is established based on an amount close to the amount of the true [solar year], as it will be discussed thoroughly—God the Almighty willing.

[2b] Now, the true lunar [year] is when one of the luminaries' [relative] positions is taken as the initial position until the moon returns to it 12 times—like **from one day of conjunction to another, or from one night of [first] visibility of the crescent to another, or from some other shape to its like.** Nevertheless, because the one whose positions are clearer and easier to perceive is the crescent—and [because] the moon in this situation is like [something that comes into] existence after non-existence, and [is like] the newborn coming out of the darkness—it is better to be taken as the origin of the motion of the moon, as has been believed by those among the exoterists/followers of the formal religion who deal with the months. Every return from these [12] returns is a true natural lunar month. **Its cycle is completed when the excess of the moon's true motion over the Sun's true motion becomes one revolution. Finding this is difficult. Compounding the difficulty is that it varies due to the irregularity of their motions.** As such, the excess of the moon's true motion over the Sun's true motion cannot be recorded. Therefore, it is not possible to keep the record of the cycle by [the true month]. Due to this [issue], and also because this situation, meaning the visibility, is one of those things that varies by the variation of the situation of the localities and by the variation of the moon distances from the Sun—as there is no boundary to be surpassed in the visibility of the crescents—those who rely on calculation do not consider the credibility of the visibility in issues other than legal affairs

and they take the beginning of the month to be the conjunction moment and the period of a month, the mean period between the two conjunctions.

[2c] The conventional lunar [year] is when [the number of] days and months is taken into account, not the moon's true motion nor the crescent visibility, as [was practiced by] the astronomers and those who rely on calculation. Hence, according to them, the lunar year is 354 days and 1/5+1/6 of a day. The reason for this is: since they take the conjunction as the beginning of the month, as we have mentioned, and obtaining the cycle—which is the time between two conjunctions—through the difference between the two luminaries' true motions is difficult for them; [hence,] they obtain the cycle through the difference between the two mean motions, that is, they subtract the mean Sun from the mean moon and thus what remains is the amount called the moon's overtaking [*sabq al-qamar*, *i.e.*, the mean elongation]. [This way,] the Sun seems as if it is stationary. Then, since the ratio of a single day to the elongation arc [*qaws al-sabq*] is like the ratio of the desired [number of] days [*i.e.*, the period of the cycle] to the cycle [*i.e.*, 360°], the first will be multiplied by the fourth—which will not make any changes to [the fourth] as [the first value] is one—and will be divided by the elongation. Therefore, the [number of] days between the two conjunctions will be obtained as 29 days and a half day and a fraction, the sum of which will be 31 minutes and 50 seconds of a day. Then, this amount will be multiplied by 12, the number of months of the year; thus, what we have mentioned will be obtained as the [number of the] days of a conventional lunar year. Then, since the sum of [the number of days of] every two consecutive months is 59 days, those who rely on calculation have conventionally adopted to set the first month of the year, which is Muḥarram, at 30 days, the second 29 days, and continued this arrangement till the end of the year so that Dhū al-Ḥijja becomes 29 days and (1/5+1/6) of a day, *i.e.*, 22 minutes of a day, obtaining from 1 minute and 50 seconds that is [the abovementioned fraction] added to a half day multiplied by 12. In a leap year, Dhū al-Ḥijja will be 30 days and that [extra] day is called an intercalary day, and that year a leap year. Since the fraction that is added [to a year, *i.e.*, 22 minutes] is 11 out of 30; the intercalary cycle is 30 years and the [number of] intercalary days are 11 days, because one fifth of 30 is 6 and one sixth of 30 is 5. According to the practitioners of this science, the leap years are in the order of the [*abjad*] letters *b-h-z y-j-w-ḥ a-d-w-ṭ* [*i.e.,* 2, 5, 7, 10, 13, 16, 18, 21, 24, 26 and 29], and thus the leap years of the Arab are called *bahaz yajūḥ adūṭ*. Because in the first year [of the intercalary cycle] the fraction [that exceeds a half day] does not reach ½, they do not

intercalate [that year], but in the second [year] it exceeds ½, so they intercalate [that year]; and one should draw analogous conclusions from this for the remaining [years]. Some intercalate the fifteenth year, instead of the sixteenth year, because they do not consider [the criterion of] the fraction surpassing ½ for the intercalation; rather, they intercalate even when it reaches ½, which is clearly so in the fifteenth year based on the [abovementioned] consideration. These are the conventional lunar months, also called mean due to the consideration of the mean [motions] of the two luminaries in them. It is clear from what we have mentioned that the intercalary day is the accumulation of the fractions that exceed the full days.

[3] Now, *taʾrīkh* literary means knowing the time but technically means the determination of a certain moment in order to relate to it the time that comes after it; or, as it has been said, a certain day in order to relate to it the time that comes after it; or, as it has been said, defining the time by basing it upon the beginning of the occurrence of a well-known affair, like the appearance of a nation or a dynasty, or a formidable incident like a storm or a strong earthquake and its likes among the heavenly signs and terrestrial tokens; or, as it has been said, a certain period between the occurrence of a clear affair and the time of other incidents. Based on what is being conveyed by the mentioned definitions, there is a point to each of them, arising from different considerations in using [the word] *al-taʾrīkh* for different meanings. The word *al-taʿrīkh* is an Arabized [word] derived from [the Persian word] *māh-rūz*. Its origin is that Abū Mūsá Ashʿarī wrote to ʿUmar b. al-Khaṭṭāb—may God be pleased with both—that "we have received letters from the Commander of the Faithful [but] we do not know upon which we should act. We had examined a check dated Shaʿbān but we did not know which Shaʿbān, the last or the coming." Or it has been said that a check, dated Shaʿbān, was handed to ʿUmar, then he said "which Shaʿbān, the one we are in or the one that is coming?" Thus the prominent Companions [of the prophet] gathered and said that the property has grown and what we have distributed is undated, so how can one arrive at something according to which [the distribution of money] can be recorded. Thus, Hurmuzān, who had been the ruler of Ahwāz and was captured during the Fārs conquests and taken to ʿUmar and converted to Islām through him, said that Persians have a [time] reckoning [system] called *māh-rūz* and they relate it to the Chosroe who is victorious over them. Thus, they arabized the word *māh-rūz* into *muʾarrakh* and took its infinitive to be *al-taʿrīkh* and conjugated it in different forms. Then Hurmuzān described the usage of it for them. After that, ʿUmar—may God be pleased with him—said: "Set a *taʿrīkh* [*i.e.,*

calendar] for people, based on which they can do business with each other and [so that] the time when they pursue their business can be recorded." Then, some of the attendees who were converted Jews said to him that they have a similar [time] reckoning attributed to Alexander, but others were not satisfied with it due to the length of it[s procedure]. Some people said let us write based on the Persian calendar. They were told that their calendars are not related to a certain beginning point but [that] whenever a king rises, they start their calendar from his rise and discard what came before that. So they agreed to consider [the beginning] of the calendar of the Islamic government from the emigration of the Prophet—peace be upon him—from Mecca to Medina, because there is no disagreement on [this time], contrary to the time of his mission about which people disagree, and likewise [with regard to] his date of birth, to the extent that it has been said that he was born the night of the 2nd of Rabīʿ al-Ākhir, or the night of 8th, or the night of 13th of it. Similarly, people disagree on the year he was born, so it has been said the year 40 of the Anūshīravān's kingship, or year 42, or year 43 of it. Now, the time of his death—peace be upon him—though it is certainly known, it is not appropriate to be taken as the starting point of the calendar because its consideration is not rationally commendable. Taking the time of emigration [as the starting point] is essentially more appropriate, due to its being the time of perseverance of the people of Islam, uninterrupted conquests, continuous delegations and the Muslims' domination over disbelieving people; and [things] are blessed in virtue of it and people attach great importance to it. The emigration was on Tuesday, certainly 8 days passed from the month Rabīʿ al-Awwal, and the beginning of the year, *i.e.*, Muḥarram, was a Thursday, based on the average [synodic period] and according to the statement of the scholars of *ḥadīth*; but, based on the crescent visibility and the conjunctions, it was a Friday. Thus, this [idea] was pursued, and the time was reckoned from the emigration as the starting point. Their agreement on this was in the year 17 after the emigration. Until this year, they used to call every year by the name of the occurrence that happened in it, and reckoned the time using that. So, [for example,] the first year of the prophet's—peace be upon him—stay in Medina was called the year of the permission to journey from Mecca to Medina, the second the year of the command to fight, and so on and so forth. After that, they avoided calling the year by events and reckoning time by them. This calendar is known as the *Hijra* [emigration] calendar.

[4] Now that you have learnt the meaning of the [word] *al-taʾrīkh* [calendar], you should know that there are six well-known calendars in our time: the Byzantine, Hijra, Persian, Malikī, Jewish and Turkish calendar.

[5] Byzantine calendar. The years are conventional solar, as for them the year is 365 days and a quarter of a full day, without any addition or subtraction. Similarly, their twelve months are also conventional, since they consider seven of them to be 31 [days], four 30 and one 28 [days]. There is no basis for this arrangement. Every four years, they consider the 28-day month to be 29 days due to the accumulation of the aforementioned quarters. This day is an intercalary day, and that year is a leap year. The details of the names of their months and the number of their days are as follows: Tishrīn al-Awwal, 31 [days]; Tishrīn al-Ākhir, 30; Kānūn al-Awwal, 31; Kānūn al-Ākhir, 31; Shubāṭ, 28; Ādhār, 31; Nīsān, 30; Ayār, 31; Ḥazīrān, 30; Tamūz, 31; Āb, 31; and Aylūl, 30. The beginning of their year is Tishrīn al-Awwal and its time is close to the time at which the Sun is, more or less, in the middle of Libra because the fraction they consider to be a quarter is [actually] a bit less than a quarter. That is why the beginning of their years is variable. Christians reckon [their time] based on these months, except that they consider their feast to be in accordance with the Jewish Passover, using a reckoning system they know but this is not a proper place to discuss it. The starting point of this calendar is a Monday, which is 12 solar years after the death of Alexander son of Fīlqūs [Philip], the Greek who conquered the kingships of the seven climes.

[6] Hijra calendar. The years and also the months are true lunar [years and months]. Because, as the Arab people were not skilled in keeping the record of the two luminaries' motions, they considered the beginning of the month from the visibility of the crescent and the period of the month based on what falls between every two [consecutive] crescents. Therefore, some months may be complete, *i.e.*, 30 days, or incomplete, *i.e.*, 29 days. Consecutive months may be [all] complete, to a maximum of four, [similarly,] consecutive months may be [all] incomplete, to a maximum of three. This is the case if the visibility has been taken into account; however, if the average [period] of the conjunction has been considered, then the years and months are conventional. You have learnt about this and also about the starting point of this calendar and the quality of intercalation from what has been discussed before. You should know that Arab people in pre-Islamic times [*Jāhiliyya* era] used the crescent[-based] months and went to Mecca for pilgrimage, and their pilgrimage season at that time was on the 10th of Dhū al-Ḥijja, as it was laid down by Abraham—peace be upon him. However, since it [*i.e.*, Dhū al-Ḥijja, or the month of pilgrimage] was not [always] in one of the yearly seasons, but varied, and it was once in the summer, and another time in winter, and also [sometimes] in the other two seasons, and they wanted it to be in one invariable time—which was the time of ripening of the fruits and grains and the time of temperate weather regarding heat and cold—to make traveling easy for themselves and to be able to trade their goods and provisions while performing their rituals, [once] during the [pilgrimage] season when Arab people were coming from everywhere, a speaker stood and, after praising God and extolling Him, told people that "I postpone the end of this year for one month, *i.e.,* I add one month to this year, and I will do so every three years until the time of your pilgrimage becomes the time of ripening of the fruits and grains so that you come to us with them." They agreed with him on this and did so for the sake of themselves. Then he postponed the month of Muḥarram and considered it intercalary, and deferred Muḥarram to Ṣafar, and Ṣafar to Rabīʿ al-Awwal, and the same for the rest of the months. Thus the pilgrimage of the next year was in the 10th of Muḥarram, which was Dhū al-Ḥijja for them, because since they called Ṣafar, Muḥarram and made it the beginning of the year, the next Muḥarram became Dhū al-Ḥijja and the end of the year. Thus the first year had two Muḥarrams: one at the beginning of the year and the other was the added one, and [the number of] months [of that year] became 13. This way, for three consecutive years their pilgrimage was in Muḥarram, then it moved to Ṣafar and stayed there for three years, till the end of the months. The intercalation of their years was 12 lunar months every 36 lunar years. For whoever does this intercalation, the agreement of the yearly seasons with the seasons of the solar year is more probable than whoever does the opposite, which is that the Arab people used to intercalate 12 lunar months every 24 lunar year, and this was the well-known postponing cycle in the *Jāhiliyya* era, rather than the first, even though it was more proper for their purpose. Either way, after passing two or three years and reaching the intercalation turn to the month in which the pilgrimage was, and deferring it to the next month, a speaker stood and said what he desired to say. He then said: "we put the name of the month so-and-so of the current year on the month that comes after it," that is why *al-nasīʾ* is translated to "postponement [*taʾkhīr*]" just as it was translated to "additional [*zāʾid*]." Because they moved around the additional [month] through all months in order, until for example in one years they had 2 Muḥarrams and in the other two Ṣafars and so on and so forth, when they agreed on repeating one of the sacred months—which are Rajab, Dhū al-Qaʿda, Dhū al-Ḥijja and Muḥarram, which is why it has been said three, one after another [*i.e.*, Dhū al-Qaʿda, Dhū al-Ḥijja and Muḥarram, which are consecutive], and a single one [Rajab]—a speaker stood and informed them that "in this year that a sacred month had been repeated, only one will be sacred for them according to his opinion and their benefit. When it came to Dhū al-Ḥijja in the Prophet's time—peace be upon him—and a postponement cycle of all months was completed, he performed the pilgrimage in that year, which was the tenth year after Hijra, because the pilgrimage season fell on the 10th of Dhū al-Ḥijja. That is why he did not perform the pilgrimage in one [particular] year after Hijra during which Abū Bakr performed pilgrimage with people, because the pilgrimage season fell on the 10th of Dhū al-Qaʿda. Then the Prophet addressed people and ordered them to what God willed him to, and among other things he said: "Time has completed its cycle and has come to the state of the day when God created the heavens and the earth," *i.e.*, the return of the pilgrimage season and the names of the months to the[ir] first situation. Then the Prophet recited Divine words: "Indeed, the number of months with Allāh is twelve [lunar] months in the register of Allāh [from] the day He created the heavens and the earth; of these, four are sacred […],"[clxviii] till: "Indeed, the postponing [of restriction within sacred months] is an increase in disbelief by which those who have disbelieved are led [further] astray. They make it lawful one year and unlawful another year to correspond to the number made unlawful by Allāh and [thus] make lawful what Allāh has made unlawful. Made pleasing to them is the evil of their deeds; and Allāh does not guide the disbelieving people."[clxix] [Afterward,] the Arab people were prohibited from this [kind of time] reckoning. Thus their years and months were moving around in four seasons and pilgrimage season can be in any time of the year, as it was in the time of Abraham—peace be upon him. I have seen in some of the glosses of a trustworthy individual that in the *Jāhiliyya* time, the Arab people intercalated 7 lunar months every 19 lunar years so that they became like 19 solar years. The used to add one month to the second year, one to the fifth in the sequence of 1-5-7-10-13-16-18… like what Jewish people do. It is possible that this is the reason there are different narratives from them on the fact

[clxviii] Quran 9: 36

[clxix] Quran 9: 37

that they intercalated one month every two years, or one month every three years—God knows best.

[7] Persian calendar. Their years are conventional solar year, which is 365 days. Similarly, their twelve months, *i.e.*, *Farvardīn*, *Urdībihisht*, *Khurdādh*, *Tīr*, *Murdādh*, *Shahrīvar*, *Mihr*, *Abān*, *Ādhar*, *Day*, *Bahman*, *Isfandārmadh*, are conventional, because they are all 30 [days]. This calendar originated at the time of Jamshīdh. Then they renewed it during the time of every great king, as the Byzantines do. They maintain the fraction in excess of [the number of the days of] the year, which is approximately a quarter, and take it to be a complete quarter—like the Byzantines—and add a month every 120 years to keep their years in accordance with the years of the Byzantines by this intercalation. They do not add a day after the completion of four years to the five [days] in excess of the 360 [days]—called the stolen five or the supplementary [five, *i.e.*, the epagomenal days]—or at the end of one of the months, because Persians do not have weeks; rather, every day of the month has a particular name, likewise, the supplementary five [days]; and they believe these names and the names of the months are the names of angles, and there is an invocation named after the angle of that day; hence, they believe if they add to the days of the month, their invocation will not be correct. The names of the days are: *Ūrmazd*; *Bahman*; *Urdībihisht*; *Shahrīvar*; *Isfandārmadh*; *Khurdādh*; *Murdādh*; *Day-b-ādhar*; *Ādhar*; *Abān*; *Khur*; *Māh*; *Tīr*; *Jūsh*; *Day-ba-mihr*; *Mihr*; *Surūsh*; *Rash*; *Farvardīn*; *Bahrām*; *Rām*; *Bādh*; *Day-ba-Dīn*; *Dīn*; *Ard*; *Ashtādh*; *Asmān*; *Zāmyādh*; *Mār-isfand*; and *Anīrān*. The names of the stolen [five days] are: *Ahnavadh*; *Ushtavadh*; *Isfandmadh*; *Vahasht*; and *Hashtvīsh*. Every 7 days, [the word] "*Day*" repeats, specified by the name of the next day, thus they say *Day-ba-Dīn*, *i.e.,* the *Day* that follows by *Dīn*, same for *Day-b-ādhar* and *Day-ba-mihr*. They moved the additional month from month to month. Thus, if in a year [a month] is repeated, for example *Farvardīn*, after 120 years *Urdībihisht* would repeat, and so on and so forth till the end of the months. They considered the stolen five [days] with the repeated month to keep up with the order and to avoid confusion when time extends. They are safe from making mistake in the determination of the intercalary month because they do not call it another name, nor do they repeat one single name in the coming year; but rather, they keep the intercalary month in its consecutive order so that if the intercalation falls on the month *Farvardīn*, they reckon its days to be 35 and the beginning of the year will be *Urdībihisht*, which they call *Farvardīn*, till the end of 120 years, and they continue in the same manner till it comes to *Isfandārmadh-māh*. So it will be

35 days and the beginning of the year will be *Farvardīn*. This will happen in 1440 years according to rough calculation and is called the intercalation cycle. The situation was as we have said, until the time of Yazdjird son of Shahryār son of Kasrá, known as the Just [*al-ʿĀdil*], [when] the calendar was renewed in his honor. At that time, when 960 years had passed from the intercalary cycle, the additional month had reached *Abān-māh*, to the end of which the stolen five [days] were [added]. When, at the time of Uthmān b. ʿAffān, the [Sassanid] empire fell—owing to Yazdjird['s incompetence]—at the battle with the Arabs and at his defeat before them and his assassination in the house of a miller in Marv al-Shāhjān, the five supplementary days remained at the end of the eighth month, without moving or intercalation. Because of this, some [of the Persians] always add the [stolen] five [days] to the end of *Abān-māh*, keeping it in its state, and some moved it to the end of *Isfandārmadh-māh*, because it is the end of the year. The starting point of this calendar was Tuesday, the first day of the year in which the last Persian King, Yazdjird son of Shahryār, became king, which is 22nd of Rabīʿ al-Awwal of the year 11 of Hijra. This calendar is known by his name, from among other Persian kings, because of the fall of the empire by him, as we have mentioned, and the lack of another king for whom the calendar would have been renewed to replace the former. Because the years and months of this calendar are free from fractions, astronomers employ this calendar more than others and the majority of *zīj*es, or rather all of them, are based on this calendar.

[8] Malikī calendar. It is named after the Seljuk Sulṭān Jalāl al-Dawla Malik-Shāh b. Alb Arsalan. The reason for this was that a group of scholars like ʿUmar al-Khayyām, al-Ḥakīm al-Lawkarī and others, totaling eight people, gathered at his court and set a calendar, the beginning of which was the Sun's arrival at Aries and the first day of its year, called *al-Nayrūz al-Sulṭānī*, is the first day at whose noon the Sun is in Aries. The years of this calendar are true solar years. As for its months, some consider the [number of] their days such that the Sun's arrival at the beginning of the zodiacal signs agrees with the beginning of the months, hence these months are also true solar [months]. The yearly seasons are [also] true seasons. The names of the months of this calendar are like the name of the Persian months, except that the Persian months are specified by [the modifier] "old" [*al-qadīm*], and the months of this calendar by "Jalālī," thus for example one says old *Farvardīn* and Jalālī *Farvardīn*. At that time [when the Malikī calendar was set], the arrival [of the Sun] at Aries was in the 18th of the old *Farvardīn*, so they made it the beginning of the Jalālī *Farvardīn* and took these 18 [days] as intercalary [days]. That is why people say that the beginning of the Jalālī calendar is the Malik-Shāhī or Jalālī intercalation. Some others, who are the majority of the astronomers, consider the [number of] days of each of the [Jalālī] months to be 30 so that the number of days [of each month] will not be different on the pages of the ephemerides; and they added the stolen five [days] at the end of *Isfandārmadh*, thus, the months will be conventional, and every four years they intercalate one day and [the number of] the days of the year will be 366. Since the excessive fraction is a little bit less than a quarter, the intercalation that they consider to be one day every four years is [actually] less than a day. So, they agreed that sometimes the intercalation is after five years, and this only happens after seven or eight intercalations at four year [intervals]. This, [*i.e.*, when to intercalate after 5 years] can be known through trial and error, so too, the beginning of the year in this calendar. From what we have mentioned, one comes to know ʿUmar Khayyām's mistake in his *zīj*, which he [himself] put together, where he says: "The intercalation is always every four years, and it agrees with the arrival of the Sun at the beginning of Aries." This is a clear mistake due to the fact that he did not notice what I informed you about—only God leads to prosperity.

[9] Jewish calendar. The years are solar and the months are lunar. The reason for setting up this [calendar] in this way is that Moses left Egypt with Israelites the night of Thursday, 15th of Nīsan, while the Sun was in Aries and the moon in Libra. The grandees of Israelites told him this night and its morning are not appropriate for traveling. He did not say anything and continued his way and they passed across the sea and were in hardship and poverty, eating unleavened bread. Pharaoh and his army followed them till the rest of the story in which he survived and his enemy sank. Moses regarded that day as auspicious and said: "Retain it and remember this time always and make it your feast every year at this moment, and do not change its time." At that time, the rise of the moon coincided with the sunset, while they were rubbing wheat spike by their hands to eat, and at this time in Egypt, the Sun was about to arrive at Aries. Thus, their mathematicians needed to employ solar years and lunar month and to intercalate an additional month every several year so that their prayer times would not change. They called the leap year "ʿAbbūr," and non-leap year "simple", the months of the latter being 12 and the former 13. They considered the intercalation cycle to be 19 years. They put the order of leap years and simple years like [that of] Arab intercalation in the *Jāhiliyya* time, which is 2-5-7-10-13-16-18. The difference between the two is that the Arabs moved the additional month around all the months, but the Jews do not move it around like that, rather, they simply repeat the sixth month, which is Ādhar, and postpone the sixth [month] to the seventh. Thus there will be two Ādhars in the year: first, the intercalary Ādhar, which is the one they reckon as additional; and second, the original Ādhar, which is the one they reckon within the original year, then Nīsan follows them. The beginning of their years moves back and forth between the ends of Āb and Aylūl of the Byzantine year. Therefore, the beginning of their years precedes the beginning of the Byzantine year by about a month. The beginning of Nīsan, one of their month, moves back and forth between Ādhār and Nīsān of the Byzantine year. You should know that in the time of Moses—peace be upon him—the beginning of the month was according to the crescent visibility. Afterward, the Jews split: the Karaite Jews validate the crescent visibility and, like Muslims, they do not pay attention to the difference occurring in the climes; [whereas,] Rabbinic Jews, who are the majority, consider one month to be 30 and one month 29 according to the order [employed] by those who rely on calculation, so that the beginning of the month is invariable throughout the world. In this regard, their months are like the Arabic months, which are based on the average [synodic period], except that the Jews consider three types for each one of the simple and leap years: subtractive, average and additive. The subtractive simple [year] is 353 days, the average [simple year] 354 days and the additive [simple year], also called complete, is 355 days. The subtractive leap [year] is 383 days, the average [leap year] 384 days and the complete [leap year] 385 days. They considered the starting point of their calendar from the time of Adam—peace be upon him—and believed that a period of 2448 years was between Adam's fall and Moses time—peace be upon them—and another 1000 years between Moses and Alexander. The names of their months are: Tishrī; Marḥishwān; Kislīw; Ṭībat; Shifaṭ; Ādhar; Nīsan; Iyyar; Sīwan; Tammuz; Awb; and Īlul.

[10] Turkish calendar. It is like the Jewish calendar in its years being solar and its months being lunar, except that the Turks take the beginning of the months to be from true conjunction which necessitates their calculation of ephemerides and, [contrary to the Jewish calendar,] the additional month will be whenever that agrees with their calculations of the conjunctions, so it will not be at a certain time of the year; but rather, it can happen anytime in [the year].

[11] These were examples from the calendars, and it is enough for this science; as the knowledge of each [calendar] in and of itself, and converting calendars to each other, and other

operations related to calendars belong to practical works, so whoever wants that [knowledge] should find it there.

CHAPTER ELEVEN
On the Degrees of Transit of the Stars on the Meridian and on Their [Degrees of] Rising and Setting

[1] The degree of transit of the star is the degree of the zodiacal circle that transits the meridian circle along with the transit of the star across the meridian. The degree of transit is determined by the declination circle and you have learnt that the longitudinal degree is determined by the latitude circle; therefore, if the two circles become one, like when the star is on the solsitial colure, the two degrees will be the same and the longitudinal degree will be the degree of transit. The same holds when the star has no latitude because its degree of transit will be its position on the zodiacal [circle], which is its longitudinal degree. In other situations, the two degrees differ and the maximum difference will be when [the star] is close to the beginning of Aries and Libra, and its minimum when it is close to the beginning of Cancer and Capricornus. What is between the two degrees [*i.e.*, star's longitudinal degree and its degree of transit] is called the transit difference. The equinoctial arc which is between the equinoctial's intersection with the star's latitude circle and its intersection with the star's declination circle is called the equation of transit degree. Now that you have learnt that, we say **when the poles of the zodiacal [orb] are on the meridian circle, this being when the two solstice points are also on it and the two equinox points are on the horizon, then the transit of the stars at that time is along with their degrees in longitude since the meridian circle is their latitude circle. When the visible pole of the zodiacal [orb] is to the east of the meridian (this occurring, if the visible pole is northerly, during the transiting of the half of the zodiacal orb bisected by the autumnal equinox and the rising of the southern half [of the zodiacal], or, if [the visible pole] is southerly, [during] the transiting of the [corresponding] other half and the rising of the [corresponding] other half), then the star whose latitude is in the direction of the visible pole will transit the meridian circle after its degree [in longitude has done so] since its latitude circle extending from the** closer **pole** first **meets the star,** which is on the meridian, then meets its degree, which has already transited and become westerly with respect to the meridian. **Thus when its [longitudinal] degree reaches the meridian, the star will still be to the east** of it. **The star whose latitude is in the direction opposite the visible pole transits [the meridian circle] before its [longitudinal] degree since the latitude circle mentioned above first meets the star's [longitudinal] degree that is on the meridian; it then meets the star, which has already transited and become westerly. When the visible pole is to the west**

(this occurring, if the pole is northerly, during the transiting of the half of the zodiacal orb bisected by the vernal equinox and the rising of the northern half [of the ecliptic], or, if it is southerly, [during] the transiting of the [corresponding] other half and the rising of the [corresponding] other half), then the star whose latitude is in the direction of the visible pole will transit before its degree [in longitude has done so] and that whose latitude is in the opposite direction will transit after it for exactly [the reasons] we have stated.

[2] The degree of rising or setting of a star is the degree on the zodiacal circle that rises or sets with the star. Thus, if the star has no latitude, its longitudinal degree will be its degree of rising and setting, similarly if the star reaches the horizon with the pole of the zodiacal [orb], because then the horizon will be its latitude circle due to its passing through the star and through the zodiacal pole. Now, the simultaneous arrival of the star and pole at the horizon will only be conceivable: [1] at the equator, when one of the two solstice point is the degree of the star, and [2] in the localities whose latitude does not exceed the obliquity, [when] one of the [zodiacal] parts between the beginning of Libra and the end of Sagittarius [is the degree], if the arrival happens in the eastern region [of the horizon]; [or when] one of the [zodiacal] parts between the beginning of Capricornus and the end of Pisces [is the degree], if the arrival happens in the western direction. This is because [in these situations] the northern zodiacal pole rises before the beginning of Capricornus and sets after it whereas in other situations, the degree of rising or setting will not be the same as the longitudinal degree. In this [situation], we say the horizon either has no latitude or has latitude. If there is no [latitude], like the horizons at the equator, **the rising and setting of the stars in** those [horizons] **are similar to their transit across the meridian for other horizons. Thus a star that reaches the horizon along with the solstice,** reaches [the horizon] with the pole as well and, for what we have mentioned, **rises or sets with its [longitudinal] degree; one that is in the direction of the visible** zodiacal **pole rises in advance of its [longitudinal] degree and sets after it; and one that is in the direction of the invisible pole rises after its [longitudinal] degree and sets in advance of it.** This is because the latitude circle extending from the visible pole reaches the star on the horizon before its degree in the northern [stars] and, in the southern [stars], it reaches the degree on the horizon and then the star below the Earth. **The northern pole will be visible there during the period of the rising of the half bisected by the vernal equinox and the transit of the southern half across the meridian from above [the horizon]; the southern pole will be visible during the period**

of the rising of the [corresponding] other half and the transit of the [corresponding] other half.

[3] If the horizon has latitude, the order of **the rising and setting of the stars** will be as it is at **the equator except for the transit and the rising of the halves of the zodiacal orb. For that will vary: it may be that one of the poles is visible and what transits or rises will be an arc that is smaller or larger than a half.** Then the latitude of the horizon is either greater than the obliquity, or equal to it, or less [than it]. If it is greater, the difference will be of the same nature because **one of the zodiacal poles will be permanently visible,** thus the star whose latitude is in the direction of the visible pole will rise before its [longitudinal] degree and set after it; and vice versa for the opposite [situation]. If the latitude of the horizon is northerly, this difference will be at its maximum in Aries during rising or in Libra during setting; and vice versa if [the horizon's latitude] is southerly, in the same manner as has been mentioned in [the discussion of] the degree of transit. If the star is in the first of Cancer or [the first of] Capricornus, the differences in rising and setting will be equal because the latitude circle is the declination circle at that time since the two of them are the solstitial colure; it will be the opposite if the star is at neither of the two [firsts], so the differences [in rising and setting] will not be equal. If the latitude is equal to the obliquity, the situation will be clear. If [the latitude] is less than [the obliquity], since the zodiacal pole will not be permanently visible but will rise and set, the difference will have two states. If the latitude of the horizon is northerly, the rise of [zodiacal pole] will be before the first of Capricornus and its setting after that; and vice versa if [the latitude of the horizon] is southerly. The distance of the degrees of the rising of the [zodiacal] pole and its setting from the first of Capricornus will be the same, in the same manner as we have mentioned. This being so, if the [zodiacal] pole is visible, the star whose latitude is in the direction of [that pole], will rise before its degree and set after it, and vice versa if [the star's] latitude is in the opposite direction of [the pole]. Both [cases] will be opposite if the pole is invisible, *i.e.*, the star will rise after its degree and set before it, if [the star's] latitude is in the direction of [the pole], and rise before [its degree] and set after it in the opposite [condition]. It is clear that if the rising degree is between the Sun and the part diametrically opposite [the Sun], the star will rise during the day; and if [the rising degree] is between the part diametrically opposite [the Sun] and the Sun, [the star] will rise during the night. If the setting degree is between the part diametrically opposite [the Sun] and the Sun, the star will set during the day;

and if [the setting degree] is between the Sun and the part diametrically opposite [the Sun, the star] will set during the night. It is [also clear] that from among the stars along a great circle that intersects the greatest permanently visible [day-circle], the closest [star] to the visible pole rises before the farthest star [from the visible pole] and sets before it. Because of this, the difference between the degrees of longitude and rising for [the star that is] closer to the pole is greater than the [difference] between the two degrees for [the star that is] farther from [the pole]. [This] becomes clear by consideration—God the Almighty willing.

CHAPTER TWELVE
On Shadows and Their Circumstances

[1] You should know, **firstly,** that the light is a quality, the vision of which is not dependent on the vision of another thing. [The light] is divided into primary and secondary, the primary being the light attaining from a self-luminous [object] and the secondary being the light attaining from [an object] illuminated by another; e.g., the light of the vapor sphere upon the time of daybreak is primary, because it is from the Sun, whereas the light of the Earth's surface at that time is secondary, because it is not from the Sun—as it only illuminates [what is in] front [of it]—but rather it is from the vapor illuminated by [the Sun's] light, which illuminates the surface of the Earth through reflection. In fact, when the ray [of light] comes across a thick [object] it reflects from it, and then when the reflected ray comes across another thick [object] it reflects from it again a ray weaker than the first, and so on and so forth for the third and fourth [reflections] until it vanishes. This is because [the reflected ray] becomes weaker as it gets farther from the source [of light] until it ceases to exist, thus darkness occurs, as it is equivalent to the lack of light from whatever can be illuminated. The shadow is the secondary light that bears strength and weakness, and its two extremely far limits are light and darkness.

[2] **Secondly,** [be aware] that the gnomon is an erect rod standing at right angles either on a surface parallel to the horizon's surface like a timber implanted in the ground on a level surface, or on a surface perpendicular to the horizon's surface like a pin in a wall. Thus the former is perpendicular to the horizon and the latter parallel to it.

[3] **Thirdly,** [be aware] that the shadow we are talking about is the secondary light extending from the base of the gnomon. It is the intersection between the surface on which the gnomon is [standing] and the surface of the altitude circle, as it always passes through the Sun and gnomon and thus intersects the perpendicular surface on which it stands. The end point of the shadow is the intersection point between the surface on which the gnomon stands and the line extending from the center of the Sun to that surface, passing through the gnomon's tip. [This endpoint] is actually the shadow of the gnomon's endpoint, thus it is called the shadow's endpoint, because the shadow of the endpoint is the shadow's endpoint, just as the shadow of the midpoint is the shadow's midpoint. The hypotenuse of the shadow is the line connecting between the gnomon's tip and shadow's endpoint on the abovementioned line [extending from the center

of the Sun]. Thus, from the height of any gnomon, its shadow and the hypotenuse of its shadow a right triangle occurs, [the right angle of] which is between the gnomon and the shadow. The shadow's arc is the arc of the [solar] altitude according to which the shadow is [cast], as there is a shadow for any [solar] altitude less than the upper limit, *i.e.*, 90. As the upper limit for the altitude of the Sun in terms of its distance from the Earth['s horizon] is 90 degrees and its lower limit is when the Sun is on the horizon, the upper limit for [the length of] the shadow is infinity and its lower limit is when there is no shadow.

[4] When the gnomon is parallel to the horizon /and is with the Sun in the plane of the altitude circle,/† [i] the shadow being cast from it, which is parallel to the Sine of the altitude, is called the first shadow, as it is the first shadow that appears at sunrise. [It is also called] reversed or inverted [shadow/*umbra versa*] because its tip is from beneath what comes next to the horizon; or erect [shadow/*umbra recta*] either due to its being upright with respect to the horizon, not spread over it, or due to the gnomon being erected with regard to the Sun. When the gnomon is perpendicular to the horizon, the shadow being cast from it, which is parallel to the Sine of the altitude's complement, is called the second or planar shadow, as opposed to the other which is called first and reversed; and also spread [shadow] due to its spreading over the visible horizon, and thus it is also called planar [shadow]. /The surface on which this shadow is cast is fixed, in contrast to the one on which the first shadow is cast, as it moves constantly so that it always remains perpendicular to the planes of the horizon and the altitude circle./† [ii] According to what is commonly held in the practical handbooks, the second shadow is used for determining the time, as we will discuss, and the first, for astronomical operations. In the practical handbooks, when the [word] shadow is used without any determiner, the first is intended, but in this science, when it is used without any determiner, the second at noon is meant, and by "its directions," the north and south directions [are meant].

[5] Since the beginning of one of the two shadows [*i.e.*, the first and second] is like the end of the other, and vice versa; because when the Sun is on the horizon, there will be the beginning of the first [shadow] and the end of the second , and afterward the first keeps increasing and the second decreasing in accordance with the solar altitude till the Sun reaches the zenith, when there

---

[i] and is with the Sun in the plane of the altitude circle] margins of **K** and **L**.
[ii] The surface on which this shadow is cast… to the planes of the horizon and the altitude circle] margins of **K** and **L**.

will be the end of the first and the beginning of the second—one should draw analogous conclusions from this for the other quarter [of the solar altitude]—then, the first shadow for any [solar] altitude will be the second shadow of that altitude's complement, and vice versa. The [length of the] shadow of one eighth of a revolution, be it first or second, is equal to [the length of] the gnomon. When the shadow coincides with the east-west line, the altitude has no azimuth, and when it coincides with the meridian line, the Sun is at the meridian.

[6] You should know that the shadow is always measured by the unit with which the gnomon is measured. The shadow can be measured by the gnomon, no matter which unit it is supposed to have. However, it is common to consider the gnomon of the first shadow 60 parts, and some take it to be one degree. [It is also common], sometimes, to divide the second [shadow's] gnomon into 12 divisions, called digits [*aṣābiʿ*], because the span of the hand is the first thing with which one measures, and its amount is 12 digits. Or this is because when one wants to install a pole on the horizon's plane, or on a plane perpendicular to it, he is usually intent on its amount being one span of the hand. [It is also common sometimes to divide the second shadow] into 7 or 6 ½, called feet [*aqdām*], because the height of an average person is 6 ½ or 7, together with the fact that if one wants to know if the shadow of a thing becomes as long as [the thing], he measures [the thing] with his height and then [the shadow] with his feet. The [second] gnomon is also divided into 60 [divisions], called parts. The first is called the shadow in digits, the second the shadow in feet, the third the sexagesimal [*al-sittīnī*] shadow.

[7] According to what you have learnt from previous chapters, since the maximum solar altitude is the inclination of the Sun's degree plus local colatitude if the Sun is in the direction of the visible equinoctial pole, or by the excess of the local colatitude over the inclination if the Sun is in the other direction; thus, the longest shadow in the northern regions with one shadow will be the shadow of the head of Capricornus because its altitude is the smallest altitude, hence its shadow is the longest shadow; the shortest will be the shadow of the head of Cancer, as its altitude is the greatest altitude; and the midpoint of the two shadows [*i.e.*, the longest and shortest] will be the shadow of the equinoxes, due to its altitude being the midpoint of the two altitudes. One should draw analogous conclusions for the southern region and regions with two shadows.

[8] Now that you have learnt sufficiently about the circumstances of the shadow in [the chapters on] the characteristics of horizons, listen to [some] examples about the circumstances of its endpoint. Thus we say that the endpoints of the gnomon's shadows describe [one of] the five orderly lines, *i.e.*, the outer limit of three [conic] sections, [namely] hyperbola, ellipse and parabola, together with the circle and straight line—as only these five lines or a combination of them are orderly. The proof of [the fact] that [the gnomon's shadows describe the five orderly lines] is: it should be clear for you, after grasping what has passed from the previous chapters, that the gnomon's tip is considered to be the center of the Earth since [the Earth's] size is insignificant compared to that of the Sun's orb; and that the visible horizon is like a surface below the center of the world; and that in 24 equal hours the Sun describes a circle parallel to the equinoctial, although approximately, not precisely; and that if the line extending from the center of the Sun, *i.e.*, from the circumference of its day-circle, and passing through the gnomon's tip, continues through in the other direction, it will reach the [day-circle] directly opposite to the aforementioned [solar] day-circle because the gnomon's tip is considered to be the center. /This is so when the [solar] day-circle is other than the equinoctial, otherwise the aforementioned line will reach the equinoctial in the other direction as well and necessarily passes through its intersection with the horizon; so keep it in mind, to make use of in future—may God, the Almighty willing./† [iii] [It is also clear] that the aforementioned line with its complete revolution produces two cones with their vertices as the gnomon's tip and their bases are two equal day-circles parallel to the equinoctial from either side and their axis is the axis of the world, one with the [light] ray on its surface and the other with the shadow of the gnomon's tip on its surface. We call the first [cone], which is next to the Sun, the ray cone and the other, the shadow cone. [It is also clear] that the plane of the meridian due to its passage through the axis of two [cones], which is the axis of the Universe, creates two triangles in them, and that the intersection of the horizon with the meridian, in fact with the triangles, as they are in the plane of the meridian, will be at right angles.

[9] This being so, the visible horizon upon which the given gnomon is erected and seems to be beneath the center of the world, intersects either both triangles or only one of them. If the first is [the case], it will produce a pair of hyperbolas in the two cones because the intersection of

[iii] This is so when the day-circle is other than the equinoctial … God the Almighty willing] margin of **K** (without "the Almighty"); margin of **L**.

each triangle and the plane perpendicular to it, *i.e.*, the horizon, traverses one of the [triangles'] sides and meets the other [side] in the direction of the triangle's vertex. The transverse axis of the pair of hyperbolas is a segment of the meridian line between the two points of intersection of the horizon with the sides of the triangles. The center of the pair of hyperbolas is the midpoint of this axis. If the second is [the case,] the intersection between them, *i.e.*, between the horizon and the triangle, will either be parallel to the other side [of the triangle] or intersect it in the direction of the base, as there is no possibility of intersecting it in the direction of the triangle's vertex on this assumption, otherwise it would intersect both triangles which contradicts the assumption. If it is the first [case], then it will produce a parabola in the cone because the intersection of the triangle and the plane perpendicular to it meets one of the [triangles'] sides and is parallel to the other [side]. If it is the second, then the intersection of the triangle and the plane perpendicular to it is either parallel to the triangle's base or not. Then, if it is the first [case], it produces a circle in the cone, for what has been mentioned earlier in [proposition] 39. If it is the second [case], it produces an ellipse in [the cone] because the intersection of the triangle and the plane perpendicular to it traverses both sides of the triangle in the direction of the base, while it is not parallel to it. It is impossible for the opposite situation [*i.e.*, being parallel] to happen, such that it would produce a circle, given that the cone is isosceles. This could only happen in a scalene [*i.e.*, oblique] cone. The [ellipse's] longest diameter is a segment of the meridian line between the intersections of the horizon with the two sides of the triangle.

[10] Now that you have learnt this, we say that the Sun is either in one of the equinoxes or not. If it is the first [case], then the endpoint of the gnomon's shadow describes a straight line in all horizons except for the latitude 90 where, under this circumstance, there is no shadow endpoint for anything. This is because the Sun is always in the same plane with the illuminated object and the opaque object, if the latter is a point or a line. Thus any plane on which the shadow of the gnomon's tip is cast will certainly intersect the equinoctial plane; and the shadow will be cast along the intersection between them, /which is a straight line,/§ [iv] /and/§ [v] upon which the shadow's endpoint traverses, hence it describes a straight line.

[iv] which is a straight line] - **B**; crossed out in **K** and **L** = + as has been mentioned earlier that the ray line passes along the intersection of the equinoctial and the horizon which is a straight line that at the equator coincides with the equator line and passes through the gnomon's base, but in localities other than the equator it is parallel to it and is to the north of the gnomon's base in the northern region, and to the south of it in the southern, and thus does not pass

[11] When the Sun is not in the equinoxes, the endpoints of the gnomons' shadows in [localities] between the equator and the latitude equal to the complement of obliquity describe hyperbolas facing each other, *i.e.*, those described by the northern ones are facing those described by the southern ones. This is because these horizons intersect all solar day-circles as they all rise and set at those localities. Therefore, their horizons intersect both triangles and produce what we have mentioned because every plane that intersects with two cones facing each other, without passing through their vertices, produces a pair of hyperbolas in them, except[§ vi] in the equinox days wherein [the endpoints][§ vii] describe a straight line in the cones—which is the major axis of the aforementioned sections, since it passes through their center and is the point of the transverse axis, *i.e.*, the line that falls between the two loci of the shadow's endpoints at noon of those days [of the equinox].

[12] And[§ viii] in the head of the solstice that is in the direction of the visible pole—like the head of Cancer in the north in this latitude, which is the latitude equal to the complement of obliquity—the endpoints describe a parabola. This is because the line extending from the center of the Sun, which is the north point, passing through the gnomon tip and ending at the south point, is parallel to the plane equivalent to the horizon, on which the gnomon has been installed. Thus, the intersection of this plane and the meridian plane, which meets one of the triangle's sides, is parallel to the aforementioned line, which is the other side of the triangle. Hence, the horizon produces a parabola upon whose perimeter will be the loci of the endpoint of the

through it, as comes to the mind. Otherwise, it is impossible to have the shadow of equinoxes at noon in localities other than the equator, and the reality contradicts this: **B**; margins of **R**, **K** and **L**.

[v] and] and because: **B** and **R** = +because: added later within the text of **K** and **L**.

[vi] except] but: **B** = has been changed to "but:" **K**, **L** and **R**.

[vii] that they] + as you know: **B**; above the line in **K**; margins of **L** and **R**.

[viii] and] + as you know: **B**; above the line in **K**; margins of **L** and **R** = + If one says that since the straight line is the major axis for them, if the convexity of the northern sections is toward the north, and the southern ones toward the south, in spite of all of them being to the north of the gnomon, as the aforementioned axis is to the north of it in these latitudes, as we have explained, we will say that it is so, because the Sun either reaches the zenith or does not. If it reaches there, section's convexity at that time will be [touching] the gnomon's base because of its coincidence on the surface of the shadow cone. Otherwise, the convexities are to the north of gnomon and toward the visible pole, when the Sun is in northern day-circles, because the gnomon is inside the shadow cone, and the horizon cuts off whatever next to its north; or toward the invisible when the Sun is in southern [day-circles], because the gnomon is outside of it, and the horizon cuts off whatever next to the south of it. It is clear that the convexity of sections and the distance between their vertices and axis increase in accordance with the increase in the distance between the bases of the cones, the maximum of which is when the Sun is in the solstice. They also decrease by the decrease in the distance between them, the minimum of which is when the Sun is in the day-circle from which it shifts to the equinoctial, because the perimeter of the section at that time is nearly straight till it reaches the equinoctial when both bases coincide with it and the perimeter of the section becomes a straight line for what has been mentioned before, and also for the cones are vanished. Learn this as is of subtle conceptions. Now: **B**; margins of **K**, **L** and **R**.

gnomon's shadow, if the Sun is in the solstice which is in the direction of the visible pole. If the Sun is in the other [solstice], no shadow will be cast for anything, since the Sun is below the Earth at that time.

[13] [In the localities] whose latitude exceeds this latitude, but does not reach a quarter [of a revolution, *i.e.*, 90°], where the zodiacal orb is divided into four segments: one of them—bisected by the solstice which is in the direction of the visible pole—is permanently visible; the second, facing [the first]—bisected by the other [solstice]—is permanently invisible; and the two remaining ones rise and set. [In such localities,] the endpoint of the gnomon's shadow describes hyperbolas when the Sun is in the arc that rises and sets because the horizon intersects all the day-circles of the parts of that arc. [It describes] parabolas when the Sun is at the two endpoints of the permanently visible arc because the horizon touches the day-circles of both points. [It describes] ellipses when the Sun is in the rest of the permanently visible arc because the horizon intersects all the sides of the shadow cone but is not parallel to its base, as the pole is not at the zenith, and hence it produces an ellipse. Its longest diameter [*latus rectum*] is [a segment] of the meridian; and the diameter's two endpoints are where the shadow's endpoint falls when the Sun is in the meridian at that day; and the center of the section [*focus*] bisects this diameter. But when the Sun is in [the arc] opposite the permanently visible arc, the shadow's endpoint describes nothing as there is no shadow for anything at that time.

[14] In the latitude 90 where the day is 6 months and 7 days, and that is 187 days, and the night is approximately 178 ¼, the shadow's endpoint describes approximately parallel complete circles, one within the other, on one center, which is the center of the gnomon's base; the smallest of them is when the Sun is in the visible solstice and the greatest of them when the Sun is near the horizon above the Earth. It describes a circle because the horizon intersects with the shadow cone parallel to its base, as its axis is perpendicular to the horizon plane. Since the loci of the shadow's endpoint is the five aforementioned lines, namely, the straight line, circle and three [conic] sections, it is correct that the shadow's endpoint describes four orderly forms and the straight line. Here is the end of the discussion.

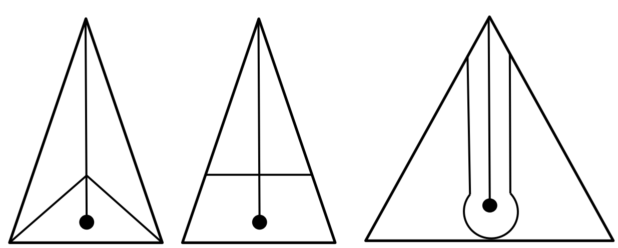
[15] Now, the determination of the [prayer] times whose explanation was promised. Be aware that everyone agrees that the time of *ẓuhr* prayer is after noon, even if it is one minute, not when the Sun is at the meridian. This time can only be determined through the inclination of the

shadow to the east with respect to the meridian line. If the meridian line is not extracted, then it is through the formation of the shadow, in case there was no shadow at noon; or through its addition to what was [at noon], in case there was some shadow at that time. Then, when the shadow grows more than what remained from it[s length at noon] by the amount of the gnomon['s length], or [when] it is formed equal [to the length of the gnomon]—in case no shadow was left [at noon]—it is the beginning of *ʿaṣr* time according to the *Ḥijāz* authorities, on the school of al-Shāfiʿī—may God be pleased with him. According to *ʿIrāq* authorities, if it forms or grows by the amount of twice the gnomon's [length], it is the beginning of *ʿaṣr* time on the school of Abū Ḥanīfa—may God be pleased with him. The easiest method of its determination is to install a cone shaped gnomon with a sharp tip perpendicular to the horizon plane, divided into 12 or 7 parts. As long as the shadow decreases gradually, the Sun has not yet reached the meridian. Then, when the shadow stops and grows no longer, the Sun has reached the meridian. When the shadow has started to grow in the least bit, it is the beginning of *ẓuhr* time. Then we mark the shadow's tip and call that the noon amount. Then, we wait for the shadow to become equal to the gnomon from the marked position, or twice [the gnomon's length], to be the beginning of *ʿaṣr* time according to both schools. Now, the beginning of *maghrib* time is [determined] by sunset, if its setting is visible, like in deserts. But if it is not visible, like in the middle of mountains or populated areas, [it can be determined] by the fact that no ray stays at the top of walls or mountain peaks, and the darkness and blackness proceed from the eastern side. The beginning of the *ʿishāʾ* time is [determined] by the setting of dusk, which is the redness—according to al-Shāfiʿī—or whiteness—according to Abū Ḥanīfa, may God be pleased with both—that follows the Sun. The beginning of the *ṣubḥ* prayer time is [determined] by the rise of the true second dawn, which is a wide spreading whiteness, not the false first [dawn] which is a thin elongated whiteness.

[16] This is what we wanted to present about the circumstances of the shadow and what pertains to it.

CHAPTER THIRTEEN
On Finding the Meridian Line, Which Is Also Called the Noon Line **and on the *Qibla* Direction**

[1a] For this purpose we need a level surface. In order to obtain it, we level an area by choosing a ruler free of any deformation, positing its middle on a point at the middle of that area, and rotating the ruler on that surface until it touches the ruler all around so that no light is visible between them. Then we examine the correctness of this way using a plumb square [*al-afādhayn*], which is also called a set square [*al-gūniyā*]—its illustrations follow—by placing one base [of the plumb square], no matter which one, the way [that is shown in the illustration] and examining the conformity of the plumb line with the height of the triangle. We then level the highs and lows of the surface till it becomes such that if the base of the triangle rotates all over the surface, the [plumb] line does not incline from the height. This is what is called a level surface—on which the observational astronomers and workers rely—as opposed to the prevalent [definition], which is: the ground is leveled so that if water is poured over it, it flows evenly in all directions; or if a rolling thing, a hazelnut for example, is thrown on it, it stands in place trembling, without inclining to any direction. [The latter definition] will not be helpful, as is clear. Then, if the level surface is not on the ground, but on a rock or its likes, we fix it so that its position and balance will not change.



[Figure 10]

[1b] We draw on the level surface a circle smaller than the greatest one that can be drawn on it, by the amount of a finger, in order to indicate the place of the entrance and departure of the shadow. [Then,] using a polishing instrument, we make a cone-shaped gnomon out of copper or

wood so thin that the shadow [it makes] will not be thick. [However,] it should not be extremely thin so that its shadow will not appear. We consider the width of its base so that if we place it on a surface, it stays up-right without trembling. [We do this] by creating a hole in the middle of its base—if it is [made] from wood, not copper or its likes—and cast some lead in it so that it becomes heavy and stands firm. It is generally understood that the length of the gnomon should be a quarter of the diameter of the circle drawn on the surface or more, on the condition that it does not reach half of the diameter. This condition is imposed because if its length is equal to half of the diameter, and given that when the altitude [of the Sun] is 45 [degrees] the shadow of everything will be equal to it[s length]—according to what we have mentioned about the shadow that the shadow of [the solar altitude of] 1/8 a revolution [*i.e.*, 45º which is 1/8 of 360º] equals the gnomon [length]—then, the endpoint of the shadow will only reach the circumference of the circle wherever and whenever the [solar maximum] altitude is 45, [hence] this method will not work. [However], it is better to say that the length of the gnomon should be [equal to] the amount by which its shadow at noon falls short of [reaching] the circumference of the circle, and exceeds it before and after noon.

[1c] Then we draw around the abovementioned center a circle equal to the base of the gnomon or a bit larger so that if we place the base on it, [either] it coincides with it or we see the circle parallel to it encompassing the base from all directions . Then the center of the gnomon will coincide with the center of the circle, and the gnomon will be perpendicular to the surface. This is what is taken into account and upon which is acted to render the gnomon upright, not its examination with the plumb line, nor by measuring [the distance] between the gnomon's tip and the circumference from three points on the circumference such that [the distances] are of equal amount—even though they are common. Then, before noon we observe the endpoint of the shadow reaching the circumference of the circle from the western direction. Upon its reaching there, and before its entering to [the circle], we bisect the width of the shadow and put a mark there. The middle point is the entrance point. We do the same on the other side. Thus the middle point will be the exit point of the shadow. We then bisect one of the two arcs [between the entrance and exit points] and connect the middle point to the center with a straight line. That will be the meridian line, *i.e.*, the intersection of the horizon and the meridian circles. This is because the two shadows [of the entrance and exit time] are equal, for they are equal to the radius of the same circle, and equal shadows are cast for equal [solar] altitudes. This, even though it can be

proved, is no less than the first principles when it comes to conceiving the increase and decrease in the shadow['s length] with respect to the decrease and increase of the altitude [of the Sun]. Hence, the altitude [of the Sun] for the two shadows are equal and thus the chords of their complements are equal, which are equal to the lines extending from the center of the gnomon along the two shadows, as the shadows are on the intersection of the horizon and altitude circles, and likewise for the two mentioned lines. These two lines end where the stones of the altitudes fall, *i.e.*, their chords. The line connecting between these two endings is equal to the chord of the revolution of daylight between the times of the two altitudes along the day-circle and parallel to it. This is because the lines connecting the endpoints of equal parallel lines—like the two chords in our examples, which are equal and parallel because both of them are perpendicular to the horizon—are equal and parallel.

[1d] Since every two points in one day-circle with equal amounts of altitude are in different directions from east and west, they have equal distance from the meridian, since the meridian bisects the segment of the day-circle that falls between the two points. This is because, due to the equality of their altitudes, their altitudes' almucantar that intersects the day-circle is the same. Due to the intersection of the almucantar and the day-circle, and the passage of the meridian through their poles, their segments will be bisected, as has been mentioned in [proposition] 8. Thus, the plane of the meridian bisects the chord of the revolution of daylight between the two altitudes and [also bisects] the line parallel to it which connects the two ends of the chords of the complement of the two altitudes. That plane also bisects the line connecting the two endpoints of the shadows, due to the similarity of the two triangles for their bases being parallel, apparent from the coincidence [of the two bases], and also for the equality of their vertex angles, and [for] their being isosceles. If the meridian bisects the line connecting the endpoints of the shadows, then the line connecting its midpoint and the center of the gnomon will be in the plane of the meridian, which was desired. We actually bisected the arc, since it does not require any other action, in contrast to the halving of the connecting line, which [actually] needs to be drawn.

[1e] Now, we should resolve the desired in another way. We say: since the meridian bisects the segment of the almucantar between the two altitude circles, as has been mentioned earlier, and the meridian and the two altitude circles pass through the poles of the horizon and the almucantar, which are parallel; therefore, similar arcs will be cut from any parallel [circle]

between them, as has been explained in the *Sphaerica*. Thus, the two arcs along the almucantar are equal [to one another] and similar to the corresponding ones on the horizon; thus, [the arcs along the horizon] are also equal. Because of their equality and the horizon's being parallel to the circle drawn on the level surface—as their centers are the same, which is the center of the [base of the] gnomon—if one connects the center and the endpoints of each one of the arcs on the horizon by two straight lines, two equal arcs will be cut from the constructed circle. This is because the lines extending from the centers of the parallel circles cut between them similar arcs from their circumferences. Thus if the meridian bisects the arc between the endpoints of the two shadows, then the line passing through the center, halving the mentioned the arc, is in the plane of the meridian and its line, which was desired.

[2a] After comprehending what we have mentioned, it becomes clear that if the length of the gnomon is equal to the radius [of the circle drawn on the surface], when the endpoint of the shadow reaches the circumference of the circle, then the shadow will be in the plane of the meridian, if the maximum altitude is 1/8 of a [complete] revolution [*i.e.*, 45º], according to what has been mentioned. The line **pass**ing **through the center of the drawn circle,** being in its plane, perpendicular to the meridian line, is aligned with the circle of the initial azimuth, **is the east-west line,** and the equinox line**. The two [lines] divide the circle into fourths. Each fourth is then divided into 90 equal parts in order to find the measures of the azimuths from the shadow lines falling on the circumference, since [the number of] these parts between the east and west points and the shadow line is the azimuth. This circle is known as the Indian.**

[2b] You should know that the best time to record a shadow is when the altitude of the Sun is [approximately the lengths of] two spears. Since, when the Sun is close to the horizon, the shadows are long with blurry endpoints and thus their endpoints cannot be ascertained through sensation. If the Sun is close to the meridian, the shadows, even though fully dark [and clear], shrink slowly; therefore, the moment of the entrance of the shadow or its exit cannot be determined. Thus, neither the equality of the two intervals from the noon, nor the meridian line can be determined. However, in the middle position, the shadow's fast motion and its color [*i.e.*, full darkness] come together, and one stays safe from the blurry end of the shadow and its slow motion. [Also the best time to record a shadow] is when the Sun is in the summer solstice or

close to it. This is because its inclination from a [day-circle] parallel to the equinoctial at the time of its motion in the period between the entrance of the shadow and its exit, is not a considerable amount such that it would be disruptive to [our] purpose; since this proof is based on the fact that according to one's perception, the Sun rotates along a [single] circle parallel to the equinoctial during a single day. [This is also] because at the time [of the summer solstice], [the Sun's] light is more intense than its light [when it is] in Capricornus, as was mentioned earlier regarding the accumulation of the rays in summer rather than winter. The more light, the clearer the distinction between the ray and the shadow.

[2c] You should know, along with what you have learnt, that just as the equal shadows correspond to equal [solar] altitudes, the equal altitudes correspond to equal shadows. This being so, if two equal altitudes are observed in one day before and after its maximum altitude, and the azimuths of their shadows from a single gnomon are drawn on the level surface, and if the angle occurring between the two [azimuths] is bisected by a line, that line will be in the plane of meridian, and the *a posteriori* justification for this is clear from what has been mentioned earlier. Now, in order to bisect an angle, two equal amounts from the shadow from the axis of the gnomon should be separated, and a line should be connected between them. Then that line should be bisected, and its midpoint and the angle['s vertex] should be connected with a line. It is easier to consider the angle's vertex as a center and draw a circle that intersect with the two shadows, and then bisect the arc between them and connect [the midpoint and the angle's vertex], as was mentioned.

[2d] Kūshyār says: "We level an area on the ground until its surface becomes parallel to the horizon and draw a circle on it, then we insert a straight needle into the center [of the circle] and examine its being perpendicular to the surface from three distant points on the circumference of the circle. Then, if it were almost noon, we observe the shadow of the needle's tip, which is becoming shorter, by marking its positions using the tip of another needle, very closely, as they rotate, and we continue marking till the shadow starts to become longer. Then we connect the center to the closest mark to it with a straight line, which is the meridian line. Another way is to level the ground and [draw] the circle and [erect] the gnomon, as we have mentioned, except that the circle is [made] equal to the altitude circle, which is at the back of the mater of the astrolabe in use, and that the height of the gnomon is such that its shadow at noon will not be less than the

circumference of the circle. Then we extract the azimuth of the altitude before or after noon, and during the time of that altitude we mark the position of the shadow on the circumference of the circle. Using a pair of compasses, we separate the amount of the complement of the azimuth from the altitude circle on the astrolabe, and put one of the compass' legs on the mark, and the other leg where it falls on the circle's circumference in the direction of the altitude, whether it be eastern or western, and extend a line from there to the center of the circle to be the meridian line. If there is no azimuth for the altitude, the azimuth of the shadow is the east-west line and the line extending from the midpoint [between] its two endpoints to the center of the circle is the meridian line. There are many ways to obtain this line, except that all of them are inferior to these two in their being thorough and close to correctness, if we take practice into account; otherwise, all of them are correct and justified scientifically." All of this is his wording, and I quoted it beside what is against it so that we examine if what he says is correct or not. It is clear that these two ways are not close to correctness, unlike the two preceding ones. This will be clear through examination for whoever succeeds in it.

[3a] As for the *qibla* direction, it is the intersection point between the horizon of a given locality and the azimuth circle passing through the zeniths of the locality and Mecca. The line connecting the center of the horizon [circle] and that point is the line of the *qibla* direction, which is the axis and bisector of the arc based on which the prayer niche [*miḥrāb*] is constructed. Therefore if the praying person considers that [line] between his legs, prostrating upon it, he will be praying on the circumference of a circle on the Earth's surface passing through the location of his prostration, through what is between his feet and the center of the House [*i.e.*, the *Kaʿba*]; [in other words], he will be facing the line connecting the House and the point in the sky that is aligned with it, called the zenith of Mecca. He will not be facing the House in the sense that a straight line extending from his eye will fall on the House, because the horizon of Mecca is below the horizon of the praying person and thus his vision is not aligned with the house but with that line. From this you see the invalidity of the interpretation that takes the *qibla* direction as a point on the horizon to which if the person faces, he will be facing the *Kaʿba*. At best, the meaning of facing [*al-muwājaha*] should be interpreted differently, in order to conform to what we have said. Now, the *qibla* azimuth from the locality—also called the arc of inclination—is an arc along the horizon [circle] between its intersection with the mentioned azimuth [circle] and one of the four points *i.e.*, west, east, south and north. It is the amount by which the praying

person should incline from facing one of the points in order to be facing the House, as we have mentioned. The complement of the inclination is an arc also along [the horizon circle], between the point of the *qibla* direction and one of the [four] points.

[3b] Now that you have learnt that, you should know that in determining the *qibla* direction and its azimuth from another locality one should inevitably know the longitude and latitude of Mecca, and the longitude and latitude of the given locality. Now, **the longitude of Mecca—may God protect it—is 77 1/6° from the Eternal Islands and 67 1/6° from the coast of the western sea. Its latitude is 21 2/3°.** Thus **every locality whose longitude is less than the longitude of Mecca, Mecca is to the east of it;** and **every locality whose longitude is greater than the longitude of Mecca, Mecca is to the west of it.** If its latitude is less than the latitude of Mecca, then Mecca is to the north of it; if it is greater, to the south of it. Then, the given locality and Mecca will be different either only in the latitude, or only in longitude, or in both. If it is the first [case], they are beneath the same meridian and there will be no azimuth for any of them with respect to the other, rather, their azimuths are on the meridian line. Therefore, the praying person faces the south point if the latitude of Mecca is less, or to the north point, if it is greater.

[3c] If it is the second [case], they are beneath the same day-circle. Some people, among them Kūshyār, who had been clear about it in some parts [of his works], supposed that their azimuths are on the east-west line and that the *qibla* is toward the east point if the longitude of Mecca is greater, or toward the west point if it is less. This is an incorrect supposition and a clear mistake because, due to their difference in longitude, in one of them the initial azimuth [circle] touches the mentioned [day-]circle on a point other than the one to which [the circle of] the initial azimuth is tangent in the other one; this is because the two initial azimuth [circles] intersect with the equinoctial at two different sets of points. So, their initial azimuths will be on [points] other than the east and the west [points]. Thus, their east-west lines are not the same, nor are they the azimuth between them, nor is the *qibla* toward the true east or west [points]; but rather, it **is to the left of the rising place of the equinox for that locality, if its longitude is less than the longitude of Mecca, and to the right of the setting place of the equinox, if its longitude is greater.** It is impossible for the zenith of Mecca to be on the circle of the initial azimuth of the given locality; otherwise, its latitude would have been less than the latitude of that locality, as the latitude of every point on it, except the zenith, is less. And *a fortiori*, [it is

impossible for the zenith of Mecca to be] between the circle of the initial azimuth and equinoctial, and, otherwise, the zenith of Mecca falls necessarily outside of the initial azimuth [circle]. What we have mentioned necessarily pertains to the best one can think of, which is, it is only correct in the localities at the equator, even though they differ in longitude, until the meridian of the cupola [of the Earth] becomes the horizon for easterners and westerners; not because their east-west lines are all in the plane of the equinoctial, based on what first comes to mind, since it is so at [localities] other than the equator, but because all their zeniths are on the equinoctial because for them it is equivalent to [the circle of] the initial azimuth.

[4a] If it is the third [case], they are neither beneath the same meridian nor the same day-circle. In this [case] and in the second, the inclination arc should be determined, and **there are many ways** to do it, **but it would not be appropriate to present them here. Let us instead limit ourselves to** the simple ones, among **which is [the following]. The sun transits the zenith of Mecca when it is in degree 8 of Gemini and in [degree] 23 of Cancer at noontime there,** for the inclination of these two degrees equals the mentioned latitude of Mecca. **The difference between its noon and the noon of other localities is measured by the difference between the two longitudes. Let this [latter] difference be taken and let an hour be assumed for each 15 degrees and 4 minutes for each degree. The resulting total is the interval in hours from noon [for that locality]. Let an observation be made on that day at that time-before noon if Mecca is to the east or after if it is to the west; the direction of the shadow at that time is the *qibla* direction.**

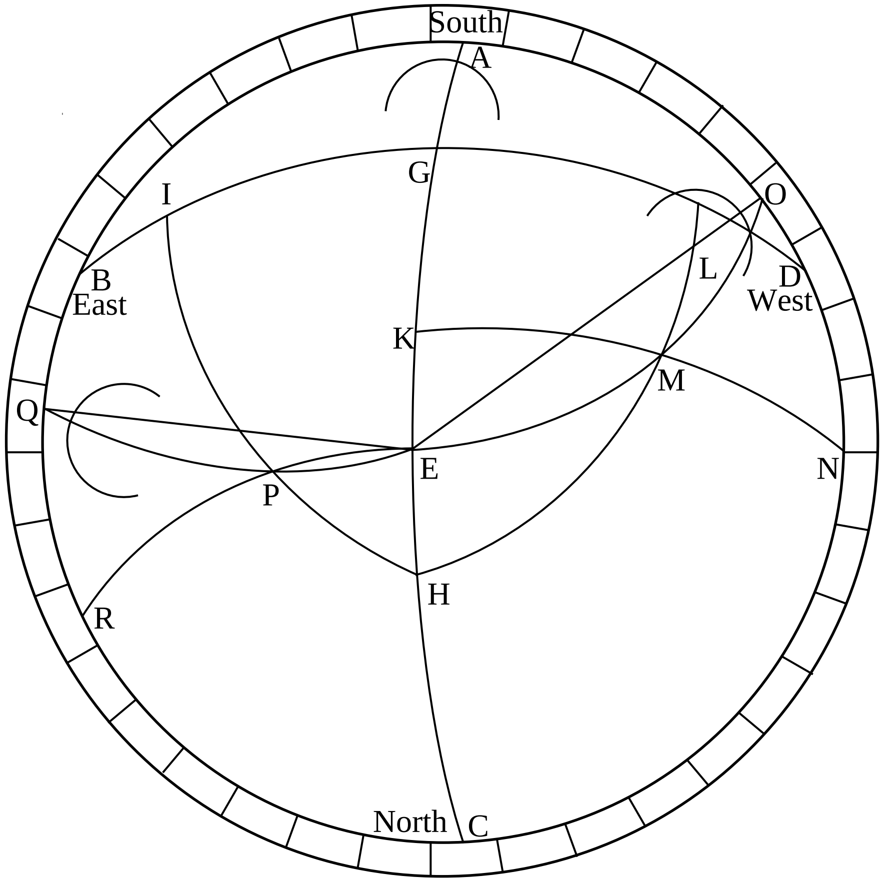
[4b] Another way is to set on the mid-heaven [line] of the astrolabe of our locality one of the two zodiacal degrees aligned with Mecca, which are 8; 21 of Gemini and 22; 39 of Cancer, and mark on the almuri. Then we rotate the rete to the amount of the longitudinal difference toward the west if our locality is to east of Mecca, and vice versa if it is to the west of it. So, wherever the degrees of the almucantar of the altitude reach, we observe the Sun's reaching there; then we erect a gnomon, its shadow at this time is the *qibla* direction. This [way] is close to the first. Another way is to count degrees of longitudinal and latitudinal differences on the Indian circle, and extend from the end of the degrees two lines, one parallel to the meridian, the other to the east-west line. They definitely intersect. We then connect the center and the

intersection point with a straight line, and let it pass through the circumference. This is the *qibla* direction line.

[4c] Another way is to divide the meridian line into equal parts and count from them the amount of the latitudinal difference between the locality and Mecca—considering the fraction, if there was [a fractional portion] —and extend a perpendicular line to its northern side, if the latitude of the locality is less than the latitude of Mecca; to the southern side, if it was greater; to the eastern direction, if the longitude of Mecca was greater; or to the western direction, if it was less. We then divide it in the same manner we divided the first line. Then we count from them the amount of the longitudinal difference—considering the fraction, if there was [a fractional portion]—and connect its end to the other point on the meridian with a line. A right triangle will be obtained and the *qibla* direction will be the third line, which is the hypotenuse. This way, and the previous ones, are approximate and do not work in a locality whose latitude is equal to the latitude of Mecca, nor [in a locality whose] longitude is not [equal to] the longitude of Mecca, because they are based on longitudinal and latitudinal differences.

[4d] Another way is to pick a perfectly round sphere, with a great circle on it, divided into 360 degrees, equivalent to the local horizon, which is *ABCD*. Then draw half of the meridian perpendicular to [the horizon], that is, *AEC*, *E* being the local zenith. We separate from it *CH*, measuring the local latitude, by taking degrees of the horizon [circle] using a pair of compasses from the north point as the latitude. Thus *H* is the pole of the equinoctial. Then we draw the great circle *BGD* about *H* [as center], intersecting the horizon at *D* and *B*, the east and west [points], and the meridian at *G*. Then, if we find the distance between *G* and *E*, [which is] the zenith, equal to the altitude of the pole, the work is correct, otherwise not. Then, if the two localities are only different in their latitudes, the meridian line is the *qibla* direction line. We extract it, which is the inevitable step in all methods. If they are only different in their longitudes, then we draw about *H* [as center], as far as *E*, the parallel [circle] *EPR*. It thus passes through the zenith of Mecca. We separate along the equinoctial from the meridian the amount of the longitudinal difference in the direction of Mecca. So, it will be to the east of the meridian, if the longitude of Mecca is greater, like *GI*, otherwise westerly if it is less than the local longitude. We draw a great circle passing through points *H* and *I*, with its poles on the equinoctial, which is [the circle] *HPI*. *P* is then the zenith of Mecca. We then draw a great circle passing through the two zeniths,

which are *E* and *P*, intersecting the horizon at *Q*. Therefore *AQ* is the azimuth arc, which is known through the horizon divisions, and *Q* is the azimuth point. Since the circle intersects the horizon at *Q*, rather than *B* and *R*, the *qibla* direction will not be on the east-west line, as was supposed, nor on the intersection of the parallel [circle] and the horizon. If [the localities] are different in [both] longitude and latitude, the longitudinal difference will be *GL* and the latitude of Mecca *GK*. We then draw about *H* [as center], as far as *K*, the parallel [circle] *KMN* and the great circle *HML*. *M* then will be the zenith of Mecca. Then we draw the great circle *EMO*. *AO* then will be the arc of the azimuth, which is known through the horizon divisions. When the arc of the azimuth is known, we either separate its amount from the Indian circle and then draw the azimuth line, or we set the meridian of the sphere on the meridian line and its nadir on the center of the Indian circle, then mark the azimuth point and draw the [azimuth] line, which is clear. I brought this method, even though it is thought to be difficult due to its peculiarity, because it is not less than others in terms of ease, as will be clear for anyone who is a bit skilled in handiwork. This is the end of Book III—praise be to God, the Giver of reason, Who makes ample generosity and graciousness.



[Figure 11]

Appendix

	City	Library	Collection	MS No.	Copy place	Copy date
1.	Berlin (siglum B/ب)	Staatsbibliothek	Petermann I	674	[Sivas]	[15 Shaʿbān–9 Dhū al-Ḥijja 680]
2.	Istanbul	Topkapı Sarayı	Ahmed III	3336		[680?]
3.	Istanbul (siglum K/ك)	Köprülü	Fazıl Ahmed Paşa	957	[Sivas]	681
4.	Tehran	University of Tehran		7070	[Sivas]	[681, missing beginning and end]
5.	Istanbul (siglum L/ل)	Süleymaniye	Laleli	2145	[Sivas]	[681]
6.	Leiden		Or.	203	Suburbs of Erzincan (Arzinjān)	682 [incomplete: missing the beginning and other parts; torn pages and other damage]
7.	Istanbul (siglum R/ر)	Köprülü	Fazıl Ahmed Paşa	956	Sivas, *Madrasa al-Ṣāḥibiyya al-Shamsiyya*	683 [the colophon has been changed]
8.	Tabriz	Ḥusayn		56		19 Ramaḍān 683

		Nakhjavānī				
9.	Istanbul	Millet	Feyzullah Efendi	1349		685
10	Patna	Khuda Bakhsh Oriental Public Library		2452		689 [Incomplete. Microfilm no. 2278 of Jaber al-Ahmad Central Library, Kuwait University]
11	Patna	Khuda Bakhsh Oriental Public Library		2453		During Shīrāzī’s life
12	Tehran	University of Tehran		2118		7^{th}–8^{th} century
13	Yazd	Shaykh ʿAlī ʿUlūmī		78		7^{th}–8^{th} century
14	Istanbul	Süleymaniye	Pertev Paşa	381		735
15	Istanbul	Topkapı Sarayı	Ahmed III	3333	Tukat	738
16	Bursa	Bursa Bölge Yazmalar Kütüphanesi	Hüseyin Çelebi	189		742
17	Tehran	Malik		3409		1 Ramaḍān 744
18	Oxford	Bodleian	Marsh	133		794
19	Baku	Azerbaijan National		225		8^{th} century

		Academy of Sciences				
20	Tehran	University of Tehran		2696		834
21	Qum	Marʿashī			Samarqand, *Madrasa-yi Ulugh Beg,* while Qāḍīzāda was teaching it	844
22	London	British Library		ADD 7482		872
23	Tehran	Sipahsālār		596		9^{th} century
24	Medina	ʿĀrif Ḥikmat	Falak	11		924
25	Tehran	Malik		3506		10^{th} century
26	Istanbul	Süleymaniye	Damad İbrahim	851		Ownership notes: 1058, 1071
27	Mashhad	Ilāhiyāt		656	Shiraz, *Madrasa-yi Laṭīfiyya*	1013
28	Tehran	Asghar Mahdavī		706		1101
29	Tehran	Majlis Library		16008		1120
30	London	British Library		IO ISL 707		1185
31	Paris	Bibliothèque nationale de	Arabe	2518		1200

		France				
32	Istanbul	Topkapı Sarayı	Ahmed III	3334		1365
33	Istanbul	Süleymaniye	İzmir	487		
34	Istanbul	Süleymaniye	Turhan V. Sultan/ Yeni Cami?	221		
35	Paris	Bibliothèque nationale de France	Arabe	2517		
36	Aligarh			626/3		
37	Aligarh			634/11		
38	Bagdad	Tawfīq Wahbī		2981		
39	Tabriz	Millī		3389		
40	Cairo	Dār al-kutub		56		
41	Cairo	Dār al-kutub	Muṣṭafỳ Fāḍil hayʾa	7/1		
42	Cairo	Dār al-kutub	Ṭalʿat	45		
43	Hyderabad	Salar Jung Museum	Hayʾa	26		
44	Manchester			751		
45	Mosul			363/71		
46	Oxford	Bodleian		924		

47	Utrecht			22		
48	Istanbul	Süleymaniye	Carullah	1347		
49	Tashkent			3756/4		

Bibliography

Abū Maʿshar. *al-Madkhal al-kabīr*. Edited by Charles Burnett and Keiji Yamamoto. Pre-print version.

Aflākī, Shams al-Dīn Aḥmad. *Manāqib al-ʿārifīn*. Edited by Tahsin Yazıcı. 2 vols. Ankara: Türk Tarih Kurumu Basimevi, 1959.

Ahmad, S. Maqbul. "Djughrāfiyā." *Encyclopaedia of Islam, Second Edition*. Edited by B. Lewis, et al. Vol. 2, 575–587. Leiden: E. J. Brill, 1965.

Almagest (*Alm.*). See Toomer, G. J. *Ptolemy's Almagest.*

Amini, Hassan. "*al-Risāla al-Muʿīniyya* of Khʷādja Naṣīr al-Dīn al-Ṭūsī: A Critical Edition and Study." Master thesis, Institute for the History of Sciences, University of Tehran, September 2008.

Anonymous. "Ṣudūr al-mushāriqa wa-al-mughāriba, Quṭb al-Dīn al-Shīrāzī." *al-Muqtabas* 2-1 (Muḥarram 1325): 3–8.

Anonymous. *Tārīkh-i Āl-i Saljūq dar Ānāṭūlī*. Edited by Nādira Jalālī. Tehran: Daftar-i nashr-i Mīrāth-i Maktūb, Āyina-yi Mīrāth, 1999.

Āqsarāyī, Maḥmūd b. Muḥammad. *Musāmarat al-akhbār wa musāyarat al-akhyār*. Edited by Osman Turan. Ankara: Türk Tarih Kurumu Basımevi, 1944.

Āyatī, ʿAbd al-Muḥammad. *Taḥrīr-i Tārīkh-i Vaṣṣāf*. Tehran: Bunyād-i Farhang-i Īrān, 1967.

Barnes, Jonathan. *The Complete Works of Aristotle: The Revised Oxford Translation*. Vol.1. Princeton: Princeton University Press, 1984. Accessed January 14, 2019. http://library.nlx.com/goto.cfm?loc=&infobase=pmari.nfo&depth=2.

Battānī, *Zīj*. See Nallino, Carlo A. *al-Battānī Sive Albatenii Opus Astronomicum.*

Berggren, J.L., and Alexander Jones. *Ptolemy's Geography: An Annotated Translation of the Theoretical Chapters*. Princeton: Princeton University Press, 2000.

Bīrūnī, Abū Rayḥān. *Al-Āthār al-bāqiya ʿan al-qurūn al-khāliya (The Vestiges of the Past), the Chronology of Ancient Nations*. Edited and annotated by Parviz Azkaei. Tehran: Mīrāth-i Maktūb, 2001.

Bīrūnī, Abū Rayḥān. *Kitāb taḥdīd nihāyāt al-amākin li-taṣḥīḥ masāfāt al-masākin*. Edited by P. G Bulgakov. Cairo: Maṭabʿa Lajnat al-Taʾlīf wa-al-Tarjima wa-al-Nashr, 1964.

Bīrūnī, Abū Rayḥān. *The Determination of the Coordinates of Positions for the Correction of Distances between Cities: A Translation from the Arabic of Kitāb taḥdīd nihāyāt al-amākin li-taṣḥīḥ masāfāt al-masākin*. Translated by Jamil Ali. Beirut: American University of Beirut, 1967.

Bonebakker, S.A. "Ḳudāma." In: *Encyclopaedia of Islam, Second Edition*. Edited by P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs. Consulted online on 22 October 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_4478>

Bonner, Michael. "The Waning of Empire, 861–945." Chapter. In *The New Cambridge History of Islam*. Edited by Chase F. Robinson, 1:305–59. Cambridge: Cambridge University Press, 2010. doi:10.1017/CHOL9780521838238.010.

Cahen, Cl. "Köse Dagh", in: *Encyclopaedia of Islam, Second Edition*. Edited by: P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs. Consulted online on 28 November 2017 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_4437> First published online: 2012.

Catalogue of the Arabic and Persian Manuscripts in the Oriental Public Library at (bankipore) Patna, Patna: Superintendent, Govt. Print., Bihar, 1962.

Combe, Etienne; Jean Sauvaget, and Gaston Wiet. *Répertoire Chronologique D'épigraphie Arabe*. Vol. 12. Le Caire: l'Institut Français d'Archéologie Orientale, 1943.

Dallal, Ahmad. "Al-Bīrīnī on Climates." *Archives internationales d'histoire des sciences* 34 (1984): 3–18.

Dallal, Ahmad. *An Islamic Response to Greek Astronomy: Kitāb taʿdīl hayʾat al-aflāk of Ṣadr al-Sharīʿa*. Leiden: Brill, 1995.

De Goeje, Michael Jan. *Ibn Rusta's* Kitāb al-aʿlāq al-nafīsa *and* Kitāb al-buldān *by al-Yaʿqūbī*. Leiden: Brill, 2014.

De Goeje, Michael Jan. *Kitâb al-masâlik wa'l-mamâlik (Liber viarum et regnorum)*. Leiden: Brill, 1889. Reprinted in Bagdad: Maktabat al-Muthanná, 1960z.

Descartes, René. *Principles of Philosophy*. Translated, with explanatory notes, by Valentine Rodger Miller, and Reese P. Miller. Dordrecht; Boston; Hingham: Reidel, 1983.

Dhahabī, Shams al-Dīn. *Dhayl taʾrīkh al-Islām*. Edited by Māzin b. Sālim Bā Wazīr. Riyadh: Dār al-Mughnī li-al-Nashr wa-al-Tawzīʿ, 1998.

Dihkhudā, ʿAlī-Akbar. *Lughat-nāma*. 14 vols. Tehran: Muʾassasa-yi Lughat-nāma-yi Dihkhudā, 1993–1994.

Farghānī, Aḥmad ibn Muḥammad ibn Kathīr. *Jawāmiʿ ʻilm al-nujūm wa-uṣūl al-ḥarakāt al-samāwīya*. Edited by Jacob Golius and reprinted by Fuat Sezgin. Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe Universität, 1986.

Fasāʾī, Ḥasan b. Ḥasan. *Fārs-nāma-yi Nāṣirī*. Tehran: Intishārāt-i Kitābkhāna-yi Nisāʾī, 1312–1314/1894–1896. Accessed online 01 February 2018 <http://nrs.harvard.edu/urn-

3:FHCL:30800564> [Repository: Collection Development Department, Widener Library, Harvard College Library, Harvard University].

Forêt, Philippe, and Andreas Kaplony. *The Journey of Maps and Images on the Silk Road*. Leiden: Brill, 2008.

Gacek, Adam. "The Osler Codex of Nasīr al-Dīn al-Ṭūsī's Commentary on Avicenna's *al-Ishārāt wa-al-tanbīhāt*," *Journal of Islamic Manuscripts* 1 (2010): 3–17.

Gamini, Amir-Mohammad. "Quṭb al-Dīn al-Shīrāzī and the Development of Non-Ptolemaic Planetary Modeling in the 13th Century." *Arabic Sciences and Philosophy* 27, no 2 (2017), 165–203. doi:10.1017/S0957423917000017.

Gamini, Amir Mohammad, and Hossein Masoumi Hamedani. "Al-Shīrāzī and the Empirical Origin of Ptolemy's Equant in His Model of the Superior Planets." *Arabic Sciences and Philosophy* 23, no. 1 (2013): 47–67. doi:10.1017/S0957423912000070.

Ghalandari, Hanif. "A survey of the works of "*hayʾa*" in the Islamic period with a critical edition, translation and commentary of the treatise *Muntahá al-idrāk fī taqāsīm al-aflāk*, written by Bahāʾ al-Dīn al-Kharaqī (d. 553AH/1158AD)." PhD dissertation. Tehran: Institute for humanities and cultural studies, 2012.

Grant, Edward. *A History of Natural Philosophy: From the Ancient World to the Nineteenth Century*. Cambridge; New York: Cambridge University Press, 2007.

Ḥabībī, Najafqulī. *Ḥikmat al-ishrāq-i Suhrawardī, bā sharḥ-i Quṭb al-Dīn Shīrāzī, jild-i awwal: manṭiq*, Tehran: Bunyād-i Ḥikmat-i Islāmī-yi Ṣadrā, 2013.

HAMA. See Neugebauer, *A History of Ancient Mathematical Astronomy*.

al-Ḥamawī, Yāqūt. *Muʿjam al-buldān*. Vol. 3. Beirut: Dār Ṣādir, 1995.

Harley, J.B., and David Woodward. *The History of Cartography*. Chicago: University of Chicago Press, 1987–2007.

Heck, Paul L. *Construction of Knowledge in Islamic Civilization: Qudāma b. Jaʿfar and His Kitāb al-kharāj wa-ṣināʿat al-kitāba*. Leiden: Brill, 2002.

Hillenbrand, Carole. "Muʿīn al-Dīn Sulaymān Parwāna." In: *Encyclopaedia of Islam, Second Edition*, edited by: P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs. Consulted online on 28 November 2017 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_5442> First published online: 2012.

Hjelt, Arthur. *Etudes sur l'*Hexaméron *de Jacques d'Edesse, notamment sur ses notions géographique contenues dans le 3ième traité*. Helsingfors: Frenckell, 1892.

Ibn ʿAbd al-Ẓāhir, Muḥyī al-Dīn. *Tashrīf al-ayyām wa-al-ʿuṣūr fī sīrat al-Malik al-Manṣūr*. Edited by Murād Kāmil and Muḥammad ʿAlī Najjār. Cairo: al-Jumhūriÿya al-ʿArabiyya al-Muttaḥida, Wizārat al-Thaqāfa wa-al-Irshād al-Qawmī, al-Idārah al-ʿĀmma li-al-Thaqāfah, 1961.

Ibn Baṭūṭa. *Kitāb riḥlat Ibn Baṭūṭa: al-musammā Tuḥfat al-nuẓẓār fī gharāʾib al-amṣār wa-ʿajāʾib al-asfār*. Cairo: Maṭbaʿat Wādī al-Nīl, 1287/1867.

Ibn Faḍlān, Aḥmad. *Risālat Ibn Faḍlān fī waṣf al-riḥla ilá bilād al-Turuk wa-al-Khazar wa-al-Rūs wa-al-Saqāliba Sana 309/921*. Edited by Sāmī al-Dahhān. Damascus: al-Maṭbaʿat al-Hāshimiyya, 1959.

Ibn al-Fuwaṭī, ʿAbd al-Razzāq b. Aḥmad. *Majmaʿ al-ādāb fī muʿjam al-alqāb*. Edited by Muḥammad al-Kāẓim. 6 vols. Tehran: Vizārat-i Farhang va Irshād-i Islāmī, 1995.

Ibn Ḥajar al-ʿAsqalānī, Aḥmad b. ʿAlī. *al-Durar al-kāminah fī aʿyān al-miʾa al-thāmina*. Edited by: Muḥammad Sayyid Jād al-Ḥaqq. Cairo: Dār al-Kutub al-Ḥadītha, 1966.

Ibn Qāḍī Shuhbah, Abū Bakr b. Aḥmad. *Ṭabaqāt al-fuqahāʾ al-Shāfiʿiyyah*, edited by al-Ḥāfiẓ ʿAbd al-ʿAlīm Khān, Beirut: Dār al-Nashr, 1987.

Ibn Rushd. *Kitāb al-āthār al-ʿilwiyya*. Edited by Suhayr Faḍlallāh Abū Wāfiya and Suʿād ʿAlī ʿAbd al-Razzāq. Cairo: al-Majlis al-Aʿlá li-al-Thaqāfa, 1994.

Ibn Sīnā. *Al-Qānūn fī al-ṭibb*. 4 vols. Beirut: Dār Iḥyāʾ al-Turāth al-Arabī, 2005.

Ibn Sīnā. *al-Shīfāʾ, Ṭabīʿiyyāt, al-Samāʾ al-ṭabīʿī*. Vol. 1. Edited by Ibrāhīm Madkūr and Saʿīd Zāyid. Cairo: 1983.

Al-Iṣṭakhrī, Ibrāhīm b. Muḥammad. *Al-Masālik wa-al-mamālik*. Edited by Muḥammad Jābir ʿAbd al-ʿĀl al-Ḥīnī. Cairo: The United Arab Republic, Ministry of Culture and National Guidance, General Culture Administration, 1961.

Janos, Damien. "Moving the Orbs: Astronomy, Physics, and Metaphysics, and the Problem of Celestial Motion According to Ibn Sīnā." *Arabic Sciences and Philosophy* 21, no. 2 (2011), 165–214.

Jorati, Hadi. *Science and Society in Medieval Islam: Nasir al-Din Tusi and the Politics of Patronage*, Yale University, Ann Arbor, 2014, ProQuest Dissertations & Theses Global, https://proxy.library.mcgill.ca/login?url=https://search.proquest.com/docview/1659836140?accountid=12339.

Junayd Shīrāzī, ʿĪsá b. Junayd. *Hazār mazār*. National Library and Archives of I.R of Iran, MS 2437.

Junayd Shīrāzī, ʿĪsá b. Junayd. *Hazār mazār*. Shiraz: Kitābfurūshī-yi Aḥmadī, 1941.

Junayd Shīrāzī, ʿĪsá b. Junayd. *Tadhkira-yi hazār mazār, tarjima-yi Shadd al-izār (mazārāt-i Shīrāz)*. Edited by Nūrānī Viṣāl. Shiraz: Intishārāt-i Kitābkhāna-yi Aḥmadī, 1985.

Junayd Shīrāzī, Junayd b. Maḥmūd. *Shadd al-izār fī ḥaṭṭ al-awzār ʿan zawwār al-mazār*. National Library and Archives of I.R of Iran, MS 17618.

Junayd Shīrāzī, Junayd b. Maḥmūd. *Shadd al-izār fī ḥaṭṭ al-awzār ʿan zawwār al-mazār*. Edited by Muḥammad Qazvīnī and ʻAbbās Iqbāl. Tehran: Navīd, 1987.

Jūzjānī, Abū ʿUbayd ʿAbd al-Wāḥid b. Muḥammad. *Khilāṣ tarkīb al-aflāk*. Mashhad, Āstān-i Quds Librray, MS 5593/8.

Kaḥḥāla, ʿUmar Riḍā. "al-Muntakhab al-mukhtār min makhṭūṭāt al-Madīnat al-Munawwara: Maktabat ʿĀrif Ḥikmat, 4," *al-Majmaʿ al-lughat al-ʿArabiyya bi-Dimashq*, vol. 48, issue 3, (Ramaḍān 1393): 893–908.

Kennedy, E.S. *A Commentary upon Bīrūnī's Kitāb taḥdīd al-amākin; an 11th Century Treatise on Mathematical Geography*. Beirut: American University of Beirut, 1973.

Kennedy, E.S. "Late Medieval Planetary Theory." *Isis* 57, no. 3 (1966): 365-78. http://www.jstor.org.proxy3.library.mcgill.ca/stable/228366.

Kennedy, E.S. "Suhrāb and the World-map of Maʾmūn,"in *From Ancient Omens to Statistical Mechanics, Essays on the Exact Sciences Presented to Asger Aaboe*. Edited by J.L. Berggren and B.R. Goldstein. Copenhagen, 1987.

Al-Kindī, Yaʿqūb b. Isḥāq. *Al-Rasāʾil al-falsafiyya*. Edited by ʿAbd al-Qādir Muḥammad ʿAlī. Beirut: Dār al-Kutub al-ʿIlmiyya, 2017.

King, David A. *Islamic Astronomy and Geography*. Burlington: Ashgate Publishing Company, 2012.

Lane, Edward William. *Arabic-English Lexicon*. Rev. Format ed. Cambridge, England: Islamic Texts Society, 1984.

Langermann, Y. Tzvi. “Arabic Cosmology.” *Early Science and Medicine* 2 (1997): 185-213.

Langermann, Y. Tzvi. *Ibn Al-Haytham’s on the Configuration of the World*. London: Routledge, 2017.

Leiser, Gary. “al-Aqsarāyī, Karīm al-Dīn.” In *Encyclopaedia of Islam, THREE*. Edited by Kate Fleet, Gudrun Krämer, Denis Matringe, John Nawas, Everett Rowson. Consulted online on 05 November 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_26349>

Lettinck, Paul. *Aristotle’s “Physics” and Its Reception in the Arabic World: With an Edition of the Unpublished Parts of Ibn Bājja’s Commentary on the Physics*. Leiden; New York; Köln: E.J. Brill, 1994.

Lettinck, Paul. *Aristotle’s* Meteorology *and Its Reception in the Arab World: With an Edition and Translation of Ibn Suwār’s Treatise on Meteorological Phenomena and Ibn Bājja’s* Commentary on the Meteorology. Leiden: Brill, 1999.

Magruder, Kerry V. “Global Visions and the Establishment of Theories of the Earth.” *Centaurus* 48, no. 4 (2006): 234–57.

Martin, P. “L’Hexaméron de Jacques d’Edesse.” *Journal Asiatique*. VIIIe sér. XI (1888): 155-219, 401–490.

Masʿūdī, Sharaf al-Dīn. *al-Kifāya fī ʿilm al-hayʾa*. Istanbul, Süleymaniye Library, MS Hafid Efendi 154.

Masʿūdī, Sharaf al-Dīn. *Jahān-i Dānish*. Edited by Djalil Akhavān Zandjani. Tehran: Mīrāth-i Maktūb, 2003.

Minorsky, Vladimir. *Ḥudūd al-ʿālam: 'the Regions of the World,' a Persian Geography, 372 A.H.–982 A.D.* Preface by V.V. Barthold. Edited by Clifford Edmund Bosworth. London: Luzac, 1970.

Mizukami, Ryo. "Nigāhī bi zindagī va faʿʿāliyyat-hāyi ʿilmī-yi Ibn-i Fuwaṭī." *Āyina-yi Pajūhish* 157 (April–May 2016): 20–43.

Mudarris Riḍavī, Muḥammad Taqī. *Aḥvāl va āthār-i qudva-yi muḥaqqiqīn va sulṭān-i ḥukamā va mutakallimīn, ustād-i bashar va 'aql-i ḥādī-i ʿashr, Abū Jaʿfar Muḥammad b. Muḥammad b. al-Ḥasan al-Ṭūsī, mulaqqab bih Naṣīr al-Dīn*. Tehran: Bunyād-i Farhang-i Īrān, 1975.

Mudarrisī, Muḥammad. *Sargudhasht va ʿaqāyid-i falsafī-yi Khᵛāja Naṣīr al-Dīn Ṭūsī: bih inḍimām-i baʿḍī az rasāʾil va mukātabāt-i viy*. Tehran: Amīr Kabīr, 1984.

Muḥaqqiq, Mahdi. "Quṭb al-Dīn Shīrāzī va sharḥ-i ḥāl-i khudnigāsht-i ū (Quṭb al-Dīn Shīrāzī and his autobiography)." *Ḥikmat-i Isrāʾ* 15 (spring 2013), 172–175.

al-Muqaddasī, Muḥammad b. Aḥmad. *Aḥsan al-taqāsīm fī maʿrifat al-aqālīm (La Meilleure Répartition Pour La Connaissance Des Provinces)*. Translated by André Miquel. Damas: Institut Français De Damas, 1963.

al-Muqaddasī, Muḥammad b. Aḥmad. *Kitāb aḥsan al-taqāsīm fī maʿrifat al-aqālīm*. Edited by M. J. de Goeje. 1906. Reprint, Beirut: Dār Ṣādir, no date.

Nallino, Carlo A. *al-Battānī Sive Albatenii Opus Astronomicum.* 3 vols. Milan: Pubblicazioni Del Reale Osservatorio di Brera, 1899–1907 (vol. 1 [1903], vol. 2 [1907], and vol. 3 [1899]).

Neugebauer, Otto. *A History of Ancient Mathematical Astronomy*. 3 parts. Berlin; New York: Springer-Verlag, 1975.

Niazi, Kaveh. *Quṭb al-Dīn Shīrāzī and the Configuration of the Heavens: A Comparison of Texts and Models*. Dordrecht: Springer, 2013.

Niazi, Kaveh. “Quṭb al-Dīn Shīrāzī as Depicted in Early Historical Sources,” *Tarikh-e Elm*, 11 (2013): 23–39.

Park, H. *Mapping the Chinese and Islamic Worlds: Cross-Cultural Exchange in Pre-Modern Asia*. Cambridge: Cambridge University Press, 2012.

Petraitis, Casimir. *The Arabic Version of Aristotle’s Meteorology: A Critical Edition with an Introduction and Greek-Arabic Glossaries*. Beirut: Dār al-Mashriq, 1967.

Pourjavady, Reza, and Sabine Schmidtke. “Quṭb al-Dīn al-Shīrāzī (d. 710/1311) as a Teacher: an Analysis of His Ijāzāt (Studies on Quṭb al-Dīn al-Shīrāzī III).” *Journal Asiatique* 297.1 (2009): 15–55.

Pourjavady, Reza, and Sabine Schmidtke. “The Quṭb al-Dīn al-Shīrāzī (d. 710/1311) Codex (MS Marʿashī 12868) [Studies on Quṭb al-Dīn al-Shīrāzī, II].” *Studia Iranica* 36 (2007): 279–301.

Pourjavady, Reza, and Sabine Schmidtke. “Quṭb al-Dīn al-Shīrāzī’s (634/1236–710/1311) *Durrat al-taj* and its sources (Studies on Quṭb al-Dīn al-Shīrāzī, I).” *Journal Asiatique* 292.1-2 (2004): 311–330.

Qaṭṭān-i Marvzī, ʿAyn al-Zamān Ḥasan ibn ʿAlī. *Gayhān-shinākht*. Qum: Kitābkhāna-yi Buzurg-i Ḥaḍrat-i Āyatullāh Marʿashī-yi Najafī, 2000.

Ragep, F. Jamil. “Astronomy.” In *Encyclopaedia of Islam Third Edition*. Edited by Gudrun Krämer et al., Brill Online, 2016. Reference. McGill University. 04 April 2016 <http://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-3/astronomy-COM_22652>.

Ragep, F. Jamil. *Naṣīr al-Dīn al-Ṭūsī’s Memoir on Astronomy (al-Tadhkira fī ʿilm al-hayʾa)*. 2 vols. New York: Springer-Verlag, 1993.

Ragep, F. Jamil. “Shīrāzī’s *Nihāyat al-idrāk*: Introduction and Conclusion.” *Tārīkh-e Elm* 11 (2013): 41–57.

Ragep, Sally P. *Jaghmīnī’s Mulakhkhaṣ, An Introduction to Ptolemaic Astronomy*. Switzerland: Springer, 2016.

Randles, William Graham Lister. “Classical Models of World Geography and Their Transformation Following the Discovery of America.” In *The Classical Tradition and the Americas, Vol. I: European Images of the Americas and the Classical Tradition*, edited by W. Haase, and M. Reinhold. Berlin. New York: Walter De Gruyter, 1994.

Rapoport, Y. and E. Savage-Smith. *An Eleventh-Century Egyptian Guide to the Universe: The Book of Curiosities, Edited with an Annotated Translation*. Leiden: Brill, 2013.

Rāzī, Fakhr al-Dīn. *Asrār al-tanzīl wa-anwār al-taʾwīl*. Edited by ʿAbd al-Raḥmān ʿUmayra and ʿAbd al-Munʿim Faraj Darwīsh. Cairo: Dār Rikābī li-al-Nashr wa-al-Tawzīʿ, 2000

Rāzī, Fakhr al-Dīn. *Al-Maṭālib al-ʿāliya min al-ʿilm al-ilāhī*. Edited by Aḥmad Ḥijāzī al-Saqqā. Beirut: Dār al-Kutub al-ʿArabī, 1987.

Rāzī, Fakhr al-Dīn. *Sharḥ mushkilāt Kitāb al-Qānūn*. Edited by Najafqulī Ḥabībī. Tehran: Kitābkhāna-yi Majlis Shūrā-yi Islāmī, 2018.

Roger, J. “La Théorie de la terre au Xviie siècle. ” *Revue d’histoire des sciences* (1973): 23–48.

Roller, Duane W. *Eratosthenes’ Geography*. Oxford; Princeton: Princeton University Press, 2010.

Rashīd al-Dīn, Faḍl Allāh Hamadānī. *Jāmiʿ al-tavārīkh*. Edited by Bahman Karīmī. 2 vols. Tehran: Shirkat-i Nisbī Ḥājj Muḥammad Ḥusayn Iqbāl va Shurakāʾ, 1959.

Ritter, Hellmut. “Autographs in Turkish Libraries,” *Oriens* 6, no. 1 (1953): 63–90. doi:10.2307/1579235.

Sabra, A.I. “Science and Philosophy in Medieval Islamic Theology: The Evidence of the Fourteenth Century,” *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* (1994): 1–42.

Ṣafadī, Khalīl b. Aybak. *Aʿyān al-ʿaṣr wa-aʿwān al-naṣr*. Facsimile edition by Fuat Sezgin and Māzin ‘Amāwī. Frankfurt: Institut für Geschichte der Arabisch-Islamischen Wissenschaften, 1990.

Ṣafadī, Khalīl b. Aybak. *Kitāb al-wāfī bi-al-wafayāt*. Edited by: Aḥmad Arnā’ūṭ and Turkī Muṣṭafá. 29 vols. Beirut: Dār Iḥyāʾ al-Turāth al-ʿArabī, 2000.

Saliba, George. *The Astronomical Work of Muʾayyad al-Dīn al-ʿUrḍī, A Thirteenth Century Reform of Ptolemaic Astronomy: Kitāb al-Hayʾah*. Beirut: Markaz Dirāsāt al-Waḥda al-ʿArabiyya, 1990.

Sallāmī, Muḥammad b. Rāfiʿ. *Tārīkh ʿulamāʾ Baghdād al-musammá Muntakhab al-mukhtār*. Edited by ʿAbbās ʿAzzāwī. Beirut: Dār al-ʿArabiyya li-al- Mawsūʿāt, 2000.

Sanagustin, F. “Mizādj.”In *Encyclopaedia of Islam, Second Edition*. Edited by P. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel, W.P. Heinrichs. Consulted online on 09 January 2019 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_islam_SIM_8829>

Şeşen, Ramazan. *Nawādir al-makhṭūṭāt al-ʿarabīyah fī maktabāt Turkiyā*. Beirut: Dār al-kitāb al-jadīda, 1975.

Sezgin, Fuat. *The Contribution of the Arabic-Islamic Geographers to the Formation of the World Map*. Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 1987.

Sezgin, Fuat. *Geschichte des Arabischen Schrifttums, Band X–XI, Mathematische Geographie und Kartographie im Islam und Ihr Fortleben im Abendland—Historische Darstellung.* Teil 1–

2. Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 2000.

Sezgin, Fuat. *Geschichte des Arabischen Schrifttums, Band XII, Mathematische Geographie und Kartographie im Islam und ihr Fortleben im Abendland—Kartenband*. Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 2000.

Sezgin, Fuat. *Mathematical Geography and Cartography in Islam and their Continuation in the Occident, Volume I Historical Presentation Part I being an English Version of volume X of Geschichte des Arabischen Schrifttums*. Translated from the German by Guy Moore and Geoff Sammon. Frankfurt am Main: Institut für Geschichte der Arabisch-Islamischen Wissenschaften an der Johann Wolfgang Goethe-Universität, 2005.

Shalev, Zur, and Charles Burnett. *Ptolemy's Geography in the Renaissance*. London: Warburg Institute, 2010.

Shīrāzī, Quṭb al-Dīn. *Al-Tuḥfa al-saʿdiyya*. Istanbul, Süleymaniye Library, MS Ayasofya 3649.

Shīrāzī, Quṭb al-Dīn. *Faʿalta fa-lā talum*.Tehran, Majlis, Shura, MS 3945.

Sorabji, Richard. "Aristotle on Demarcating the Five Senses." *The Philosophical Review* 80, no. 1 (1971): 55-79. doi:10.2307/2184311.

Suyūṭī, Jalāl al-Dīn. *Bughyat al-wuʿāt fī ṭabaqāt al-lughawiyyīn wa-al-nuḥāt*. Edited by: Muḥammad Abū al-Faḍl Ibrāhīm. Cairo: Maṭbaʿat ʿĪsá al-Bābī al-Ḥalabī, 1964.

Thomson, W.M. *The Land and the Book: or Biblical Illustrations Drawn from the Manners and Customs, the Scenes and Scenery of the Holy Land*, vol. III (New York: Harper, 1910), 393. Accessed January 6, 2019. https://babel.hathitrust.org/cgi/pt?id=uc1.31158001277093;view=1up;seq=52

Thorndike, Lynn. *The Sphere of Sacrobosco and Its Commentators*. Corpus of Mediaeval Scientific Texts Sponsored Jointly by the Mediaeval Academy of America and the University of Chicago. Vol. 2. Chicago: University of Chicago Press, 1949.

Tibbetts, Gerald R. "The Balkhī School of Geographers," in: *The History of Cartography, Volume 2, Book 1: Cartography in the Traditional Islamic and South Asian Societies*, eds. J. B. Harley and David Woodward (Chicago: University of Chicago Press, 1992), 108–136.

Tibbetts, Gerald R. "The Beginnings of a Cartographic Tradition," in: *The History of Cartography, Volume 2, Book 1: Cartography in the Traditional Islamic and South Asian Societies*, eds. J. B. Harley and David Woodward (Chicago: University of Chicago Press, 1992), 90-107.

Todd, Richard. *The Sufi Doctrine of Man: Ṣadr al-Dīn al-Qunawī's Metaphysical Anthropology*. Boston: Brill, 2014. <http://dx.doi.org/10.1163/9789004271265>.

Toomer, G.J. *Ptolemy's Almagest.* Translated and annotated by G. J. Toomer with a Foreword by Owen Gingerich. Princeton, NJ: Princeton University Press, 1998.

Von Mžik, Hans. *Das Kitāb ʿağāʾib al-aḳālīm as-sabʿa des Suhrāb*. Leipzig: Otto Harrassowitz, 1930.

Von Mžik, Hans. *Das Kitāb ṣūrat al-arḍ des Abū Ğaʿfar Muḥammad ibn Mūsā al-Ḫuwārizmī*. Leipzig: Otto Harrassowitz, 1926.

Wiedemann, E. "Zu den optischen Kenntnissen von Ḳuṭb al-Dîn al-Schîrâzî." *Archiv für die Geschichte der Naturwissenschaften und der Technik,* iii (1912), 187–193.

Wiedemann, E. "Über die Gestalt, Lage und Bewegung der Erde, sowie philosophisch-astronomische Betrachtungen von Ḳuṭb al-Dîn al-Schîrâzî." *Archiv für die Geschichte der Naturwissenschaften und der Technik*, iii (1912), 395–422.

Wüstenfeld, Ferdinand. *Zakarija Ben Muhammed Ben Mahmud El-Cazwini's Kosmographie*. Göttingen: Verlag Der Dieterichschen Buchhandlung, 1848.

Zadeh, Travis. “Ibn Khurdādhbih”, in: *Encyclopaedia of Islam, THREE*. Edited by: Kate Fleet, Gudrun Krämer, Denis Matringe, John Nawas, Everett Rowson. Consulted online on 24 October 2018 <http://dx.doi.org.proxy3.library.mcgill.ca/10.1163/1573-3912_ei3_COM_30869>.

Zadeh, Travis. “Of Mummies, Poets, and Water Nymphs: Tracing the Codicological Limits of Ibn Khurradādhbih’s Geography”. In *School of ‘Abbasid Studies*. Edited by Monique Bernards. Warminster: Gibb Memorial Trust, 2013.

Zarkūb Shīrāzī, Aḥmad b. Abī al-Khayr. *Shīrāz-nāma*. Edited by Muḥammad Javād Jiddī and Iḥsānullāh Shukrullāhī. Tehran: Muʾassasa-yi Taʾlīf, Tarjama va Nashr-i Ā<u>s</u>ār-i Hunarī “Matn”, 2011.