The Irish Astronomical Tract:

A Case Study of Scientific Terminology

in 14th Century Irish

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SYNOPSIS

Included in this work, is a general historical overview of the development of astronomical knowledge in the West from the realms of Greek scholarship in classical times through to the Renaissance and the threshold of modern physics. The subject matter of both the Irish Tract and this review extends beyond the strict confines of astronomy, encompassing the physical sciences in general.

The extent of astronomical knowledge in medieval Ireland is given specific attention with a review of scholarly works in Latin since the seventh century. This includes a number of specialist studies on astronomical topics and related cosmographical fields. Also included are numerous incidental references to astronomical matters from both Irish and Latin literature during the Middle Ages.

Attention is devoted to the surviving manuscript copies of the Tract and the question of its sources, origin and purpose. A possible Dominican context for the compilation and dissemination of the Tract is considered. A detailed commentary of the technical content of each chapter is presented, together with reference to contemporary developments in the West and to the occasional clues as to the institutional, geographical and chronological origins of the Tract.

A study of the technical terminology used by the Irish compiler is presented in detail. Reference is made both to earlier Irish terminology where appropriate, as well as to the limitations imposed by the fact that many of the scientific concepts were yet to attain clarity that came with the advent of Newtonian physics, Copernican astronomy and post-Colombian geography.

The data entries on ms Stowe B are evaluated and compared with computer generated data of astronomical movements in the 14^{th} and 15^{th} centuries with a view to ascertaining the time of compilation of the Tract and its working life.

A revised English translation of the Tract is included in the appendices together with Maxwell Close's unpublished commentary to relevant portions. An Irish edition, closely following the ITS edition of 1914 is also included. Corruptions to the text are footnoted together with the likely run of the original text.

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This is to certify that the research work presented in this thesis was carried out by me in the Department of Celtic Studies at the University of Sydney and has not been submitted previously for any other university degree or award.

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Among those who have assisted with this work, special mention needs to be made of the late Bernard Martin, formerly of the Department of Celtic Studies at this university. Bernard was largely responsible for the scope and direction of this research and his input in its early stages as Assistant Supervisor was invaluable. His unexpected death in January last year was not without its apprehensions on my part. I am also indebted to Helen Fulton who was likewise involved in the early discussion sessions that mapped out a blueprint for future investigations. Over the last two years Helen has assumed full supervision and I am grateful for her valuable suggestions and patient proofing of thesis drafts.

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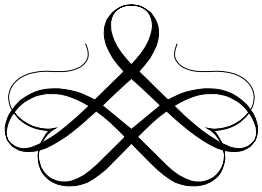
I would also like to acknowledge the assistance of Bernadette Cunningham at the Royal Irish Academy for permission to view ms Stowe B and for access to the photo-negative prints of its folios during my visit to Dublin in 1999.

It is appropriate at this point in time for me to put on record a belated expression of gratitude to David Boulton who gave me my first lessons in spoken Irish during my student days more than thirty years ago. David was then a tutor at the University of New South Wales and a recent graduate of TCD.

Lastly, I should like to mention my supportive family who have looked upon this work with a mixture of benign bewilderment, amusement and encouragement. Instrumental in the conversion of my lifelong interest into formal studies was my daughter Megan who recently graduated with Honours in Celtic Studies.



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Chapter 1: Introduction

In the preface to her 1914 edition of the 14th century Irish Astronomical Tract and its English translation, Maura Power made the following pertinent comment:

> A comparison of the text now in hand with some of the numerous medical tracts, almost all of which still remain unedited, would doubtless supply much interesting material with respect to the resources of our language in treating of purely scientific and technical subjects.[1]

It is now almost 90 years since Power made this remark and regrettably, little work has been directed towards the Tract during that time. The present study seeks to partially remedy this neglect by an evaluation of its scientific and technical terminology. It had earlier been my intention to include some of the above mentioned medical tracts, but the likely scale of this undertaking soon dictated it prudent to postpone the medical dimension. In any case, the subject matter in the so-called astronomical manuscripts is largely confined to the physical sciences, bearing little overlap of content with the biological works. Nevertheless, a natural sequel to the present study would be a review of the medical tracts along the same line.

Since the publication of Power's Irish Text Society edition in 1914, attitudes towards Irish history and scholarship in the Middle Ages have changed somewhat. Joyce, in his voluminous 'Social History of Ancient Ireland' (1920),[2] made reference to 'several ancient treatises in the Irish language.' The reference was to the three surviving copies of this Tract. There is a hint of apology in his admission that the content of these works derived ultimately from outside sources. He noted that 'they appear to have been in considerable measure copied or transcribed from foreign treatises'[3]. He then sought to highlight indigenous astronomical knowledge as if it were a self-contained and self-grown element of Gaelic culture.

A closer look at the Tract reveals it to be an integral participation in the vigorous translation and dissemination of scientific works that led to the European Renaissance. Viewed in this light, the Tract places Irish learning firmly within the cultural and scholastic life of the West; by no means a small feat for a distant country on the Atlantic fringe of Europe.

Given the size of this Tract, some 26,000 words, it provides a useful case study of the ease with which the Irish language was able to cope with the need for specific scientific and technical terminology. A number of earlier astronomical and cosmographical works had been written by Irish scholars, but invariably these were in Latin. A limited number of technical terms can be gleaned from the general corpus of Irish literature, but in the main, the compilation of this 14th century Tract provides us with the earliest substantial repository of such terms in Irish.

It will become clear in this study that there were various mechanisms employed by the Irish author to meet this need. In general, the language seems to have been remarkably adept. Many of the vernacular terms employed are still current in modern Irish. By

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[1] M. Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914), p i.
[2] P. W. Joyce, *A Social History of Ancient Ireland,* Gill & Sons, Dublin, 1920, (Vol. I) p464.
[3] Ibid., p464.

way of comparison, such terms in English (and other European languages) are usually borrowed from Latin. A typical example is the Irish word for 'element', *dúil*, a term originally signifying a 'created being'.

The precise conceptual meaning of many of these technical terms has, of course, evolved considerably since the later Middle Ages. In this sense, the Tract serves also to illustrate in small measure the historical development of science in the West. The inclusion of a revised English translation, together with the editing of Maxwell Close's comments as a separate Appendix, recognises this valuable dimension to the Tract.

I have included a digressional matter of some interest. One of the Royal Irish Academy manuscript copies of the Tract carries with it additional data relating to the movements of the sun and moon at some stage during the working life of the text. These details have been translated and subjected to computer analysis with a view to determining a possible date for these long passed astronomical observations. The results are reported in Chapter 5.

It has been said that the manuscripts of the fourteenth and fifteenth centuries bear witness to a Ireland's own Gaelic Renaissance,[1] the so-called 'Second Irish Revival'.[2] A detailed study of the surviving manuscript copies of this Tract certainly confirms this view.

Within this study I have used the name, 'The Irish Astronomical Tract', generally shortened to the Tract.

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[1]Rowena Finnane, *Late Medieval Irish Law Manuscripts: A Reappraisal of Methodology and Context*, MA Thesis, Sydney University, 1991

[2] M Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914), c.f.; Introduction, p.xi.

Chapter 2.

An Historical Overview of Astronomical Developments in the West

The ultimate foundations of the astronomical studies in the Irish Tract take us back largely to the scholarship of ancient Greece. It is true that a few elements of this astronomical knowledge appear to have been studied locally even in Neolithic times.[1] Other elements such as the signs of the Zodiac take us back to the Chaldeans in the East, but in practical terms, the systematic quest to unravel the secrets of the heavenly skies was a product of early Greek scholarship. Much of the necessary foundation was provided by the centuries of astronomical data recorded by Babylonian observers. Many scholars from the East and West have contributed in various ways towards the development of our current understanding of the universe, but for the purposes of this overview, I will mention only those of more pivotal influence.

When it comes to the question of adopting a model that can suitably describe and predict the regular progression of celestial bodies across the skies, the possibilities reduce to three basic options; a geocentric model, a heliocentric one or a combination of the two. Each of these had its proponents at one stage or another in classical times. The most obvious of these is that which considers the earth as the central reference point, with the sun, moon, planets and stars in a perpetual process of circular movements about the earth. This will be hitherto referred to as the 'geocentric' system. It has its obvious attractions, not the least of which is our inability to perceive any movement on the part of the earth. It is also able to explain much of the observable phenomena and to predict in most cases the movements of the observable celestial bodies. Pythagoras (580-500BC), among the early Greeks, postulated a spherical earth surrounded by a series of concentric spheres each of which carried a heavenly body. The innermost sphere was though to have carried the moon, and the outermost sphere carried the stars. The sun and planets were carried on the intervening spheres.

Plato's conception of the universe as a single entity having a spherical body and soul did little to further this model, but his attribution of natural circular motions to the heavenly bodies seemingly overcame the need to seek an efficient cause for their movement.

One of Plato's pupils, Eudoxus (408-355BC), conceived of each planet being on the equator of an imaginary sphere which rotated with uniform circular motion. Not all of these spheres had the same axis of rotation, but they were conceived of as being concentric with the earth. The final outer sphere carried the 'fixed' stars. It might be added that the spheres themselves were not thought of as having real existence, but were simply aids to prediction and calculations.

Aristotle (384-322BC) further embellished this model with additional spheres in an effort to better explain the irregularities of some of the celestial movements. Given that the sphere represented a more 'perfect' shape; the sun, moon and the spherical

[1] Peter Harbison, *Pre-Christian Ireland; From the First Settlers to the Early Celts*, Guild Publishing, London, 1988

spheres upon which the heavenly bodies were carried were conceived of as having a higher degree of perfection than mere earthly beings.

As with other Greek scholars of the day, Aristotle adhered to the belief that all matter could be reduced to combinations of the so-called four elements. This was taken to include the sun, moon and planets. The stars were thought to have a less earthly form of existence, being composed a fifth element or 'quintessence'. In a number of chapters within the Tract, Aristotle's conception of the Four Elements is discussed in detail. Other chapters can also be reduced to the teachings of Aristotle including those dealing with the nature of movement, meteorology and plants (see Chapters 2, 3, 4, 6, 8, 9, 13, 14, 15, 29, 38, 39 & 40).

The second of the planetary models to have been proposed in classical times was the heliocentric model of Aristarchus (310-230BC). In essence, the rotation of the earth on its axis was seen as sufficient to explain the daily motion of the stars. The earth and planets were then thought of as revolving around the sun with differing periods of rotation. There are various reasons why his views did not gain general acceptance, not the least of which was the almost unchallenged authority of Aristotle and the fact that such a system seemed to defy 'common sense'. There were other technical reasons which hindered its general acceptance until well into the 16th century, a few of which will be referred to later. Ptolemy himself was well aware of the heliocentric theory and was forced to admit that so far as the planets are concerned, it would have been far simpler.[1]

A third hybrid variation of these two models in classical times was proposed by Heraclides Ponticus. According to Heraclides, Venus and Mercury orbited the sun which, in turn orbited the earth. The outer planets, the moon and fixed-stars were thought to orbit the earth. His views did not gain general acceptance, but it is interesting to note that they briefly reappeared in an amended form in Tycho Brahe's model in the closing years of the sixteenth century.

Erastothenes (275-194BC) is chiefly remembered for his calculations of the sizes of the sun, moon and earth. Of these, his figure for the diameter of the earth, based on the midday solar elevations at Syene and Alexandria, is remarkably close to the known value. Chapter 35 of the Tract deals with this matter, although it focuses on the North Polar star rather than the sun.

The heavyweight among the astronomers of earlier times was undoubtedly Ptolemy of Alexandria (100-178AD). He improved the geocentric model of former times to account for subtle long-term variations to planetary motions that had been observed. Ptolemy's meticulous mapping of the celestial skies included 50 or more constellations and the postulation of epicycles, deferents and eccentrics to account for the irregularities of planetary motion. The retrograde motion of Saturn, Jupiter and Mars, together with their variations in brightness were thus satisfactorily accounted for.

[1] Ptolemy, *The Almagest,* Book I, c.f. Great Books, Vol 15, *Ptolemy: The Almagest*, Britannica, London, 1994, p12

Within the Greek world and among the Latin Christian philosophers of the West, Ptolemy's geocentric model held sway from late Roman times until the sixteenth century. The Latin scholars of the West were to some extent hampered by having lost contact with the original Greek writings. In general they had to rely on the commentaries of intermediary scholars. Among those who helped to pass on, albeit imperfectly, the scientific advances of classical times into the Middle Ages are to be counted Boethius, Martianus Capella, Macrobius, Chaleidius, Cassiodorus and Isidore of Seville. It has been estimated that these 'late encyclopedists of the West were removed from classical Latin authors by five or six, and from Greek authors such as Plato and Aristotle, by ten intermediary sources, and in most cases the separation was probably greater.'[1]

Hence, we can see that secular scholarship functioned under a considerable handicap in the Latin West for much of the Middle Ages. This situation prevailed until the developments of the late 13th century. It is in this context that the Irish Astronomical Tract finds itself and in which it must be viewed.

Scholars of the East were in a more fortunate position. Many valuable works were inherited by the Byzantine world and, with the Arab conquest of Alexandria, much of this scholarship passed into the hands of Arabic scholars such as the famous astronomers Alfergani and Albatani. Messahala appears to have been a Jewish scholar, a near contemporary of Alfergani and well at home within the world of Arabic learning. His work is judged as scientifically inferior to that of Alfergani, and it has been speculated that he had access only to imperfect versions of Ptolemy's works in the earliest of Arabic translations.[2] Nevertheless, his work circulated widely within the Islamic world of the Middle Ages, and translations of the work eventually penetrated the Latin West. It is one of these Latin translations of Messahala's Astronomy that served as a substantial source for much of the Irish Tract.

The Irish Astronomical Tract cannot be fully understood without some appreciation of its place in the scholastic renaissance of Western Europe. The 12th and 13th centuries witnessed a veritable flood of Greek scholarship from antiquity into the West. In its early stages, much of this came via Arab learning in Spain. Later, many of the Greek texts from the East were translated into Latin. Gerard of Cremona, working principally in Toledo, is said to have translated 76 Arabic works into Latin. These included Ptolemy's *Almagest,* many of Aristotle's works and later commentaries, and the entire corpus of Avicenna's works. His activity as a translator, together with others under the direction of Bishop Raymond, brought the world of Arabic learning within the reach of the scholars of Latin Christendom. Gerard died in 1178 and was buried in the Church of St Lucy near Cremona to which he bequeathed his valuable library. In a sense he and his associates helped lay the foundations for a cross fertilisation of ideas out of which sprang the Scholasticism of the 13th century.

Another translator of note was a Dominican scholar by the name of William of Moerbeke. He translated many Greek texts into Latin, particularly those of Aristotle.

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[1] Macrobius, *Commentarii in Somnium Scipionis*, (early 5th cent), Ed. Stahl, W H, *Commentary on the Dreams of Scipio by Macrobius,* Records of Western Civilisation Series, Columbia Univ. Press, N.Y., (1990), p10.

[2] M H Close, *Remarks on a Cosmographical Tractate in the Irish Language,* Proceedings of the Royal Irish Academy, (1900-02), pp 460

The flurry of translating activity in those years can be glimpsed by reference to Aristotle's *Physics.* By the early 13th century it had been the subject of five independent translations[1]. The first was from Arabic into Latin by Gerard of Cremona (before 1150). A Greek to Latin version of the first two books also dates from around 1150[2]. Another Arabic to Latin version of the complete *Physics* is mentioned about 1170[3]. An early 13th century Arabic to Latin text with commentary by Averroes was translated by Michael Scott before 1235[4] and a little later, William of Moerbeke revised the first Greek to Latin version.[5]

The emerging picture is one of vigorous translation and dissemination of texts in the quest for the 'wisdom' of the Ancients. In the physical sciences, Aristotle's cosmology and the geocentric mathematical models of celestial movements of Ptolemy became the framework from which men like Copernicus, Galileo, Brahe, Kepler and even Newton undertook the founding of modern astronomy and physics. The Latin translation of Messahala's Tract circulated widely in the West during the 15th century and its eventual influence upon Columbus and the generation of explorers and navigators that followed him would be hard to overestimate.

We can see this period as pivotal in the development of the West. The emergence of the Irish Astronomical Tract in Ireland may thus be seen as a participation in the much wider developments of the Renaissance that helped to shape the world as we know it today.

Within the timeline of scientific developments, the Irish Tract is clearly pre-Copernican in its conception of the universe and pre-Columbian in its knowledge of world geography. Its duration of relevance for educational purposes would appear therefore to have stretched from the latter half of the fourteenth century to the end of the fifteenth century and not much later.

It is of interest to trace briefly the sequence of scientific contributions which were to render much of the Tract's content obsolete. Nicholas Copernicus (1473-1543) was well versed in the writings of the Greek philosophers and astronomers. With him began the inevitable move towards the adoption of a heliocentric model of the solar system. The inability to detect any stellar parallax delayed its general acceptance, as did its initial inability to predict planetary movements more accurately than the Ptolemaic system.

Tycho Brahe (1546-1601AD) spent a lifetime amassing data from extensive observations of the angular positions of the planets. His hybrid geocentric-heliocentric model envisaged the sun orbiting a stationary earth while the other planets orbited the sun. It did little to further our knowledge, but his data enabled Johannes Kepler (1571-1630AD) to make a detailed study of the movements of the planet Mars. The result was his three 'theorems', now generally known as Kepler's Laws. Integral to Kepler's

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[1] F Van Steenberghen, *Aristotle in the West,* Louvain, Nauwelaerts, 1955.
[2] Now preserved in *Cod. Vat. Regin.* 1855, c.f., Introduction to, *Commentary on Aristotle's Physics; St Thomas Aquinas,* ed.; Richard, J., *et al.,,* Routledge & Kegan Paul, London, 1963.
[3] Vernon J Bourke, Introduction to *Commentary on Aristotle's physics by St Thomas Aquinas,* Routledge & Kegan Paul, London, 1963
[4] Ibid.,
[5] M.Grabmann, *Gugleielmo di Moerbeke,* Roma, Pont. Univ. Gregoriana, 1946, pp. 90-91

mathematics was the assumption of elliptical orbits for the planets around the sun. This last element enabled predictions of planetary movements whose accuracy vied with that of Ptolemy.

The telescopic observation of planetary phenomena by Galileo (1564-1642AD) gave added weight to the heliocentric model, but it was the application of Isaac Newton's Law of Universal Gravitation and his mathematical derivation of Kepler's Third Law that sealed our current understanding of these matters.

To complete the story, Einstein's Theory of Relativity has modified our modern perspective, among other things, with the notion that any stationary object is a purely relative concept. In regard to our solar system, the centricity of the sun reduces merely a mathematical convenience. Furthermore, the gravitational influences and resulting movements of the sun and planets are mutually interacting. Such notions, and all those since the time of Copernicus are, however, beyond the immediate relevance of the Irish Astronomical Tract, which occupied a fairly narrow window of time in the history of scientific thought within the West.

Those parts of the Tract that do not relate directly to astronomical matters can be mostly included under a few generic headings: Geography (physical & human), Physics (kinematics & forces, light & optics), Meteorology, and small portions of Chemistry, Botany & Medicine. Each of these areas were subject to eventual obsolescence during the 16th and 17th centuries. Although the Tract speculates on the possibility that one could circumvent the globe, the matter is never referred to in anything other than a subjunctive sense, e.g., 'if one were able to . .'.[1] The voyages of Columbus and subsequent navigators of the early 16th century would have rendered much of the Geography obsolete. The assertion that the southern hemisphere was uninhabited because of the 'excessive heat' of the Sahara Desert[2] strikes one as particularly parochial, but probably not out of place in the northern fringe of 13th and 14th century Europe. A glance at the late medieval maps of the world reveals notions of the Antipodes to have been vague in the extreme. The 15th century Harley ms in the British Library is a typical example.[3] It is based on Ptolemy's world map (c.150AD).

The advent of the microscope and the extent to which it opened up new avenues in the biological sciences parallels the role of the telescope in the transformation of astronomical knowledge. The Tract predates both of these instruments.

All in all, one is left wondering how the three surviving copies of the Irish Tract came to be preserved in view of the fact that most of their content was so thoroughly dated as the 16th century progressed. Unlike a literary work of art, its usefulness to posterity would have been hard to envisage.

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[1] c.f. Chapter 7 of the Tract (Appendix I)
[2] c.f. Chapter 36 of the Tract (Appendix I)
[3] ms Harley 7182, fos 58v-59, The British Library, London.
c.f. Peter Whitfield, *Mapping in the World,* The Folio Society, London (2000)

Chapter 3

Knowledge of Astronomy in Medieval Ireland

Most of the early medieval Latin works of Irish provenance that bear upon astronomical matters resulted one way or another from the need within the early Christian Church to arrive at a satisfactory method for calculating the date for Easter. Controversy in this matter, between East and West, and within the Latin West, persisted for several centuries, giving rise to specialised works of an astronomical nature. One could even say that for a period of time the 'Easter controversy' preoccupied the interests of astronomical scholars in the West.

One of the earliest of Irish authors to venture upon these matters was a certain Augustin[1] from the monastery of St Carthagus in Waterford. These may be found in his essay on the wonders of the Bible. When he comes to Joshua's miracle of the sun and moon, he embarks upon a description of the lunar cycle of 19 years and the solar cycle of 28 years. He explains how these can be combined to yield a *Great (Pascal) Cycle* of 532 years ~ this figure being the product of the two lesser cycles and the time required for the two cycles to synchronise their periods. His application of this Cycle to contemporary events enables us to date his own writings to the year 655AD.[2]

This 19-year Lunar Cycle, otherwise known as the Metonic Cycle, is recorded as having been discovered by the Greek astronomer Meton of Athens in about the year 430BC. In simple terms, it is the time taken for the moon to attain the same phase on the same day of the solar year. The cycle encompasses a total of 235 lunar months. The 28-year Solar Cycle approximates to the time required for the rotation of the earth and its orbit around the Sun to return to the same phase on the same day of the week.

This combination of Solar and Metonic Cycles for the measurement of time dates back to the fifth century. In 463 AD, Victorinus of Aquitain was appointed by Pope Hilarius to undertake a revision of the calendar. The result was the so-called Great Paschal period of 532 years. It was adopted by some scholars but does not seem to have become widely adopted in Western Christendom until its acceptance by the Venerable Bede early in the 8th century.[3] Augustin from the monastery of St Carthagus was therefore in the *avant garde* when it came to utilising developments from the field of astronomy.

Victorinus himself seems to have acquired a significant profile in early medieval Ireland. He is among the few scholars to be found among the august company of saints, prelates and kings in the Irish Annals. The Annals of Ulster inform us under the year 455 that 'the astronomer Victorius flourished'.[4] The Annals of Inisfallen are a

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[1] Augustinus Cartaginensium, *De mirabilibus sacrae scripturae,* c.f., Smyth, Marina Bridget, *Understanding the Universe in Seventh Century Ireland,* Ph.D. Thesis, Notre Dame, Indiana (1984) p11.
[2] Reeves, Proc. Royal Irish Academy, VII. 516.
[3] C. A Ronan, *Early Calendar Systems,* Encyclopaedia Britannica (Macropaedia) Vol. 3, (1984) p595-612.
[4] c.f.; Liam De Paor, *Saint Patrick's World,* Four Courts Press, Dublin, 1996, p119.

little more informative. We are told that in the year 457, 'Victorius wrote the Pascal Cycle'.[1]

Much has been written about the so-called Easter controversy, but for the purposes of this review it might be noted that it gave rise to numerous technical studies. One might venture to say that it provided the major incentive for astronomical studies in the West during the 6th and 7th centuries. The Irish monk Columbanus makes reference to these questions in a number of his letters and he appears to have written a book on the matter which was sent to the French bishops in 600AD.[2]

The following extract is from a letter of Cummian dealing with the Easter Question. It is addressed to Segéne, the fifth abbot of Iona (623-652). The author may be Cuimíne Fota who was associated with the monastery of Clonfert.[3] He died in the year 661AD.

> . . . Finally, having thoroughly investigated the Easter cycles derived from various computations, comparing the opinions given in different languages on the course of the sun and the moon, I discovered cycles at variance with this one which you adhere to – admittedly cycles that diverge from yours in different ways – one in the day, another in the moon, another in the epact, and another in the increase of the moon, which you call the "leap". The first of these computations is that which holy Patrick, our *papa,* brought to us and practiced, in which the moon is regularly observed from the fourteenth to the twenty-first, and the equinox from the twenty-first of March . . . [4]

His views on the Easter Question are not relevant to this study, but it can be noted that a significant body of written material appears to have made its way to Ireland and much critical evaluation of these astronomical models had been stimulated among Irish scholars of the day.

This preoccupation with the solar and lunar cycles for the purpose of calculating the date of Easter inevitably gave rise to a number of astronomical works during the early Middle Ages. One of them was the *Liber de Astronomia* or *Computus*[5] of Dicuil, an Irish scholar writing on the Continent.

There are said to be up to four Irish scholars of this name who are known to have worked on the Continent in those years. The present subject was employed at the court of Charlemagne in the early 9th century. His *Computus* was one of a number of texts compiled for the purposes of conveying the elementary knowledge of astronomy needed for the calculation of the date of Easter. Among other matters, the treatise contains the rules for finding out what month it is, and what day of the month, what the moon's age is, and what days Easter and Lent will fall upon. As well as the details

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[1] Ibid.; p124.
[2] Tomás Ó Fiaich, *Columbanus in his Own Words,* Veritas, Dublin, (1974)
[3] The other contender for the authorship of this letter is Cuimíne Ailbe who became abbot of Iona in 657. C.f. Liam De Paor, *Saint Patrick's World,* Four Courts Press, Dublin, 1996, pp 151-153.
[4] Ibid., p152.
[5] Dicuil, Liber De Astronomia (Computus), Ed. M Esposito, Irish Books and Learning in Mediaeval Europe, Cha VIII, p378-446, Variorum, London (1961),
Dicuil, *Computus* or *Liber de Astronomia*, Edition of Esposito, Proc. RIA, 1907, 26C pp381-445.
Esposito,
M., *Dicuil's Computus: Study & Emendations,* in Modern Philology, xviii, 1920, p177-188

relating to the solar and lunar cycles, an account is given of the distances from the earth to the firmament and the various planets. Most of these details are seen resurfacing a century or so later in the 10th/11th century collection of poems known as *Saltair na Rann.* I will elaborate upon this work later. For the moment, it suffices to say that a certain continuity of astronomical knowledge during the Irish Middle Ages begins to emerge.

Perhaps the most interesting comment made by Dicuil in his *Liber de Astronomia* is his admission that the theories concerning the motion of the sun, stars & planets appear to him to be unsatisfactory. He remarks that if anyone could give him a better solution to the problem, he would gladly adopt it. He is no doubt referring to the complicated system of epicycles, deferents and eccentrics required to account for planetary motion. The heliocentric model of Aristarchus (310-230BC) had been known since Classical times, but its assumption of circular orbits rendered it less accurate than the Ptolemaic model which could approximate for the effects of elliptical motion. For this reason (and others), the geocentric model was almost unchallenged until the time of Copernicus. Dicuil shows a critical spirit, rare in the 9th century.[1]

Interest in the *Great Pascal Cycle* however, seems to have waned with the passing of the early Middle Ages. By the time we come to the Irish Astronomical Tract in the 14th century, it had dropped entirely from the agenda. Clearly, the Easter controversy and the necessity for astronomical knowledge required to calculate its date had long since passed. Furthermore, Messahala, upon whose work much of this Tract was based, would have had little interest in the Great Pascal cycle, given his own religious context.

Other matters unrelated to the Easter Cycle were addressed in a number of works during the early Middle Ages. One of these is also by Dicuil: his *Liber de Mensura Orbis Terrae*[2]. It is particularly relevant to a number of Chapters in the Irish Tract and deals principally with the physical geography of the earth. It displays a very comfortable familiarity with the learned writings from the Classical World, from Greek to Late Roman times. The works of five former authors are quoted directly: Pliny the Elder (AD 23-79), C. Iulius Solinus (3rd cent AD), Priscianus (5th cent AD), Isodore of Seville (6th cent AD) and Sedulius (5th cent AD). A further twenty-five authors including Herodotus, Eudoxus of Rhodes, Artemidorus of Ephesus, Hecataeus of Miletus, Pytheas and Ptolemy are referred to.

The work as a whole does little to quicken the heart beat, but Dicuil's description of the Island of *Thule,* (generally thought to be Iceland) is fascinating. Pertinent to this review, are his details of the sun's movements with respect to the vernal & autumnal equinoxes, and the winter & summer solstices on the edge of the Arctic Circle. Of particular interest is the fact that his informants were Irish monks who were familiar with the island as a place of hermitage. It is also interesting to note that Dicuil does not fall prey to the widely held error at the time of Pliny, that day and night were of

[1] M Esposito, *An Unpublished Astronomical Treatise by the Irish Monk Dicuil,* Chapter VII, of *Latin Learning in Mediaeval Ireland,* Variorum Reprint, London (1988) p378

[2] Dicuil, *Liber De Mensura Orbis Terrae,* (English translation by J J Tierney), Dublin Institute for Advanced Studies (1967)

six months duration in Iceland. His treatment of this topic has a refreshing air of authenticity, not always found in the other geographical works of that time:

> It is now thirty years since clerics, who had lived on the island from the first of February to the first of August, told me that not only at the summer solstice, but in the days round about it, the setting sun in the evening hides itself as though behind a small hill in such a way that there was no darkness in that very small space of time, and a man could do whatever he wished as though the sun were there, even remove lice from his shirt, and if they had been on a mountain-top perhaps the sun would never have been hidden from them.
>
> In the middle of that moment of time it is midnight at the equator, and thus, on the contrary, I think that at the winter solstice and a few days about it dawn only appears for a small space at Thule, when it is noon at the equator.
>
> Therefore those authors are wrong and give wrong information, who have written that the sea is solid about Thule, and that day without night continues right through from the vernal to the autumnal equinox, and that vice versa, night continues uninterrupted from the autumnal to the vernal equinox, since these men voyaged at the natural time of great cold, and entered the island and remaining on it had day and night alternatively except for the period of the solstice. But one day's sail north of that they did find the sea frozen over.[1]

Although separated from the Irish Tract by more than five centuries, there are parts of Dicuil's cosmography that find a clear echo in the Tract. His treatment of volcanic eruptions and their causes, particularly with reference to Mount Etna, is remarkably similar to that in the 14th century treatment. It would seem they both had common reliance on the works of earlier Classical authors, notably Solinus[2] and Servius[3].

The following brief extracts give the general picture:

> Dicuil:
> There are two openings on Mount Etna, called craters, through which vapour is vomited forth, after a preliminary roaring, which rolls with long bellowings through dark caverns within the bowels of the earth. The balls of flame do not shoot up without being preceded by the interior rumblings.[4]
>
> Irish Tract:
> I declare that it is the amount of sulfur which is the cause of the fire that is constantly burning, . . . in veins . . . beneath the earth. . . . so that it cannot be extinguished . . . (The) growth of sulfur and the burning of the fire are ever increasing, and the flame as it rises from it, throws up many balls and masses of fire which come forth from the substance of the sulfur. . . . There is often heard a great, terrible sound from the wind going into these hollows and blowing with the flame as it comes out.[5]

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[1] Dicuil, *Liber de Mensura Orbis Terrae,* ed. J J Tierney, The Dublin Institute for Advanced Studies, Dublin, 1967, VII, 11-13.
[2] C. Iulius Solinus, *Collectanea Reum Memorabilia,* ed. Th. Mommsen, Berolini, 1895.
[3] Seruius, *Commentarius in Aeneidem,* ed. G. Thilo, Lipsiae, 1923.
[4] Dicuil, *Liber de Mensura Orbis Terrae,* ed. J J Tierney, The Dublin Institute for Advanced Studies, Dublin, 1967, VIII, 9.
[5] The Irish Astronomical Tract, Chapter 10. (See Appendix I)

Although the two authors' explanations of volcanic activity severely limp in the light of current knowledge, they are, if nothing else, poetic in their graphic imagery!

A small but interesting work by another Irishman on the Continent was precipitated by the eclipse of the sun in Europe in the year 810AD. Charlemagne, clearly troubled by this potential omen, had sought an explanation of the event. A certain Dungal, the Recluse, who resided at the monastery of St Denis was consulted and the result was his 'Epistle to Charlemagne on the Nature of Eclipses'. The letter is based largely on the 'Commentary of Macrobius on the *Somnis Scipionis.*' It follows the traditional Ptolemaic explanation of the phenomenon.[1] The Irish Tract also treats of the solar eclipse (Chapter 23), and while conforming to the traditional geocentric explanation, it is clearly of independent origin.

Another relevant author of this period is Virgilius, Bishop of Salzberg (d.745AD), otherwise know as Fearghal, the Astronomer[2]. He attained fame for his cosmographical writings[3] whose boldness at one stage attracted the condemnation of St. Boniface. His view of the universe held that the earth was round and that people might be living in the Antipodes! To the orthodox mind, this seemed to put Virgilius in contempt of Holy Scripture. Prior to his appointment as bishop of Salzberg, his case was brought before the Pope who decided in favour of Virgilius.[4] His knowledge of astronomy is thought to have been derived principally via the works of Pliny, Macrobius and Martianus. It is worth noting that the assertion that people might live in the Antipodes contrasts with the Irish Tract of later times. The author of the Tract declared that the region south of the equator was uninhabitable.[5]

Johannes (Scottus) Eriugena[6] was another who might be added to our present list. He was principally a philosopher and theologian. Indeed, Coplestone, in his *History of Philosophy,* refers to him as 'standing out like a lofty rock in the midst of a plain'.[7] One of his early works however, does seem to venture into the realms of cosmology: his commentary on the *De Nuptiis Philogiae et Mercurii* of Martianus Capella (859-60AD). His resulting cosmological theories are an uncomfortable synthesis of philosophical, scriptural and astronomical themes. Among other things, he describes the soul's journey from its celestial home through the planetary spheres into the body and back again.[8]

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[1] Dicuil, *Liber De Mensura Orbis Terrae,* Scriptores Latini Hiberniae Vol. VI, Edited by J J Tierney, The Dublin Institute for Advanced Studies, Dublin (1967), cf p6 of the Introduction.

[2] c.f., M Esposito, *Latin Learning in Mediaeval Ireland,* Variorum Reprint, London (1988)

[3] Tomás Ó Fiaich, *Irish Cultural Influence in Europe, VIth to XIIth Century,* Mercier, (1971)

[4] Patrick H Montague, *The Saints and Martyrs of Ireland,* Colin Smythe, Gerrards Cross, Bucks. (1981) pp65-67

[5] c.f., IAT, Chapter 36.

[6] John J O'Meara, *Eriugena,* Mercier Press, Dublin (1969)

[7] Frederick Copleston, *History of Philosophy,* Vol. II, Part 1 – Augustine to Bonaventure, London 1964, p112.

[8] One is reminded of the caution advised by Augustine of Hippo a little earlier, towards those tempted to draw upon Scripture for scientific purposes: 'You have stated that Mani taught you the beginning, the middle, and the end, and how and why the world was made, and about the course of the sun and the moon and about other things which you have mentioned. Nowhere in the Gospel do we read that the Lord said: "I am sending you a Paraclete who will teach you about the course of the sun and the moon." For he wanted to make Christians, not mathematicians.' Augustine, *De actis cum Felice Manichaeo,* I, 10. See Jurgens, William A., *The Faith of the Fathers,* The Liturgical Press, Minnesota, 1971.

Esposito has identified two further commentaries by Irish scholars on the Martianus work. One is an anonymous manuscript in the Bibliothèque Nationale.[1] As far as I know, it is yet to be published. The other is by a certain cleric named Dunchad. It was written for his pupils in the monastery of St Remigius at Rheims during the 9th century.[2]

This brief summary of astronomical writings reveals a number of characteristics that separate them from the Irish Tract of later times. For a start, they all belong to the earlier half of the Middle Ages, whereas the Tract brings us to the latter half. In fact it already shares in the flurry of scholarship that led ultimately to the Renaissance of the West. Furthermore, the works themselves were all in Latin, while the Tract is in the vernacular. To this extent their usefulness in the study of the evolution of scientific terminology in the Irish vernacular is necessarily limited. Nevertheless, they do bear eloquent testimony to a significant participation in the scholarship of the West, at least among the educated of Irish society.

Vernacular Works of the Later Middle Ages

Further insights into the knowledge of astronomy in Ireland and the extent to which the language was able to cope with the matter of scientific terminology can be gleaned from vernacular sources. These are all in the nature of writings that bear incidentally upon technical matters. The 14th century Tract is among the earliest of scientific works as such to be written in Irish.

The following examples throw a little more light on extent of astronomical knowledge at the time. They serve to provide us with a small but interesting list of Irish astronomical terms that were in use prior to the compilation of the Tract.

A number of poems in Middle Irish manage to include a considerable amount of astronomical knowledge. One of these is *Saltair na Rann,* attributed to Oenghus the Culdee but almost certainly written a century or so after the saint's time. It is in fact an anthology of poems setting forth Biblical history from the time of creation. The first poem entails a short description of the universe. The earth is described as being "like an apple, goodly, truly round." The names of the seven known 'planets' are given; *Saturn, Ioib, Mercuir, Mars, Sol, Uenir* and *Luna.* The distances from the earth to the moon, the sun, and the firmament are also given, but are all wildly inaccurate. The firmament is described as enclosing the earth "as the shell is around the egg" (*mar uball febda fircruind*).[3]

The signs of the Zodiac with their names and correct order are also given. This is accompanied by the day and the month on which the sun enters each. The sun is said

[1] Anonymous*, Commentary on De Nuptiis Philologia et Mercurii, of Martianus Capella*, MS No. 12960, Bibliothèque Nationale, Paris. c.f. Esposito, M, *Latin Learning in Mediaeval Ireland,* Variorum Reprint, London (1988)

[2] Dunchat, *Commentum Dunchat,* Ms. Reg. 15, A, XXXIII (British Museum). Commentary written for his pupils in the monastery of St Remigius at Rheims (9th cent) c.f. Esposito, M, *Latin Learning in Mediaeval Ireland,* Variorum Reprint, London (1988)

[3] Whitley Stokes, (ed.), *Saltair na Rann,* Anecdotia Oxoniensia; Mediaeval & Modern Series, Vol. I Part III, Oxford (1883) p1.

to be 30 days and 10½ hours traversing each constellation of the Zodiac. Five Zones of the earth are listed: north and south frigid, two temperate zones and the torrid zone in between.

All of these details are the subject of more elaborate scientific treatment in the Irish Tract. The dates at which the sun arrives at each sign of the Zodiac are not given in detail in the main body of the Tract, but they are included on the cover page of the Stowe B manuscript copy in the RIA. These details may have been taken from the accompanying rotula during the working life of the Tract by a now anonymous medieval Irish lecturer.

In general, the details agree with those to be found in the Tract with the exception of the division of the earth into geographical zones: five habitable zones in the case of *Saltair na Rann*, and seven in the case of the Tract, these being limited to the northern hemisphere. This of itself should not be surprising, as divisions such as these are ultimately arbitrary, depending merely upon whichever earlier authority is being followed.

The following extract gives something of the flavour of the verses that make up *Saltair na Rann*:

Ri rochruthaig, nícuac cinte,	King who shaped within no narrow limits
Hicuairt na firmiminte,	In the circle of the firmament
Domun delbda derbda druing,	The globe, fashioned like a goodly apple,
Mar ubull febda fircruind.	truly round.
. . .	. . .
Rosuidig secht rinne reim	He set the course of the seven Stars
O firmimint co talmain,	From the firmament to the earth,
Satuirn, Ioib, Mercuir, Mars,	Saturn, Jupiter, Mercury, Mars,
Sol, Uenir, Luna lánmas.[1]	Sol, Venus, the very great moon.[2]

The poem is able to provide us with a short list of technical vocabulary current in the 10th and 11th centuries. Aside from the terms mentioned above, we are given the names of the constellations of the Zodiac and many technical words that resurface in the Astronomical Tract. These are included in the Tables 3.1 & 3.2. Among other things, it seems that Irish did not possess vernacular terms for either the planets or the constellations of the Zodiac prior to the advent of Classical learning.[3]

The *Feilire* of Oenghus is a calendar of Celtic Church festivals, likewise attributed to Oengus the Culdee. It entails a verse for each day of the year, occasionally revealing an astronomical detail. The summer solstice for example, is referred to as the *grain-tairisem,* lit. 'sun-standing'. It is correctly indicated as falling on the 21st of June.[4]

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[1] Whitley Stokes, (ed.), *Saltair na Rann,* Anecdotia Oxoniensia; Mediaeval & Modern Series, Vol. I Part III, Oxford (1883)
[2] Eleanor Hull, *The Poem-Book of the Gael,* Chatto & Windus (1913)
[3] In the commentary on the *Senchus Mór*, a similar description of the universe is to be found.
[4] P. W. Joyce, *A Social History of Ancient Ireland,* Vol I, Longmans, Green & Co, London, (1920) p466.

In the 'Life of St Senan' in the Book of Lismore, passing reference is made to the autumnal equinox. It relates that at the time of the saint's birth, his mother happened to be alone on the garden *fria deiseabhair na grene,*[1] 'about the autumnal equinox.' *Deiseabhair na grene* means literally, 'the southing of the sun,' i.e., the sun going south of the equinoctial. It was clearly understood that the apparent annual motion of the sun along the ecliptic entailed half of the year north of the equinoctial and the other half south. One presumes there was a corresponding Irish term for the vernal equinox, but as far as I know it has not found a place among Irish writings that have survived.

Surprisingly, nowhere do we find a term in Irish that equates succinctly with the word 'Astronomy'. A medieval Law Glossary compiled by a certain Duald Mac Fibris details the seven grades of knowledge required of professors in ecclesiastical and monastic schools. The fifth such grade, the *Foirceadla Dhe,* the 'lecturer' in Profane Literature, was required to know; Grammar, Criticism, Syllabification (Orthography), Enumeration (Mathematics), and the *courses of the sun and moon.* This latter phrase is about as close as we get to a term that might describe the discipline we refer to as Astronomy. Indeed, throughout the 26,000 words of the Irish Astronomical Tract, the term is conspicuous by its absence.

I will conclude this Gaelic miscellany with a charming window into these matters from the Saga literature. The following passage arises from Cú Chulaind's desire to honour his commitment to attend two feasts in the one night:

> It was then that Cú Chulaind said to Lóeg son of Ríangabur: 'Go outside' good Lóeg, and examine the stars, and determine if midnight has arrived, for you have often waited and watched for me at the boundaries of distant lands.' Lóeg went out, then, and he watched and waited until it was midnight; then he returned to the house and said 'Midnight now, O Cú.'[2]

The relevant point from this brief incident is that knowledge of the movements of the constellations across the night sky was not considered to be anything out of the ordinary. One could also infer that such astronomical knowledge was not uncommon among the patrons of these tales. It might be added that the measurement of time by the movement of the constellations is considerably more difficult than that by solar observations during the day. The constellations in the night sky vary from month to month as do their positions during the month. As a matter of interest, Joyce noted that he had come across intelligent country folk in the late 19th century who retained this skill.[3]

* * *

[1] Whitley Stokes, *Lives of SS.,* line 1885, and Pref. Ciii.
[2] *The Intoxication of the Ulaid*, trans. Jeffrey Gantz, *Early Irish Myths and Sagas,* Penguin (1981) p190-218
[3] P W Joyce, *A Social History of Ancient Ireland,* London, Dublin, 1920.

From the above collection of incidental references to astronomical matters, gleaned from the corpus of Gaelic letters, one can draw together a modest list of Irish terms that can be presumed to have been already current during the Middle Ages, at least among educated people. There are included in Tables 3.1 & 3.2.

Table 3.1: General Astronomical Terms

	Irish	**Origin**
sun	*grian, grien* *sol*	c.f., Old Ir.; *grían* (Quin) Latin; *sol*
moon	*re, re easca, & easca* *luan, luna*	Old Ir.; *re esca* (Quin), (*gealach* – Mod. Irish) Latin; *luna*
Saturn	*Saturn*	Latin; *Saturni stella*
Jupiter	*Ioib*	Latin; *Iuppiter*
Mercury	*Mercuir*	Latin; *Stella Mercurii*
Mars	*Mars*	Latin; *Mars*
Venus	*Uenir*	Latin; *Venus*
Solstice (summer)	*grein-tairsen*	Lit.: 'sun-standing (above the equinoctial line)'. Latin; *solstitium*
autumnal equinox	*deiseabhair na grene*	Lit.: 'southing of the sun'. Latin; *aequinoctium*
sundial[1]	*solam*[2] *soiler*[3]	Presumably both are from the Latin *solarium*
element	*duil*	Old Ir.; *dúil* (Quin)
earth	*talman* (g)	Old Ir.; *talam, talman* (g) (Quin)
world (universe)	*domun*	Old Ir.; *domnán* (Quin)
firmament	*firmimint*	Latin: *firmamentum*
planets	*secht rinn(e)*	From *Saltair na Rann,* lit.; the 'seven stars'

[1] C.f.; Harbison, Peter, *Pilgrimage in Ireland, The Monuments and the People,* Barrie & Jenkins, London (1991), see Chapter 19, Sundials, pp 211-215.
[2] Johann Casper Zeuss, *Grammatica Celtica* (1853) 771, 15
[3] Glosses the Latin term *solarium,* c.f., Whitley Stokes, *Irish Glosses,* Irish Archeological & Celtic Society, Dublin (1860) p 91, No 740 (p91 No 740)

Although the subject of sundials is not mentioned in the Irish Tract, they were commonly used in Ireland during the Middle Ages. No less than nine sundials carved in stone are known to have survived from medieval Ireland. Most, if not all of these, appear to have been monastic in origin or associated in some way with sites of early Christian pilgrimage. Frequently the subdivisions carved into the face of the sundials tend to suggest that their principal reference points were the times at which the monastic office was recited, such as *terce, sext* and *nones.*[1] We find the technical aspects of the sundial addressed in a small Irish manuscript in the Abbey Library of St Gall in Switzerland.[2] Its anonymous author discusses various scientific subjects including the Pascal Cycle and the age of the world. It dates to the eighth century and would tend to suggest that Irish scholars of the time were familiar with the device and its operation. This in turn required an operative knowledge of the path of the sun along the ecliptic.

Table 3.2 The Constellations of the Zodiac

Irish	**Proximate Origin**
c.f.; *Saltair na Rann,* Bodlian copy: ms Rawl. B 502, ff	
Aquair	Latin: *Aquarius*
Ariet	Latin: *Aries*
Pisc( )	Latin: *Pisces*
Tauir	Latin: *Taurus*
Gemin	Latin: *Gemini*
Cancer	Latin: *Cancer*
Leo	Latin: *Leo*
Uirginem	Latin: *Virgo*
Librum	Latin: *Libra*
Scoirp	Latin: *Scorpio*
Saigitairium	Latin: *Sagittarius*
Capricornú	Latin: *Capricornus*

[1] c.f.; Peter Harbison, *Pilgrimage in Ireland, The Monuments and the People,* Barrie & Jenkins, London (1991), see Chapter 19, Sundials, pp 211-215.
[2] c.f., Keller, Ulster Journal of Archeology, VIII. 294, (Belfast)

Chapter 4

The Irish Astronomical Tract: Its Manuscripts & Context

Our knowledge of the Irish Astronomical Tract derives principally from three surviving manuscript copies. Two are almost complete. The third copy contains a little over half of the Tract. I will retain, as far as possible, the terminology and chapter numeration used by Power in her scholarly translation earlier last century.[1] The texts are referred to as: Stowe B II (RIA), ms Z.2.2.1 (Marsh Lib) and ms 23.F.13 (RIA). They may all be dated to around the close of the 14th century give or take a generation.

The three manuscript copies of this Tract are all from different hands. Manuscript RIA Stowe B II was the subject of a detailed study by Tomás Ó Concheanainn in the 1970's. He concluded that the chief scribe for this manuscript was a certain Aedh Buidhe Ó Leighin. He was also one of the scribes of a medical manuscript known to have been copied not earlier than 1415. The Uí Leighin produced many men of learning and a number of scribes who are known by name. They resided in Fir Mhuighe (Fermoy), Co Cork, and their patrons were the Roches of Castletownroche during the fifteenth and sixteenth centuries (and possibly earlier).[2]

Concerning the Marsh Manuscript, Z.2.2.1, it appears to have entered Marsh's Library some time between 1719 and 1730 under the heading of *Anonymi Elementa Astronomiae*.[3] To my knowledge, the identity of its scribe has not yet been investigated. Both this and the Stowe B ms have most of the final vellum page damaged being virtually illegible beyond the first paragraph. This involves Chapter 40, which derives ultimately from Aristotle's *De Plantis*.

It is not known how the third manuscript came into the possession of the RIA. O'Curry dated it to "Circa A.D. 1400".[4] It is from the hand of a third scribe, likewise unknown at this point in time. Its vellum manuscript is described as being in 'bad condition' and only twenty-seven chapters of the text survive, parts of which are illegible.

Regarding the question of the relationship between the three surviving manuscripts, Power was unable to arrive at any definite conclusions. The Marsh manuscript generally has fewer scribal errors, its text being described as 'remarkably good'. On the other hand, its diagrams are inferior to those of Stowe B, and at times lacking agreement with the text. The half copy at the RIA in general conforms more closely to the Marsh ms. A comparison of manuscript errors reveals no obvious lines of dependence among the three surviving copies.

Power concluded that none of these manuscripts is the work of the original Irish author/translator. The mutilation of the Latin spelling in the chapter headings would seem to confirm this. Each of the three surviving manuscript copies reveals

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[1] Maura Power, *An Irish Astronomical Tract,* Irish Texts Society, London (1914)
[2] Tomás Ó Concheanainn, *The Scribe of the Irish Astronomical Tract in the Royal Irish Academy,* B ii 1, Celtica 11 (1976) p158-67
[3] Maura Power, *An Irish Astronomical Tract,* Irish Texts Society, London (1914) p vii.
[4] Ibid., p viii

independent corruptions to the chapter headings. The corruptions vary in degree, but as a general rule they tend towards a phonetic rendition of the Latin in Irish orthography. That for Chapter 20 of ms Stowe B is good example:

Nissisario idhitur fadendum est. (Necessario igitur fatendum est)

It would seem that the scribes were familiar with the titles to the chapters in Latin, but more at home with Irish orthography. It was common practice in the Middle Ages for learned works to be known by the opening phrase of their Latin source. If the Tract were to have been widely used over an extended period of time, the sequence of topics might well have been known under their Latin titles, even by those with minimal knowledge of Latin.

It is possible that the original Irish work might date to the mid 14th century or a little earlier. Power placed an earlier limit of 1325, based largely on the reference to the use of spectacles. Maxwell Close took the same detail to infer an earlier limit of 1320AD.[1]

There are very few points of internal evidence that might suggest a specific date at which the original prototype of the Tract might have been compiled. One possible detail is the reference to the regression of the planet Saturn from Aries to Pisces, known to have taken place in the year 1350. This matter will be discussed in the following chapter.

The Irish work does not seem to have acquired (or retained) a name in contemporary circles. It has since been variously referred to as: *Anonymi Elementa Astronomiae,*[2] *An Irish Astronomical Tract,*[3] and *Cosmographical Tractate in the Irish Language*[4]. None of these terms strikes me as entirely adequate. I have taken the liberty of adding an Irish name to the Irish edition in Appendix II taken from its author's own description of the work in the prologue: *Da Cailibh na Firmaminnti ⁊ na Ceithre Dula,* 'Concerning the Characteristics of the Firmament and the Four Elements'. It might be loosely said to refer to the physical properties of everything in the heavens and on earth; a fitting summary of the Tract.

The Irish Tract appears to have been based on a single Latin work which is not known to have survived. Close designates this work as '*Latin B*'.[5] It is thought to have been a compilation based on two earlier works: '*Latin A*', which was a Latin translation of the Arabic work of Messahala, and a second Latin text. This second text was, in part at least, also derived from an earlier Arabic cosmographical work of the Middle Ages. The occasional Arabic word retained in the text would seem to verify this.

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[1] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 7.
[2] Robert Dougall, *MS Catalogue of the Marsh Library, c.*1730.
[3] T Ó Concheannainn, *The Scribe of the Irish Astronomical Tract in the Royal Irish Academy*, B, ii, 1, Celtica, (1976) p 158-167
[4] Maxwell H. Close, *Remarks on a Cosmographical Tractate in the Irish Language. . .,* Proceedings of the Royal Irish Academy, 22: 457-64, (1902)
[5] M H Close, *Remarks on a Cosmographical Tractate in the Irish Language,* Proceedings of the Royal Irish Academy, (1900-02) p457-464

On the other hand, this inferred Latin prototype may never have existed as a single entity. It is quite possible that the author of the Irish Tract compiled the present work from two separate Latin source texts, retaining each chapter division together with its Latin title for reference purposes. These Latin chapter headings would therefore be simply the remnant tags of the two independent Latin works. The custom of referring to a work by its opening phrase in Latin was well established even after its translation into the vernacular.

It would seem unlikely that, if such a potentially useful Latin work for educational purposes were to have been compiled, it could have disappeared without a trace, either by text or reference.

Concerning Messahala's work, a Latin translation is known to have been made in Toledo during the latter half of the 12th century by Gerard of Cremona. He died in the year 1187. This work was published by Stabius at Nuremburg in 1504[1] and reprinted in 1549.[2]

It appears however, that the Latin translation used by the author of *Latin B* was not that of Gerard. The occasional Arabic word has survived in the Nuremburg editions, its meaning seemingly unknown at the time. The Irish text, however, has the correct meaning translated. The Arabic word for a potter's wheel, *bathara,* appears as such in the Stabius edition and other ms copies of Gerard's translation. The Irish text refers to it merely as *rotha,* 'wheel'.[3] Furthermore, a comparison of the Latin headings of the Chapters of the Tract with the opening lines of the Stabius edition reveals identical meanings but clearly independent translations. The following two examples give the general picture:

Chapter 6
Irish ms: Notandum est unum quodque quatuor elementorum . . [4]
Stabius: Et manifestum est iterum quod prima elementa quatuor. (Cap.VI)

Chapter 36
Irish ms: Asserunt antiqui philosophi . . [5]
Stabius: Et dico quod sapientes primi dixerunt . . (Cap.XXV)

In each of the above cases, the meanings are roughly the same. They are simply independent translations.

Returning now to Messahala and his works. He is known to have been a Jewish Astronomer from Alexandria who wrote in Arabic. He lived during the reigns of the Khalifs Al-Mansur and Haroun Al-Raschid, roughly within the period 754AD and 833AD. He was a contemporary of the noted Arab astronomer Alfragani. Of his many works in Arabic, only a few are known to have survived in that language. One is a rather insignificant text dealing with the prices of wares in the market[6] and another

[1] J. Stabius, (editor), *De Scientia Motus Orbis,* Nuremburg, (1502)
[2] Joachim Heller (editor), *De Elementis et Orbibus Celestibus,* Nuremburg, (1549)
[3] c.f., Chapter 26
[4] "It is clear that each of the four elements . . ."
[5] "The old philosophers say . . ."
[6] c.f., Hamed A Ead, *History of Islamic Science,* Univ of Cairo, (1999)

deals with weather predictions.[1] A short work entitled *The Book on Eclipses of Masha'allah* would, from the title, appear to bear some relevance to his astronomical tract. It is known only by translations into Hebrew and Latin. The earliest of these was a Hebrew translation made in Spain by Abraham Ibn Ezra in 1148.[2] A Latin translation was later undertaken by Gerard of Cremona. Closer inspection, however, reveals the work to be wholly astrological in nature. It is difficult for us, from a contemporary perspective, to understand how such a scholar could so completely remove his scientific hat and don the astrological one. But such was the case. The twelve chapters of this work bear no relation to the scientific content of the Irish Tract.

Messahala's treatise on astronomy entered the realms of European scholarship in the late 13th century after its translation into Latin by Gerard and is known to have circulated widely. The treatise itself is based chiefly on Ptolemy's *Almagest,* and Aristotle's *De Coelo* and *Meteorologica.* Generally speaking, the meteorology and natural science component of Messahala's work is Aristotelian and the astronomy is Ptolemaic. His frequent reference to the 'Philosopher' relates usually, but not always, to Ptolemy. Both Ptolemy and Aristotle are mentioned by name in places.

Close was of the opinion that Messahala had access to the first generation of Arabic translations of Ptolemy's works. His exposition of Ptolemaic astronomy is decidedly inferior to that of Albatani who came only two or three generations later and had access to much more reliable translations from the Greek.

As regards the subject matter derived from Aristotle, Messahala was even further removed from the 'Philosopher'. Some eleven centuries had elapsed since the days of the Academy. The works of early Greek scholars would have been known only via many generations of copyists and commentators. Even so, he was probably at closer range than his contemporaries in the West who had to rely on the Latin works of scholars such as Macrobius, Martianus Capella and Cassiodorus of later classical times.[3]

Returning now to the question of those Chapters that do not relate to Messahala's tract, some thirteen in all. It is quite possible they derive from more than one source. They exhibit a certain internal lack of scientific consistency, occasionally to the point of contradiction. Whatever the case, there seem to be no surviving Latin texts that might lay claim to being the progenitor. An Arabic word *al Kotera* (the diameter), in Chapter 35 would seem to confirm the presence of at least one other Arabic text behind the thirteen non-Messahalic chapters.

The content of these chapters ultimately leads us back principally to Aristotle's *De Caelo* and *Meteorologica.* Chapter 40 is derived from Aristotle's *De Plantis.* The

[1] c.f., Bernard R Goldstein, *Theory and Observation in Ancient and Medieval Astronomy,* Variorum Reprints, London, 1985.
[2] An English translation of the Hebrew version is contained in Goldstein's *Theory and Observation in Ancient and Medieval Astronomy,* Variorum Reprints, London, 1985. Pp 208-213.
[3] W H Stahl, *Commentary on the Dreams of Scipio by Macrobius,* Records of Western Civilisation Series, Columbia Univ. Press, N.Y., 1990, pp. 9-10.

additional influence of other scholars, both Greek and Latin, can be detected notably Posidonius, Erastothenes, Pliny, Strabo, Cleomedes and even Isidoro of Seville.[1]

The Irish Tract is not a literal translation of Messahala's Latin edition. In some parts it is close but most chapters have content either more or less than that contained in the relevant chapters of the Latin text. Frequently the Latin is only loosely paraphrased. The deviation becomes more pronounced from Chapters 30 to 38. Furthermore, the Tract includes details relating to Northern latitudes that would have been unknown to Messahala, as well as other obvious interpolations of a later era. These may have had many possible points of entry right up till the compilation of the Irish Tract itself.

The unknown Arabic author whose work or works contributed to the remaining thirteen chapters could well belong to a period some centuries later than Messahala. His source texts seem to be mostly Greek derivatives as might be expected. The possible influence of a Latin author, Isidore of Seville, at first seems to be an anomaly until we remember that his writings could easily have passed into Arab hands in Spain. Seville and in fact most of Spain, came under Arab rule during the latter half of the eighth century. On this basis, one could imagine Toledo or Córdoba as his possible centre of activity. It is tempting to link him with Averroës who is known to have written on the subject of Astronomy in 12th century Córdoba.

Close was of the opinion that the immediate Latin predecessor of the Irish Tract had been compiled in Ireland for teaching purposes. 'It seems likely that his object was to compile a text-book for students; as such it was probably used in Ireland.'[2] That is, if such a Latin compilation ever has physical integrity.

Internal evidence that might suggest a geographical context in which the subject matter assumed its final form is scanty. A possible clue is found in Chapter 36, which deals with the 'Seven Habitable Climates'. Such divisions had existed since the time of Hipparchus, but those of the Tract carry the hospitable zones to more northerly regions than did the earlier Classical authors. The inhabitants of the first four climes are described as having skin colour ranging from black in zone 1 to swarthy in zone 4. When the author comes to zone 5 the inhabitants are described as being of 'medium-sized bodies and their complexion is neutral.' One could infer from this that the author identifies with zone 5. Based on the stated lengths of the daylight hours, this zone would begin at a latitude of around 50° and carry through to about 56°. The southern tip of Ireland is at a latitude of a little over 51° and the northern most parts a little over 55°. The scenario is at least compatible with the Tract (or its Latin prototype) being compiled in Ireland.

[1] Details of these relationships are footnoted in the English edition of the Tract in Appendix I.

[2] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901), see Introduction, pages iii – vi.

The Irish Astronomical Tract: A Dominican Context?

In June 1259 a group of intellectuals from the Dominican confraternity met at Valenciennes.[1] Their purpose was to recommend a new program of studies for the training of members of the Order of Preachers. It recommended the new program include study in the liberal arts. It had the strong support of Albert the Great and Thomas Aquinas. Secular learning, including the sciences and philosophy, thus became an integral part of the curriculum in Dominican monastic schools.

The Dominicans came to Ireland in 1224 with the establishment of monasteries in Dublin and Drogheda. By the early 14th century the Dominicans had set up twenty five monasteries spread geographically across Ireland from Cork in the south to Coleraine in the north, and from Dublin in the east to Tralee and Rathfran on the west coast. Most of these were quickly 'Irishised'[2]. Many were set up at the invitation of local lords who provided the necessary real estate.

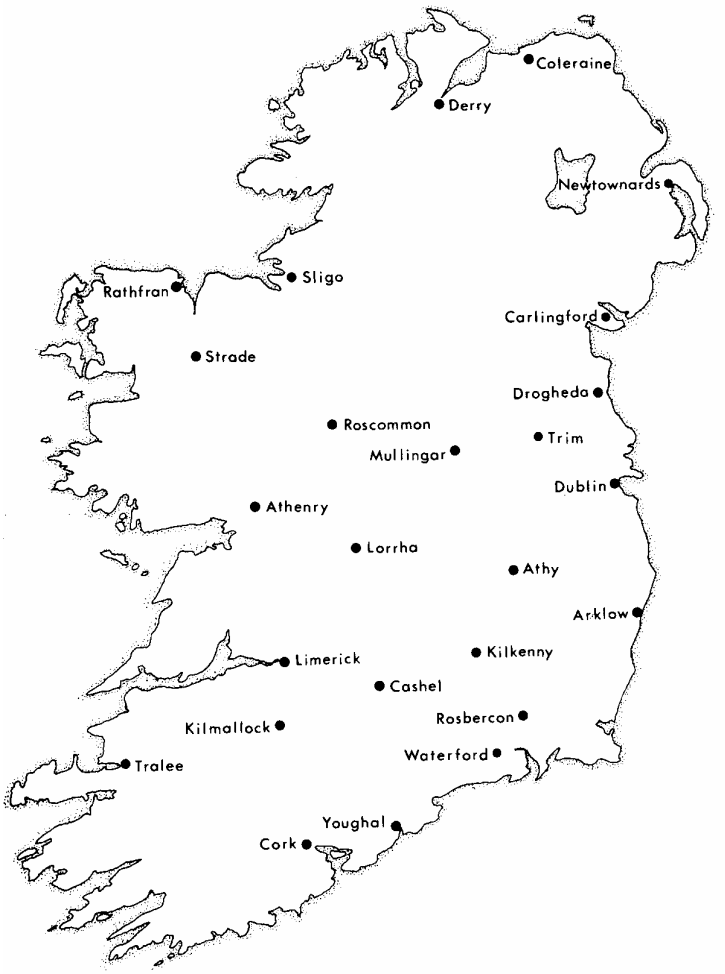

Fig 1, Dominican Houses in Ireland, 1305 [3]

[1] Vernon J Bourke, Introduction to *Commentary on Aristotle's physics by St Thomas Aquinas,* Routledge & Kegan Paul, London, 1963, pp. xviii - xix

[2] John Watt, *The Church in Medieval Ireland,* Gill & Macmillan, Dublin, (1972) p60-67

[3] John Watt, *The Church in Medieval Ireland,* Gill & Macmillam, Dublin, 1972, p 60-73

Given their newly established teaching program, it would be easy to envisage the Irish Tract and its Latin predecessor finding a place in Dominican circles in Ireland. It strikes me that the preservation of multiple copies of this tract, obviously used for educational purposes, demands some form of institutional provenance to account for its dissemination. I do not know what the survival rate for such texts would be, but if we assume a rate of one in ten, we might expect there to have been around twenty five copies or so. In this regard the two and a half copies that survive are not out of place.

There were of course other monastic communities in Ireland since before the coming of the Normans. The Fransciscans, Augustinians and Cistercians all had numerous houses but their particular foundational charisms render them less likely candidates for this role. The early history of the surviving manuscript copies is not known, but the attribution[1] of the scribe Aedh Buidhe Ó Leighin to the Stowe B II text is compatible with a commission from the Dominican House in Cork. Ó Leighin is known to have worked in and around the district of Fermoy in County Cork.

Internal evidence also favours an ecclesiastical provenance. The lengthy dedication to the 'Glory of God' would not sit well with the secular humanists of the early Renaissance. Furthermore, we are told in the preface that:

> since He did not wish to remain for ever without manifesting himself to men, He instructed the learned in His works and arts, so that the worker would be known from the works and the creator from the deeds, and therefore, it is fitting for the learned ones to whom He revealed His secrets to glorify Him above everything.[2]

The sentiments fit comfortably with the Dominican ethos.

The absence of any dedication of the *opus* to a secular patron (a practice common in the later Middle Ages), and the anonymity of its author, could also be taken as implying a monastic context for the work. This anonymity would also tend to exclude the hand of a member of the secular clergy. The likes of Geoffrey of Monmouth or Gerald of Wales would not have left their authorship in doubt.

Within the context of a monastic school, it is not too difficult to see the forty Chapters of the Tract as lecture notes for a class per week over the duration of one academic year. The fact that the vernacular was used would tend to indicate that students were junior novices.

Leaving aside the possible Dominican connection, there are a number of contemporary references concerning the place of secular learning in the monastic and ecclesiastical schools of the Middle Ages. Joyce and O'Curry quote *The Seven Grades or Orders of Wisdom* as compiled in a Law Glossary by Duald Mac Fibris.[3] As might be expected, these were heavily weighted in favour of theological matters, culminating in the *Saoi Canoine* or Professor of Canon (Law) and the *Druimcli* or

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[1] T Ó Concheanainn, *The Scribe of the Irish Astronomical Tract in the Royal Irish Academy,* B ii 1, Celtica 11 (1976) p158-67

[2] M Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914), p3.

[3] P. W. Joyce, *A Social History of Ancient Ireland,* Gill & Sons, Dublin, (1920), pp430-36

"man who has perfect knowledge of wisdom". Nevertheless, Grade V related almost entirely to matters of secular scholarship.

> The *Foirceadla Dhe,* i.e., 'Lecturer' of Profane Literature, who knows Grammar, *Crosan* or Criticism, Syllabification or Orthography, Enumeration or Arithmetic, and the courses of the Sun and Moon, (i.e., Astronomy).[1]

It appears that the Irish Tract would have been a welcome teaching resource for any 'lecturer' of Grade V on the pathway to wisdom!

Appendices to MS Stowe B II (RIA)

One of the three surviving copies of the Tract, Stowe B II, carries with it additional related data not found in the other two copies. The opening page of this copy has a detailed astronomical rotula with movable index containing the names and signs of the Zodiac and the planets in Latin. It also has the names of the months and accompanying numerical figures.

This rotula would have been used to indicate the positions of the sun and moon in the Zodiac for any particular date of the year. I have not been able to study this device in detail, but from my observation of the copy in the Irish Text Society publication, it does not seem designed to predict the positioning of the planets, nor the times of moonrise.

Beneath the rotula, a short paragraph has been added indicating the position of the sun in the Zodiac for each month of the year. A day of the month is given which I presume corresponds to the time at which the sun enters the constellation. These constellations would not have been visible due to daylight hours but the relative locations could have been easily confirmed after nightfall.

A second short paragraph follows equating each of the constellations of the Zodiac with a particular part of the human anatomy.[2] At this point the distinction between science and pseudo-science has become a little blurred and we venture into the realms of astrology. I am reminded of a similar entry in one of the Medieval Welsh manuscripts. Mostyn 88, p 26, goes one step further by including the diagram of a human figure with signs of the Zodiac drawn on it.[3]

Above the rotula, there are two further entries. To the left of the folio, an entry relates lunar details for each month of the year in Irish accompanied by a corresponding entry (in Latin) for each month giving the length of the day and night in hours. The Irish

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[1] P. W. Joyce, *A Social History of Ancient Ireland,* Gill & Sons, Dublin, 1920, Cha XI, p 435.
As mentioned earlier, Irish had no one word for the discipline of Astronomy. The word 'Astronomy' for example does not occur anywhere in the Tract.

[2] These items are in Irish and have been included as such in Power's edition. English translations have not been published as yet. I have included these entries together with an English translation in Chapter 7.

[3] Morfydd E. Owen, *Functional Prose: Religion, Science, Grammar, Law.* Chapter XI of, *A Guide to Welsh Literature Volume I,* A O H Jarman & Gwilym Rees Hughes (editors), Christopher Davies, Swansea, (1976) pp248-76.

and Latin are included in Power's edition but mutilation of the front page of the manuscript has rendered some parts obscure.

The positions of the sun with respect to the Zodiac during the year seem to have been derived largely from the rotula. The times of moonrise were probably taken from direct observation and added to the Tract during its working life as a teaching document.

To the right of the page, also suffering from some mutilation, is a list of weights and measures. Power dismisses these with the comment, "a list of weights and measures which are very difficult to decipher owing to stains on the MS."[1]

Closer examination reveals some interesting details. Five different units of measurement are listed, together with their short hand symbols for the units and short hand notation for simple multiples of these units such as *a half*, *one and a half*, *double* and *quadruple*. At first sight they appear to be reference notes for a teacher giving an elementary class on the physics of weights and measurement.

It transpires that the collection of units relates to a rather specialised field of medicine, that of pharmaceutical formulations, and is thus unrelated to the major theme of the Tract. A number of possibilities present themselves. If in a monastic context, one might conjure up thoughts of a Brother Caedfal in charge of the monastery herb garden, as presented to us by Ellis Peters. Presumably, intellectually gifted monks had to wear many hats!

Another lead presents itself. Aedh Buidhe Ó Leighin, who may have been the scribe of Stowe B II 1, is also known to have been the scribe of one of the Irish Herbal manuscripts. The Irish Herbal was translated from Latin in the year 1415 by a medical scholar named Tadhg Ó Cuinn.[2] Perhaps the Stowe copy might have belonged to one of the learned families of physicians in the Fermoy district of County Cork?[3]

On the other hand, it is likely that the additions to the facing page were made during the working life of this 'text-book' by an anonymous medieval lecturer. They may have no connection with the professional scribe who produced the copy. If nothing else, these appendices would tend to exclude any suggestion that the text was commissioned merely for antiquarian purposes.

As these appendices were not translated by Power, it has seemed fitting to include an English version within this study.

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[1] M Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914) p v..
[2] Tómas Ó Concheanainn, *The Scribe of the Irish Astronomical Tract in the Royal Irish Academy,* B ii 1, Celtica 11 (1976), p165
[3] Ibid., p 166.

Chapter 5

Scientific & Technical Content of the Irish Astronomical Tract

The Irish Tract begins with a lengthy prologue dedicating the work 'to the glory of God'. The Tract is seen as a study of 'his works and arts' from which the Creator himself may be known. The sentiments fit comfortably with the traditional line of reasoning among Scholastic philosophers from the latter Middle Ages.

The work is divided into forty chapters, each of which is given a short title outlining the content. I have numbered these chapters as per that of the 1914 ITS edition of the Tract and all references to the chapters accord with Power's numeration. Although the chapters are not numbered in any of the Irish manuscripts, the start of each new chapter is usually fairly obvious. In a few places, the intended divisions are a little blurred. This has led to minor discrepancies between the editions of O'Farrelly and Power.

The summary headings in the prologue correspond readily portions of the Tract, but some are seen to overlap with the chapter divisions of the above editions. One however, seems not to correspond to any specific section of the Tract as we know it. It would lie between Chapters 35 and 36. It is entitled, 'The Change of the Stars in different Countries'. Presumably it addressed the changing elevation of stars and constellations with change in latitude of the observer. It would appear to have slipped from the general body of the Tract in very early years as both the Stowe B and Marsh copy omit this topic. Perhaps it occupied a single folio that was inadvertently detached at some stage.

The title of the fourth chapter as listed in the introduction is in error. The author (or a subsequent scribe) has inadvertently repeated the theme of the preceding chapter.

Chapter 1 of the Tract is very different from Stabius' Latin edition of Messahala's work. There is, however, a definite correspondence of subject matter. The chapter begins with a description of the seven spheres of the firmament but evolves into an apologetics lesson, according to which the order and regular governance of the world is seen as proof for the existence of 'He who created the world'.

The second chapter is more closely aligned with the corresponding chapter of the Stabius edition of Messahala. It deals with a description of the Four Elements: fire, air, water and earth, and the geometry of their location in the universe. The subject matter derives principally from Aristotle's *Meteorologica* and his *De Caelo.* The first of the Tract's 31 diagrams illustrates the location of these spheres around the earth.

Chapter 3 is moderately close to Chapter 5 of the Stabius edition but with additional explanation regarding its diagram. It deals with the division of natural motions into three types: that from the centre of the earth, that towards the centre and motion around the centre. The natural motions of each of the four elements are discussed in this context. The diagram illustrates the circular motion of the firmament. Once again, it is based principally upon Aristotle's *Meteorologica* and the *De Caelo.*

Chapter 4 embarks upon an explanation of the physical 'accidents' of the elements, notably their qualities of heat, cold, wetness and dryness. The resulting effects on the natural motions of the elements are described. It is moderately close to Chapter 4 of the Stabius edition which, in turn, is taken from Aristotle's *Meteorologica* and *De Caelo.*

Chapter 5 of the Tract corresponds to Chapter 5 of the Stabius edition but is rather like a free paraphrase. The geocentric framework from which all subsequent astronomical matters are dealt with is firmly established in this chapter. The spherical nature of the earth is asserted as well as the spherical nature of the surrounding air.

Chapter 6 is not very close to Stabius' Chapter 6. Its subject matter is a natural sequel to that contained in Chapter 4 of the Tract and is likewise derived from Aristotle's *Meteorologica* and *De Caelo.* The matter addressed is the opposition of the accidents of heat and cold in the elements and their effect on the natural motions of the elements. Maxwell Close noticed a curious alteration to the concluding sentence from the Stabius edition. The Tract concludes the chapter with: "Thus the Blessed Creator created and arranged the world with its four elements." The term 'Blessed Creator' corresponds to "Creator, cuis nomina sanctificentur" (Creator, whose names are made holy) in the Stabius edition. According to Close, 'the Moslems say that there are 99 names of God; The Jews reckon 72. Was it the Latin or the Irish translator who omitted the orientalism in this place?'[1] This is only one of a number of places in the Tract where subtle variations to the work of Messahala bear witness to the faint but discernible fingerprint of Christian handling.

Chapter 7 does not correspond to anything in the Stabius edition. It is a rather lengthy chapter devoted largely to the question of the spherical nature of the earth. This assertion is proved in a variety of ways, some of which are more convincing than others. One of the arguments is quite erroneous. Two diagrams accompany the text, devoted chiefly to an explanation of the sun's orbit around the earth and its implications were the earth to be flat.

Among the points of interest in this chapter is the reference to glass spectacles. It arises in a discussion of the refraction of light as it passes through moisture. This refraction is posited as an explanation for the apparent increase in the size of the moon when it is close to the horizon. Using this detail, Power took the year 1325 as being the earliest possible date for the composition of the Tract.[2] Close tended towards1320 as the year in which spectacles were first used by the general public. Further examples of the refraction of light are given including the curious case of a 'naked person under water.'

Another point of interest is the assertion that it would be theoretically possible to travel westward over the Atlantic and eventually return to your starting point from the east. The conditional nature of the statement places the Tract firmly in pre-Columbian times.

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[1] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901)

[2] M Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914) See Introduction, p x.

An entire line seems to have slipped from the Tract in this chapter, but the general run of it is fairly obvious. I have included this in the Tract and English translation in Appendices I and II.

Close was of the opinion that this chapter finds its continuation in Chapter 35 of the Tract. He speculated that both may be derived from an Arabic original, as Chapter 35 retains an Arabic word, *al kotera* (the diameter). Both chapters are non-Messahalic.[1]

Chapter 8 is also derived from sources other than the Messahala work. A remote source could be Aristotle's *Meteorologica,* but Close was inclined to think that one or more of Avicenna's works, recently translated into Latin, are the more proximate source.[2] A number of relevant works by this esteemed 11th century Arabic philosopher and physician are known to have entered the realms of Western scholarship via Toledo in the late 12th century.[3]

The chapter is of a geological nature and deals principally with the cycle of weathering, erosion, transportation, sedimentation and petrification commonly referred to these days as the Rock Cycle. It seeks to explain the formation of geographical landforms such as mountains, valleys, rivers and so forth. The suspected organic origin of fossils is discussed but the absence of a suitable Irish word to describe these remains is apparent. The likely origin of fossils had been suggested as early as the 5th century BC by Herodotus, but so far as the Irish Tract is concerned, Avicenna's *Ut Supra* is a more likely proximate source.

Chapter 9 is another chapter that does not correspond to any in Messahala's work. It deals with a variety of matters relating to physical geography, one of which is the action of heat and cold on the surface regions of the earth. Among other things, it seeks to explain the causes of earthquakes and tsunami waves, the latter being correctly attributed to the effect of submarine earthquakes. Also touched upon are the following phenomena in kaleidoscopic sequence: salination of ground waters, river erosion, the formation of wells, the cause of saltiness in the sea, evaporation of water from the sea and the formation of clouds, dew, rain, hail and snow, the crystallisation and formation of salt and the formation of ice. The majority of these items can be traced back to Aristotle's *Meteorologica.*

Chapter 10 is likewise not from Messahala's work. In the Latin heading to this chapter we find the term "huis ignis" (this fire)[4]. The 'this' obviously refers to something previous in the Latin text upon which this chapter was based. This text does not seem to have survived.

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[1] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901)

[2] "It may be suggested by Aristotle's *Meteorologica.* But perhaps it is more than suggested by Avicenna's *De Congelatione et Conglulinatione Lapidum,* Cap II., *De Causa Montium.* This is printed along with Geber's *Summa Perfectionis Magisterii in sua Naturate.* Avicenna died in AD 1030 (sic.)." Close, Maxwell, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library, (1901). (Commentary on Chapter 8)

[3] Gerard of Cremona, working in Toledo during the latter half of the 12th century, is said to have translated the entire corpus of Avicenna's works.

[4] "*Dico quod occasio huis ignis, etc*. "

The chapter embarks upon a short but graphic description of the workings of volcanoes, notably those of Etna in Sicily and Vesuvius in the region of Apulia. The technical treatment limps severely by today's standards, but accords well with the traditional understanding since late classical times. As mentioned earlier, it is reminiscent of similar descriptions by an earlier Irish scholar, Dicuil, in his *Liber De Mensura Orbis Terrae* (c.820).[1] The two works would seem to share a common pedigree, possibly dating back to the writings of Iulius Solinus[2] and Servius[3] in late Roman times.

Chapter 11 deals with the ebb and flow of the earth's tides. It does not correspond to anything in the work of Messahala. Two somewhat conflicting views are put forward to explain the causes of tidal movements. The connection with the orbit of the moon is clearly noted as it had been since the time of Poseidonius. The suggestion that light from the moon is (in part at least) concerned with the production of tides possibly derives from the writings of the 12th century Spanish-Arab philosopher Averroës who is known to have held such views. In earlier times, both Pliny[4] and Strabo[5] held similar views.

Later in the chapter a more progressive view is put forward. The author suggests that the moon exerts forces on the earth's waters analogous to that of the attraction of iron towards lodestone. This concept was a little ahead of its time as the role of the gravitational forces was not clarified until the work of Kepler in the late 16th and early 17th centuries.[6]

Reference is made to the tidal differences between the Red Sea, the African Sea and the Great Ocean. Presumably, the latter two refer to the Mediterranean and the Indian Ocean respectively. This context would tend to suggest the influence of an Arabic source via medieval Latin translation for this chapter. A diagram accompanies the description of the moon's influence on tidal movements.

Chapter 12 does not correspond with any in the Latin of Stabius. It is a fairly lengthy self-contained treatment of the annual flooding of the river Nile. One could assume with a degree of confidence that this chapter derived ultimately from a medieval Arabic work, presumably from Alexandria. In the process of relating an early legend surrounding the Nile's flooding, the author informs us that, "I heard it from my own elders". I think we could safely discount the remote possibility that the Irish compiler had elders living in Egypt. The legend itself concerns the Egyptians' belief that the

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[1] Dicuil, *Liber De Mensura Orbis Terrae,* Scriptores Latini Hiberniae Vol. VI, Edited by J J Tierney, The Dublin Institute for Advanced Studies, Dublin (1967)

[2] C. Iulius Solinus, *Collectanea Reum Memorabilium,* ed. Th. Mommesn, Berolini, 1895.

[3] Seruius, *Commentarius in Aeneidem,* ed. G. Thilo, Lipsiae, 1923.

[4] Strabo, *Geogr.,* III, V, 8-9,

[5] Pliny, *Nat. Hist.,* II, 99 (97)

[6] Maxwell Close had the following pertinent comment to make in regard to this matter: "Here a quite different cause is given for the Tides, the magnet-like attraction of the moon on the water. This is also given by the Jesuits of the College at Coimbra. See *Commentarii Collegii Conimbricensis in Aristot. Meteor.* Tractus VIII, *De Mari,* Cap VI, p87 (Colonia, 1596). Compare Kepler's *Mysterium Cosmographicum,* also 1596. He, however, would not limit the attractive power of the moon to moist substances and the waters of the sea. - - - But we find they were themselves anticipated, on this matter, in our Irish ms., which was written about 200 years before their Commentary."
C.f., Close, M H, *Remarks on a Cosmographical Tractate in the Irish Language,* Proceedings of the Royal Irish Academy, (1900-02) p457-464."

Nile would not flood until "the fairest maiden of greatest beauty" was cast into it. This ritual was said to have been performed at the start of August each year. The relevant point is that the author states this custom survived until the time of *Thomarus, Ri na hEigifti* – 'Omar, King of Egypt'. This would appear to be Umar I, the Caliph of Egypt during the mid 7th century. Hence, an Arabic original could conceivably be dated anywhere from the time of Messahala until Averroës in the 12th century.

The author correctly states that the Nile's flooding is not the result of local rainfall, but he is unable to provide a satisfactory alternative meteorological explanation. Reference is made to the Nile's source in the 'southern quarter of the world', but the author was clearly unaware of its origin in the snow-covered peaks of East Africa. Brief reference is made to flooding in other locations, but one is left with the impression that this chapter would have had limited relevance for Irish students. Perhaps this chapter with its dramatic tale provided a bit of light relief from the more taxing themes in the Tract.

Chapter 13 appears to be a freely paraphrased version of Chapter 7 in the Stabius edition. It addresses the question of the nature of the firmament with its 'one identical, steady, constant motion until the end of the world'. Its apparent absence of accidental qualities such as heat, cold, wetness or dryness was seen to be proof that it could not have been composed from the four elements. The treatment follows the traditional view as described in Aristotle's *De Caelo.*

Chapter 14 is not from Messahala's work. It does, however, overlap with portions of Chapters 1, 3, 4, 6 and 29, all of which have corresponding chapters in the Stabius edition of Messahala. In minor points it contradicts some of Messahala's own statements. The chapter ends with a promise to return later to the point at hand. As the Tract stands, there is no return. One assumes that in the text from which the compiler worked, there was such a return. Much of the chapter derives ultimately from Aristotle.

A number of diverse themes are worked into the chapter. The nature of the firmament is further addressed in relation to its perfect circular motion that knows neither beginning nor end. It is contrasted with the contingency of the compound motion of natural bodies composed of the four elements.

It is asserted that the earth is uninhabited in its southern hemisphere and uninhabitable at latitudes within 16 degrees of the equator. This presents a minor inconsistency with Chapter 36 of the Tract where habitation is considered to begin at the equator. It is in this chapter that "Negroes" are first mentioned.

The chapter goes on to outline the various spheres of the firmament, including those of the sun, Mercury, Venus, Mars, Jupiter and Saturn. For the first time, the Sphere of the Twelve Signs (the Zodiac) and their names are introduced. It is interesting to note that the author of this Tract distances himself from any suggestion of astrology. He admits that some people ascribe various attributes to the individual signs and that they are viewed as favourable or inauspicious as the case may be, but these people are described as being 'ignorant'. In this respect, the author of the Irish Tract surpasses his masters Ptolemy and Messahala.

Chapter 15 has no corresponding chapter in the work of Messahala. It deals primarily with matters concerning the nature and qualities of the firmament. The chapter begins with a warning that we can be deceived by the accidental properties on our quest to understand the nature of natural bodies. The permanence of the firmament is contrasted with the corruptibility of all earthly matter, among which are included 'gold, iron, the body, hyacinth and many other precious stones'.

Modes of change, both of quantity and quality, for 'everything that is beneath the moon in the sphere of the four elements', are discussed and contrasted with the unchangeable nature of the firmament. An interesting point is the assertion, among other things, that the universe is of fixed size and does not expand, "for if it had, it would surely be found written"! These notions trace back ultimately to Aristotle's *De Caelo.*

Chapter 16 is moderately close to Chapter 10 of Stabius' edition of Messahala. It attempts to describe the celestial circles, lines and points of the firmament. An effort is made to equate the Irish terminology with the then current Latin names for these imaginary grid lines. The descriptions are somewhat confusing and would have been more easily defined with the aid of diagrams. None, however, are known to have accompanied the chapter.

Chapter 17 has no equivalent in the Latin edition of Stabius. It seeks to explain the changes in times of sunrise and sunset as one moves east or west on the globe. It is another chapter that betrays the hand of an earlier Arab scholar. Three locations are cited in the example: Africa (presumably Carthage), Egypt and Babylon. The Irish author has made an initial attempt to substitute France for Africa, but as the chapter progresses he lapses back to the original example. The accompanying diagram, although badly distorted, has retained Africa, which no doubt was copied unchanged from the Latin source text.

Chapter 18 of the Tract possibly relates to Chapter 8 of the Stabius edition but it is not at all close. It deals with the size of the sun in relation to the earth. Its reasoning rests on the erroneous assumption that the stars of the firmament do not emit their own light but rather reflect light from the sun. Isidore of Seville was of a similar view.[1] The chapter includes a less than adequate diagram to illustrate the phenomenon of 'stellar eclipse'.

Chapter 19 continues this theme but it differs considerably from the Latin edition of Stabius. It concludes with the assertion that the sun cannot be less in size than the earth. A similar diagram also accompanies this chapter.

Chapter 20 is loosely based on Messahala, differing considerably from the Latin edition of Stabius. It continues with the question of the relative sizes of the sun and

[1] Maxwell Close adds that; "Isidore of Seville thought this; *De Reum Nature,* XXIV. See also his Lib. III *Originum, sive Etymologiarum,* Cap lx. Albertus Magnus thought the same; *De Coelo et Mundo,* Lib., II, Cap 16. Riccioli, in his *Almagestum Novum,* Tom.I, Pars I, Lib.VI, Cap II, tells us that the following entertained the same notion, *viz:* Metrodorus, Albatani, Vitellio, Reinhold, Blancanus & Scheiner. Even Copernicus thought this."
c.f., Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). Comments to Chapter 18 & 19.

earth, finally coming to the conclusion that the sun is much larger than the earth. The reasoning, however, is invalid, based on the initial assumption that the stars reflect light from the sun. The author attributes the reasoning to an earlier authority, referred to simply by the pronoun 'he'. The reference is no doubt to Ptolemy. Elsewhere in the Tract, he is referred to simply as 'the Philosopher'. In several places in the Tract, however, this formula relates to Aristotle. The line of reasoning is accompanied by a diagram, whose inappropriate scale does only partial justice to the text.

Chapter 21 deals with the phases of the moon. It corresponds with Chapter 9 of the Stabius edition but is by no means close. Within the context of a geocentric framework the explanation of the waxing and waning of the moon throughout each stage of the lunar cycle is adequately described. Five diagrams of varying quality accompany the text.

Chapter 22 deals with the cause of the eclipse of the moon. It corresponds with Chapter 11 of the Stabius edition, but it is not very close. The author correctly explains why the phenomenon is not witnessed each and every month at the time of a full moon. He also indicates the necessary location on the firmament for the moon to be able to pass through the shadow of the earth. The distinction is made between a partial and total eclipse. Overall, the treatment may be described as adequate. The chapter is marred by a minor corruption to the Irish text in one particular line. Conformity with the surrounding text can be restored with minor changes. Maxwell Close suggested one of these. I have footnoted it in the English translation in Appendix I. I have footnoted an alternative solution in the Irish text in Appendix II. The accompanying diagram in this chapter is adequate.

Chapter 23 is moderately close to Chapter 12 of the Stabius edition. However, three additional diagrams are provided in the Irish Tract. The chapter begins with a reaffirmation of the assertion that the stars only give off light reflected from the sun.[1] It is one of a few places in the Tract where the planets and stars are referred to collectively as stars. It also affirms their spherical nature, the geometry of which is not visible to the naked eye because of their extreme distance. The retrograde motion of the planets Mercury and Venus is discussed in relation to their being tethered to the movements of the sun. A remarkable point is the author's prediction that when these planets are about 12º separated from the sun, they will exhibit "a horned effect, after the manner of the new moon".[2] We are told that the change, however, "is not evident to us, ... as they (i.e., Mercury and Venus) are much further from us than the moon".[3]

The interesting point is that the phases of Venus were not observed until Galileo directed his telescope towards Venus in December 1610. He then took this as

[1] In relation to this matter, Maxwell Close makes the following pertinent comment: "Muller states that Copernicus believed this. . . . See Copernicus *De Rev. Orb. Cel.,* Cap 10, towards the end. He there implies that the sun is the lamp which illuminates the whole temple [of the universe] and that it is suitably called *lucerna mundi.*"
c.f.; Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901), comments to Cha 23.
[2] c.f. Chapter 23 of the Tract in Appendix I.
[3] Ibid.,

confirmation of the heliocentric model of Copernicus.[1] As we can see in the Irish Tract, phases of Venus (albeit incomplete) were also to be expected by the retrograde motion of Venus about the sun in Ptolemy's geocentric model.

The four accompanying diagrams to this chapter illustrate the movements of Mercury and Venus in relation to the sun and earth. They are poorly drafted but sufficient to get their point across.

Chapter 24 concerns itself with the cause of solar eclipses. Its subject matter corresponds with Chapter 13 of the Stabius edition, although the text is not close. In Close's opinion, the treatment in the Irish Tract 'is superior to that chapter (i.e., of Stabius) on the whole.'[2] Among other things, the Irish text distinguishes between total and partial eclipses, a detail missing in the Stabius edition of Messahala. The same is true also of lunar eclipse covered in Chapter 22 of the Tract.

The geometry of the moon eclipsing the sun is adequately explained, giving the location of the full moon on the firmament when this phenomenon could be expected to occur. The reasons why it is only visible in certain locations, and then to differing degrees, is dealt with in considerable detail. Likewise, the reason for its shorter duration than the lunar eclipse is explained.

One of the less conventional outcomes alluded to is the possibility of an annular eclipse of the sun, i.e., where the angular cross-section of the moon is insufficient to eclipse the entire sun. The possibility of this phenomenon does not appear to have been mentioned by any of the Greek astronomers. Indeed, 'such would be impossible if the apparent diameter of the moon, in apogee, were equal to that of the sun, as Ptolemy believed it to be'.[3]

It is interesting to note that one of these rare 'annular' eclipses was recorded as having occurred when King Håkon IV (the Old) of Norway sailed from Bergen with his Norse fleet to punish the king of Scotland. As he landed in the Orkney Islands, the sun appeared as a thin, bright ring. The British physicist Sir David Brewster found that an annular eclipse of the sun was visible in the Orkneys on August 5, 1263, at about one o'clock.[4] It is just possible that this event was still in living memory among the learned of the Gaelic world at the time of compilation of the Tract.

The accompanying diagram and its explanation has undergone some corruption. The geometric distortions are such as to render the figure unusable. The corresponding figure in the Stabius edition is also deficient.

Chapter 25 is not at all close to Chapter 14 of the Stabius edition. It is a short chapter that delves into the limits of visibility of the crescent moon in close proximity to the sun. The moon is described as being at its prime when it first appears visible at an

[1] Strictly speaking the phases of Venus are equally compatible with Tycho Brahe's variation to the geocentric model.
[2] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 24.
[3] ibid., See comments to Chapter 24.
[4] c.f., David Cahan, (ed.), Hermann von Helmholtz and the Foundations of Nineteenth Century Science, Univ of California Press, London (1993)

angular displacement of 12º from the sun. A slight distinction is made between the angle of first visibility depending on whether the moon is viewed from the east or west. Taking this into account, the moon is said to become visible at an angle ranging from 11º to 13º. The Messahala text refers to the angle as '12º or somewhat'. According to the Arab astronomer Albatani, "the distance varies from 10º50' to 13º30' under different conditions".[1]

There is a significant corruption to the text in the closing line of the chapter, where the moon is said to attain its greatest size when its angular displacement from the sun is 18º. Even those with minimum knowledge of astronomy would have known that a full moon is only attained at an angle close to 180º. It appears likely that an early scribe, with little or no knowledge of the subject matter, has mistakenly taken the numerals '180'(degrees) to refer to 18º.[2] It is only one among many places in the Tract where the transcription of numerals has led to errors. The particular line in question is not taken from the Messahala work.

Chapter 26 has its counterpart in Chapter 15 of the Stabius edition of Messahala. It is moderately close. The chapter addresses reasons for the variation in brightness of the moon and stars from place to place and season to season. Traditional explanations are given, but during the course of the explanations, the author of the Tract throws in an additional line not in Stabius: "Also you will see them clearly at the time of an eclipse of the sun." He is referring to the visibility of the stars during daytime. This rather casual comment gives the distinct impression that the author may have personally witnessed such a total eclipse.

A diagram is included showing the location of the spheres of the sun and moon together with the firmament around the earth. The location of four cities around the globe are shown. The rather detailed figure is accompanied by a lengthy and somewhat cumbersome explanation of why there are, simultaneously, locations at the four corners of the globe experiencing daylight, night, sunrise and sunset as the case may be. The reason seems fairly obvious these days, but it may not necessarily have been so obvious to young scholars of the 14th century. Concerning this passage, Maxwell Close recorded the following laconic comment: "Confused, but right. Fair enough in Stabius."

Chapter 27 is moderately close to Chapter 16 of the Stabius edition. The chapter is devoted to an explanation of the spheres, according to the Ptolemaic system, by which the movements of the moon can be explained. The effects of four spheres are described in detail: the Great Sphere, the 'sphere like the sphere of the signs', the 'eccentric sphere' (Ptolemy's correction for the elliptical nature of the actual orbit), and a fourth sphere which is entitled, 'the sphere which revolves downwards to the moon'. The action of this latter sphere is similar to that of the epicycle of the planets except that the resulting effect is not sufficient in magnitude to yield any observable retrograde motion on the part of the moon. The rather practical example of the immovability of a nail in a board in relation to one of these spheres is not found in the

[1] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 25.
[2] The text of ms Stowe B refers to the angle as, 'ocht ceiminna deg', but earlier manuscripts may have simply used numerals to describe the angle.

Messahala text. The Tract frequently contains practical examples not found in the relevant parts of the Stabius edition.

The accompanying diagram is in conformity with Ptolemy's version of the geocentric model, as is the treatment of the spheres in the text.

Chapter 28 is a small one dealing principally with the spheres of the sun. The chapter is moderately close to Chapter 17 of the Stabius edition. The sun's motion is derived primarily from the action of the 'Very Great Sphere', which is responsible for the passage of night and day, and the 'Eccentric Sphere',[1] which governs the annual progression of the sun along the ecliptic.

The eccentricity of the sun's own sphere is said to render the sun closer to the earth at certain times and further from the earth at others. The resulting extremes of heat and cold are suggested as the reason for the equatorial latitudes and arctic regions of the globe being uninhabitable.

In relating this latter point, the Irish text is consistent whereas the corresponding portion of Stabius' Latin edition has an error. In reference to the uninhabited regions, Stabius has 'ubi est habitatio'. The 'non' has clearly dropped out. It is another reminder that the author of the Irish Tract had at his disposal, a Latin translation of Messahala, other than that of Gerard of Cremona.

The spheres in relation to the sun are illustrated in an accompanying diagram.

Chapter 29 is unusually close to the corresponding chapter in Stabius (Chapter 18). It deals with the nature and ordering of the ten celestial spheres and begins with an acknowledgement to "the Philosopher". The reference is no doubt to Ptolemy. What follows, however, is a little at variance with Ptolemy who mentions only eight spheres. These are the spheres of the sun, moon, the five planets and the sphere of the fixed stars. The two additional spheres in the Tract are the 'Very Great Sphere' and the 'Sphere of the Signs'. Messahala has only one additional sphere, referred to as the direct sphere: *orbis rectus* in the Latin of Stabius.

The planets are considered to move within their sphere at uniform speeds, a notion which is derived ultimately from Aristotle's *De Caelo.*[2] The apparent inequality of planetary velocities is put down to the differing radii of their respective spheres.

The period of orbit of Saturn is stated as being 30 years. This compares favourably with the known period of 29.4 years. The period of the moon's orbit, 27 days, also compares well with the known value of 27 days, 7 hours and 43 minutes.

The chapter includes a rather clumsy explanation of the reason for the discrepancy between the periods of Saturn and the moon, given that their speeds were considered equal. Minor corruptions to the numerals in the text are evident, although there is no

[1] The actual term used in Irish is the rather circumspect formula, *Speir sa seantrom ata leth amuith da sheantrom na talman.* It translates literally as, 'Sphere whose centre is outside the centre of the earth.' The use of this formula is consistent throughout the Tract.

[2] Aristotle, *De Caelo,* Lib.II, Cap. 10. C.f., English translation by J L Stocks, Vol 7 of *Great Books of the World,* Britannica, (1994) pp359-408

obvious reason for this. For example, 360 (degrees) has been reduced to 359. Also the moon's period is in one place referred to as 'seven weeks less a day'. This was clearly intended to be 'four weeks less a day', i.e., 27 days. Perhaps in an early manuscript the numeral '4' was misread as '7', the symbol later being replaced by the word.

The movement of the planets in their respective spheres is explained by the analogy of balls rolling along grooves on a potter's wheel. The analogy is attributed in the Tract to Ptolemy, but the illustration appears to have been first used by Cleomedes,[1] with minor variations being employed in the Irish Tract.

In using this analogy, the Tract speaks of a 'potter's wheel', whereas the corresponding portion in the Stabius edition refers to it solely by the Arabic term *alii bathera.* We may conclude from this that the Irish compiler worked from a text derived from an alternative, and presumably more reliable, translation from the Arabic.

The accompanying diagram includes all ten spheres referred to in the chapter.

Chapter 30 is not very close to Stabius' Chapter 19 in the early part, and in the latter part, not at all. The chapter deals principally with the properties of the 'Very Great Sphere', it being also identified with the 'Straight (or direct) Sphere'. It is correctly credited with being the cause of night and day. The matter of the precession of the equinoctial points on the ecliptic is also dealt with. This results from the gradual change in orientation of the earth's axis of rotation. Its wobble (akin to that of a spinning top), has a period now known to be 25,868 years. Ptolemy was of the opinion that the rate at which equinoctial points progressed was one degree per century. This is the value used in the Tract. By way of interest, the 10th century Arabic astronomer, who had the advantage of an additional eight centuries of observation, estimated the value to be one degree in 66 years.[2]

The changes of season, spring, summer, autumn and winter, are also attributed to the influence of the Very Great Sphere on the other spheres.

The latter part of this chapter has no corresponding section in Messahala. The sphere is specifically distinguished from that of the sphere of the fixed stars, a distinction not recognised by Ptolemy. We are also told that, "the ill-informed have said that it has life and that everything receives life from it." This notion of an over-riding soul to the firmaments derives ultimately from Plato. The Tract then distances itself from the

[1] Maxwell Close recorded the following comment in relation to this matter; "The following illustration was given by Cleomedes, not by Ptolemy. See Cleomedes' *De Contemplatione Orbitum excelsorum Disputatio;* or, as it is also called somewhat oddly*, Circulorum Caelestium Conversione.* Cleomedes supposed ants, not balls, moving in the circular grooves. This is preserved in the Latin of Stabius, who has *formica.*"C.f., Close, Maxwell, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 29.

[2] Maxwell Close recorded the following comment: " 'one hundred years', - This was Ptolemy's estimate founded on mistaken data. Albatani (d.929) pointed out that Ptolemy's estimate of the rate was considerably too small; he made it 1° in 66 years; much nearer the truth; but too large. The real rate of the relative movement of the equinoctial points and the fixed stars is 1° in 72 years. . . . Shah Cholgi, the Persian, fl. AD 1260, says that 1° in 70 years was adopted in his time; wonderfully near the truth". Close, Maxwell, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 30.

astrological suggestion that the celestial sphere has "great powers over everything". A short apologetic discourse follows whereby the natural world is said to " receive these powers from its own Creator." The actions performed by the Very Great Sphere are seen to stand in need of an external being as regards their efficient causality, i.e., the Creator. The line of argument is reminiscent of scholastic reasoning since the 13th century and is possibly another hint of a Dominican context for the compilation of the Tract.

Chapter 31 is moderately close to the corresponding Chapter 20 of Stabius. It deals principally with the Sphere of the Signs, otherwise known as the Zodiac. Within the Tract, this corresponds to the second of a total of ten celestial spheres. The first and second spheres are said to have their axes of rotation inclined at an angle of 24 degrees to each other. In a heliocentric context, this corresponds to the angular difference between the axis of the earth's rotation and that of the earth's orbit around the sun. This angle is known to be 23º 27' at present and decreasing at the rate of 28 seconds per century. Its value in the 14th century would have been very close to that quoted in the Tract.

The author is at pains to insist that this sphere is specifically distinct from the Sphere of the fixed Stars. The constellations of the Zodiac, therefore, are not actually located in that sphere, but rather in the Sphere of the fixed Stars, which is elsewhere identified as the firmament. The Tract treats of the division of the Zodiac into twelve parts, along with their names and their relevance to the annual calendar. The path of the ecliptic along the Zodiac is described in detail, together with the sun's positions when the spring and autumn equinox occur. The positions on the sun at the start of spring, summer, autumn and winter are correctly identified.

The last paragraph of the chapter deals with the variations in degree of heat and cold, wet and dry, during the seasons. These are incorrectly attributed to the influence of the movement of the individual planets through the signs of the Zodiac. Concerning this paragraph, Close commented: "pretty close to the corresponding chapter (21) in Stabius, but much better expressed".[1] The chapter concludes with the usual acknowledgement to "the Blessed Creator himself (who) has ordained them (to act thus)".

Chapter 32 is also moderately close to the corresponding chapter (22) in the Stabius edition. It attempts to define the four motions of the planet Saturn, under the influence of its four spheres: the Very Great Sphere, the Sphere of the Signs of the Zodiac, eccentric Sphere of Saturn and sphere in which Saturn is fixed in the middle. The chapter contains an ambitious attempt to describe in simple terms the complex retrograde motion resulting from the movement of these latter two spheres. The example is given of the path traced out by the movement of a nail on the rim of a rolling cartwheel. Although not a perfect analogy, it would have been close enough to provide a useful concrete example for an otherwise abstract and obscure notion of an epicycle.

[1] Close, Maxwell, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 31.

These two spheres were thus able to explain both the variation in distance of Saturn from the earth, and the variations to its apparent velocity. Overall, the explanations are relatively clear and the four accompanying diagrams are of positive assistance to the text.

Chapter 33 is moderately close to Chapter 23 in the Stabius edition of Messahala. The chapter deals with the retrograde motion of the planet Saturn. The text is accompanied by one of the most elaborate diagrams in the tract. It goes into considerable detail to explain the action of the epicycle and the influence of its eccentric. The particular occasion being described has the retrograde motion taking place between Aries and Pisces. The concept of epicycle motion is difficult to explain at the best of times, a fact well exemplified by this chapter.

As well as giving the reason for Saturn's variable velocity, the epicycle is also cited as the reason for the apparent change in size of the planet as it traverses the Zodiac. The final paragraph to the chapter is not in the Stabius edition. It goes on to explain how the same can be said of the spheres, motions and qualities of the other outer planets, Mars and Jupiter.

The phenomenon of Saturn regressing from Aries to Pisces provides a possible clue to the date of compilation of the Tract. Saturn passes through Aries approximately once every 29 years. Computer calculations[1] reveal that there is a clear regression to Pisces late in the year 1350. During the 14th century, Saturn also passed through Aries in 1320 and 1379, but these passes were not accompanied by a regression to Pisces. There was another passage in the year 1409 but this did not yield a clear regression to Pisces either. Furthermore, the date is a little late when it appears that the manuscript copy Stowe B seems to have been already in use at that time.

Given that this phenomenon was related in the Messahala work, it could be that at the time of compilation of the Tract, Saturn was again in the same phase of its orbit, and hence appropriately retained by the compiler. On the other hand, it is more likely that the detail was simply transcribed irrespective of its current relevance. Transcription of a finished work by unacquainted scribes would certainly retain the data as per the original text, but the compilation of the Tract would appear to have been made by a scholar familiar with the subject matter and it is far from clear that obsolete data would not have been updated. In the final analysis, no firm conclusions are possible, but one could at least view the year 1350 as being a contender for the year in which the prototype Irish Tract may have been compiled.

Chapter 34 is a small chapter corresponding with Chapter 24 of the Stabius edition. Close recorded the comment that while it is not very close to that in Stabius, "it is better expressed".[2] It deals with the eighth of the ten spheres: the Sphere of the Fixed Stars. The uniformity of motion of the stars is stressed, and the relative movement of this sphere with reference to the Very Great Sphere is reiterated. As in Chapter 30 of the Tract, the rate of precession of the equinoctial points is stated as being one degree per century.

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[1] I have scanned the movements of Saturn during the 14th and early 15th centuries using the computer program EZ-Cosmos 3.0.

[2] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 34.

Chapter 35 does not correspond to any in the Latin edition of Stabius. It is a rather interesting chapter dealing with the use of an astrolabe in the determination of the circumference of the globe. It is another of the chapters betraying an Arabic original. The Arabic word for diameter, *alkoterra,* is retained, together with an equivalent term for diameter in Irish. A minor transcriptional error for one of the angles is to be found, but, later in the chapter, the correct angle is used in the actual calculation of the circumference and diameter. The final value for the earth's circumference is said to be 24,000 miles and its diameter 8,000 miles. This figure also compares favourably with the known value for the mean diameter for the earth: 7,639miles. In Classical times, Aristotle estimated the earth's circumference to be around 400,000 stadia, a figure almost twice the known value. A little later, Erastothenes of Cyrene (276BC) calculated it to be 250,000 stadia, (estimated to be approximately 24,662 miles). Posidonius (1st cent BC) also arrived at a similar value. It was not until the work of Willibrord van Roijen Snell in the late 17th century that a more precise value was arrived at.[1]

Slight discrepancies to the numerals are to be found between the Marsh ms and Stowe B. The chapter is accompanied by a simple diagram.

Chapter 36 belongs to the realms of human geography. It does not correspond with any in Stabius' Latin edition of Messahala. It deals with the division of the globe into seven hospitable zones. This notion was not new and is known to have existed in the time of Hipparcus. Needless to say, the latitudinal limits of these zones are rather arbitrary. In classical times they were limited to seven. The habitable zones within the Irish Tract are, however, extended to more northerly latitudes with the addition of an extra zone.

A curious detail from the accompanying diagram of these divisions is the location of the southern hemisphere in the top half of the globe, a custom dating back to the time of Aristotle.[2] A further interesting point is the assertion that, 'no living thing on earth can exist from the same line (*i.e., the equator*) to the Antarctic Pole.'[3]

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[1] c.f. *Erastothenes Diameter of Earth: Appendix B,* in "Commentary on the Dreams of Scipio by Macrobius", ed., William Harris Stahl, Columbia Univ. Press, N.Y., 1990, p251-2.

[2] Close makes the following pertinent comment: "The original diagram has been drawn in accordance with Aristotle's idea that the South Pole is the uppermost point of the earth; *De Coelo,* Book II, Chap.2." C.f., Close, Maxwell, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 36.

[3] Close recorded the following comment: "Messahalla himself thought this (see Ch. 26, supra). The writer of Chapter 14 thought so also, and the writer of the present chapter, whether the same person or not. Some, e.g., Cleomedes, thought it simply uninhabited, being inaccessible to man because of the intolerable heat of the equatorial zone which must be crossed in order to reach it. Poseidonius, however, thought that the neighbourhood of the equator should be temperate, on account of the sun's crossing it more quickly, when passing from one hemisphere to the other at the equinox. Our present writer agrees with this idea. In justice to him and to Messahalah, as to their notion of the uninhabitability of the southern side of the earth from heat, ... he was led into this mistake, not through a sublime ignorance of the effect of latitude on climate, but by a certain other notion, which, though equally wrong, is much more excusable." C.f., Close, Maxwell, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901). See comments to Chapter 36.

As indicated in the previous chapter, the author of the Tract seems to identify with Zone 5 of the division. The lengths of daylight hours for this zone place it within Irish latitudes, although parts of Britain and the Continent would similarly correspond.

The zones themselves are accompanied by a description of their climatic characteristics as well as the physical and temperamental attributes of their human inhabitants. The occasional transcriptional error is found among the numerals of this chapter, although the intended value is always obvious.

Chapter 37 is one of the 13 chapters not corresponding to any in the Stabius edition. It addresses the habitual daylight and night time within the Arctic and Antarctic regions of the globe. The geometry of this phenomena is described in considerable detail together with the analogy of the movement of a quern, a simile which frequently surfaces in the Tract. The Arabic astronomers Alfergani and Albatani are also known to have used this analogy.

The movement of the sun along the ecliptic, as it passes the signs of the Zodiac in relation to the equinoxes and solstices, is related in detail.

Chapter 38 is rather like a free paraphrase of the corresponding Chapter 25 in the Stabius edition. It is based ultimately on Aristotle's *Meteorologica,* Book I. After introducing the subject of the Four Winds of classical tradition, Eurus, Zephyrus, Boreas and Auster, there is a distinct note of apology on the part of the Irish compiler, with the realisation that they are ill-suited to an explanation of the Irish climate. These Mediterranean weather patterns would have been in marked contrast to the Irish experience. The fact that the 'four winds' are included at all is probably a testimony to the esteem in which Aristotle was held during the Middle Ages.

There follows a brief explanation of the Water Cycle in relation to weather phenomena. It covers the concepts of evaporation and precipitation in its various forms together with an explanation of the causes of wind, most of which is fairly conventional.

In the case of wind, an additional cause, rather humorous to contemporary readers, is suggested: "When a battle or conflict is being fought by large hosts and vast troops, with the movements and panting of the men, some of them fleeing and others in pursuit, the rarefied air flies before them, and raises wind".

The expansion and contraction of air with changes in temperature is accurately treated in a qualitative manner.

Chapter 39 deals with further meteorological phenomena such as clouds, thunder, rain and lightning. It is moderately close to Chapter 26 of the Stabius edition and is based ultimately on Aristotle's *Meteorologica,* Book II. The explanation of the formation of clouds and their production of thunder, lightning, rain, hail and snow follows the traditional line with a few variations. For example, Aristotle considered thunder to be produced before lightning. The present author correctly states that, "although the thunder and lightning are produced simultaneously, the lightning is seen before the thunder is heard."

There are also the occasional humorous gems that have found their way into the Tract: "When a great wind accompanies that tempest, it gathers the clouds together up in the sky, and binds them, and makes them assume different shapes, and ill-informed people think that they are dragons."

In a discussion of sound and the sense of hearing, a rather obscure analogy is put forward. The author again brings forth the quern, likening its movements to the functioning of the ear. The analogy limps severely, but the recognition that the ear must send messages to the brain for processing is impressive. Likewise, it is acknowledged that the eye must send its data concerning "the shape, form and colour of that object . . through the sinewy vein . . to the brain."

The final chapter of the Tract is incomplete, with the major part of the final folio being illegible. It deals with vegetative life and appears to be derived ultimately from Aristotle's *De Plantis.* It differs a good deal from the corresponding Chapter 27 in the Stabius edition. The philosophical distinction between plants and animals is made, i.e., living things, "devoid of sensation", with the surviving portions of the chapter having a distinct philosophical rather than botanical inclination. Aristotle is quoted by name in this chapter.

Such is the brief overview of the technical content of the Tract. While it is clear that astronomical matters make up a major portion of the Tract, most branches of scientific knowledge during the Middle ages are addressed, albeit in some cases in a fleeting way. Medical matters are rarely mentioned. This should not surprise us as there was at the time no shortage of contemporary Irish texts devoted to these matters.

* * *

Chapter 6.

Scientific & Technical Terminology in Irish

It is appropriate at this stage to include a few words on the scope of this Chapter. Although nominally an 'Astronomical' work, the Tract covers a wide sweep of what we might call the physical sciences. In order to simplify this multitude of so-called technical terms I have categorised them roughly into the more specialised divisions of contemporary science. Such disciplines would no doubt have appeared rather artificial to the author of this late medieval science text as an educated person would have been expected to have been abreast of human knowledge on all its fronts.

As might be expected, the discipline of astronomy and related matters accounts for the major grouping of technical terms. Several areas such as the biological sciences yield only minimal representation but they could one day contribute towards similar studies of the various medical tracts in Irish. One or two groupings are rather peripheral to the major theme of this work but have been included for the sake of completeness. One such is the modest list of place names recorded in the Tract, about a dozen & a half. A few of these names, for example, *Muir na hAfrici* (The African Sea, i.e., the Mediterranean) would not have had currency beyond the confines of the Tract itself. Other place names such as *Sisaile* (Sicily) and *Ueranes* (Versuvius) are probably their only mention in the surviving Irish letters of the Middle Ages. Perhaps half of the place names would have had general currency during that period: *Iarusalem, Riomh, Spainne* and *Frainc* to mention a few.

I have gathered the various groupings of terms together in separate tables within this Chapter. I have generally restored nouns to their nominative singular case unless otherwise stated. In most cases there is to be found variability in spelling, typical of the Middle Ages. I have included some but not all of these variations. The vowels *ea* and *i* are frequently interchanged and terminal consonants sometimes indicate lenition, at other times not, with no apparent reason. The term *gac/gach* is a typical example. More than the normal degree of variation arises when it is a Latin loan word containing letters not in the Irish alphabet, e.g., the letters *X* and *Z.*

Where appropriate I have also included the corresponding Latin term.[1] Where the technical concept is still relevant today, I have included the accepted word in contemporary Irish. In the vast majority of cases the modern term is related to the earlier term used in the Tract. Some of these would have remained in continual currency since earlier times. Others would have been revived early last century with the attempts to standardise the language and equip it for the modern world. Both O'Farrelly and Power are mentioned as contributors in Dinneen's Irish-English Dictionary of 1927.[2] I have no doubt the Tract provided more than occasional assistance to the technical staff of Tomás De Bhaldraithe in their efforts to standardise Irish equivalents to English scientific vocabulary during the 1950s.[3] The contemporary Irish equivalents listed in this Chapter are generally taken from later editions of De Bhaldraithe's English-Irish Dictionary or Niall Ó Dónaill's *Foclóir*

[1] Many of these terms are ultimately of Greek origin and occasionally Arabic. As their proximate source in an Irish context was Latin, I have left them under this generic grouping.
[2] Patrick S Dinneen, *Foclóir Gaedhilge Agus Béarla*, The Irish Texts Society, Dublin, 1927.
[3] Tomás De Bhaldraithe, *English-Irish Dictionary*, Ofig an tSoláthair, Dublin, 1959.

Gaeilge-Béarla, which was compiled under the general direction of De Bhaldraithe. References to terms in Old and Middle Irish are generally taken from the Royal Irish Academy dictionary, acknowledged in the following tables by reference to its general editor, E. G. Quin.[1]

* * *

It has been noted by Maura Power that the language of the Tract is free of affectations and archaic forms that frequently characterise Irish prose of the early modern period.

> The subject-matter of our text precludes all that rhetoric and expansion so popular in translation of narrative matter. Lucidity being the chief object, the style is simple and straightforward, sometimes even bald in its description; it bears no trace of affectation, becoming almost colloquial in places, so that one is tempted to put it down as a sample of spoken Irish of the fourteenth or fifteenth centuries.[2]

Furthermore, we see a very down to earth recourse to numerous analogies taken from every day life. The text is written on the assumption that the reader or student has minimal background knowledge of the subject matter. Some of the analogies are taken directly from source texts, while others bear the distinct imprint of rural Ireland. The analogy of the potter's wheel is from an earlier source and may or may not have been familiar to all students of the Tract. That relating to the movements of a quern (*bró*) appears occasionally in the Latin edition of Stabius, but surfaces repeatedly in the Irish work. One suspects it found a resonant chord among the young scholars of largely rural background. Its versatility is stretched to the limit, however, when the author seeks to explain human hearing by reference to the workings of a quern. Perhaps it is my lack of familiarity with the workings of a quern, but the resulting analogy appears to me to limp severely.

The author also makes frequent recourse to the analogy of a cart-wheel, including the compound motion of a nail on the wheel of a moving cart, as well as numerous references to 'nails on a plank' (*mar tairngibh daigne a clar*). Again one presumes these mundane examples were part of every day life in those days. A rather humorous illustration accompanies the explanation of the bending of light as it passes through a transparent medium such as water or glass. The author by-passes the now traditional example of the apparent bending of a pen or pointer in a glass of water, opting instead for the more vivid imagery of the body of a naked person underwater (*duine lomnocht fo uisci*). One can see at work the hand of an experienced teacher. In passing, it would appear that the above was the accepted mode of bathing in those times.

This disposition towards a simple and concrete explanation of astronomical and other scientific matters has inevitably left its mark on the vocabulary of the Tract. At the start of Chapter 2 the shape of the earth and its place in the universe is described: *Ata an talam na ponc cruind a cert medon an domain, mar mod liatroide cruinne, . . .* The latter phrase is translated by Power as 'fashioned as a perfect sphere.' The translation conceals something of the familiar nature of the Irish used. The word used to describe

[1] E. G. Quin, (Ed.), *Dictionary of the Irish Language: Based mainly on Old and Middle Irish Material*, Royal Irish Academy, Dublin (1990)
[2] c.f. ; Introduction to Maura Power's translation, p X.

the spherical nature of the earth, *liatroide cruinne,* literally means '(with) the curvature of a ball.' *Liatroide* refers to a ball, specifically, in former times, to the ball used in the game of hurley. The example would have been familiar to any student in those times. It is a word that comes with much cultural baggage, frequently surfacing in the Saga literature of the Middle Ages. A charming incident from the 'Boyhood Deeds of Cú Chulaind' comes to mind:

> The boys warned Cú Chulaind off, but he defeated them. They threw their three fifties of javelins at him, but he stopped every one of them with his shield. They threw their three fifties of balls at him, but he caught them all against his chest. They threw their three fifties of hurley sticks at him, but he warded them off and took an armful on his back.[1]

Such associations would have been as familiar as the Irish hearth to young students. The word *liatroide* appears many times throughout the Tract. By way of comparison, the author of the creation poem in *Saltair na Rann* likens the shape of the earth to that of an apple, and the enclosing of the firmament to the shell of an egg.

The shape of the firmament is also likened to that of a ball; . . *is in firmamint na cercaill cruinn mar samail liatroidi a timcill a seantruim fein,* - 'a round sphere like a ball, around its own centre, with its centre in a middle point.'

This brings us to another indigenous word with similar cultural baggage: *timceall* (also *timcill*). It has many shades of meaning but the act of encircling or enclosing something comes close to its essence. In the saga literature, it frequently relates the encircling of a foe by a chariot. In the 'Death of Cú Chulainn', we are told that 'Conall Cernach went (in his chariot), and the Liath Macha before him, and they made a circuit (*timceall*) of the battle field. They saw Cú Chulainn by the pillar. Then the Liath Macha went and laid his head on Cú Chulainn's breast.'[2] A little later in the same tale we are told that 'the Liath Macha went to bid farewell to Emer, so that he put his head in her bosom and went three times sunwise around (*timceall*) her, and sunwise around Dún nImrith, and Dún nDelga.'[3]

In the Tract the word *timcill* is frequently used to emphasise the enclosing of the firmament around the earth or the encircling of the orbit of the sun or other celestial object around the earth. In Chapter 7 we read that: *ata a timcill na talman comhcruinn & go fuil an talam mar sin ar a lar,* 'the curve around the earth is spherical, and therefore the earth is in the middle of it.' It refers of course, to the firmament. Later in the same chapter there is reference to: *an grian a na cercaill cruinn a timcill na talman,* - 'the sun moves in a circle round the earth'. The subtle difference between these two is that the former relates to a three-dimensional enclosure while the latter involves the locus of a circle in a single plane. A third use of the word is found in the term *gluastacht timcill,* meaning, 'circular motion', one of several genres of movement discussed in the Tract

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[1] translation by Jeffrey Gantz, Early Irish Myths and Sagas, Penguin, Harmondsworth, (1981), p136
[2] John T Koch, and John Cary, *The Celtic Heroic Age,* Celtic Studies Publications, Maldon, Massachusetts, 1995, p131
[3] ibid.; p133

Spherical & circular concepts are intimately united to the subject matter of this Tract and it comes as no surprise to find *timcill* frequently employed by the Irish author. It might also be noted that its use verges on redundancy at times when used in conjunction with *cercall,* from the Latin 'circulus' (as in the second of the above passages). No doubt, one assisted the other in helping to conceptualise these models for young students of astronomy.

Another example of this word's potency to conjure up graphic imagery comes from an early piece of verse in *Bretha Nemed.* It is found in a poem chanted by Athairne the Fierce, while still in his mother's womb. His mother came to fetch fire from a house in which a feast was being prepared. He leapt in her womb at the smell of the ale. She requested some ale but was refused. From his mother's womb the following was heard:

Do laith,	For the sake of ale,
Lócharn talman,	Lantern of earth,
Tetra mara	The expanse of the sea
Mos-timchella tíre . . .	Soon encircles the land. . . [1]

We are told that the hoops of the ale barrels promptly burst and all in the house were 'surrounded' by ale!

Astronomical Terms

Matters of astronomy constitute the largest single discipline within the forty Chapters of the Tract. Much of the terminology in this discipline is now obsolete as it refers to elements of the geocentric model of the universe. As mentioned earlier, there is no single word in the Tract that would equate with the term 'astronomy'.[2]

In general, an effort is made to render the complexities of the Ptolemaic model within the grasp of what we would today call undergraduate students. This has meant having to confront a body of concepts for which there were no prior terms in the Irish language. The author handles these in a variety of ways: Often he has recourse to the Latin word duly altered to accommodate Irish orthography and phonetics. Occasionally there are indigenous words that can accommodate a more specialised meaning. Lastly a Latin word is often replaced by a descriptive phrase in Irish, - some times short, sometimes not so.

[1] John T Koch, and John Cary, *The Celtic Heroic Age,* Celtic Studies Publications, Maldon, Massachusetts, 1995, p52.

[2] In Chapter 18 we find reference to *Tolimeus astrolaic* ~ 'Ptolemy, the astrologer'. This description occurs also in the Stabius edition of Messahala's work and betrays a blurring of the distinction between astronomy and astrology that often arose in the earlier Middle Ages. The Marsh ms and the incomplete RIA ms omit the term astrologer. Elsewhere in the Tract, Ptolemy is generally referred to as 'the philosopher'. Overall, there is virtually no trace of astrology with the possible exception of a few entries on the cover folio of ms Stowe B by a later scholar. Moreover, in Chapter 14, the author positively distances himself from "the uninformed" (*na haineolaidh*) who hold such views.

Table 6.1: Astronomical Terms

Concept	**Irish**	**Comment**
universe	*domain*	Old Ir.; *domnán* (Quin)
earth	*talam, talman* (g)	Old Ir; *talam* (Quin)
ecliptic	*sibal na greine*	Lit. 'path/trajectory of the sun' Mod.Ir.; *éiclipteach*
equinox	*eccinocsium,* *exenocium*	Latin; *aequinoctium, equinoxium* Mod.Ir.; *eacaineacht*
equinoctial	*eccinocialis, egecinocialis*	Mod.Ir.; *leathach, eacaineachtúil*
autumnal equinox	*eccinocium septimpir*	c.f., *deisearbhair na grene,* (Life of St Senan, Book of Lismore)
retrogression	*caisimpodh, caissimpodh*	Lit. 'turning back', (L); *Retrogradcio*
sign (of the Zodiac)	*comartha*	Old Ir; *comartha* (Quin)
Zodiac	*stodiaca*	Mod.Ir.; *stoidiaca*
eclipse (of the sun)	*dorchadus (na greine)* *eclipsis na greine* *eclipsis an re*	Lit. 'darkening', Mod.Ir.; *eiclips* (eclipse of the sun) (eclipse of the moon)
total eclipse	*eclipsis coitcinn*	c.f. Latin: *eclipsis universalis*
partial eclipse	*eclipsis rannaighi*	c.f. Latin: *eclipsis particularis*

Table 6.1: Astronomical Terms (continued)

orbit	(*cercall,* (*rotha* (g.s.of *roth*-wheel)	Lit.; circle, circuit, from *circulus* (Latin) e.g.; *a gac rotha do rothaib na firmaminti.*
planet	(*plained,* (*retlannaib seacranacha,*(d.pl.) (*retlann*	Lat.; *planeta* Lit.; 'wandering stars' (occasionally) Cha 34 Lit.; 'star'. (rarely, e.g., Chas. 23 & 32)
sphere	(*speir,* (*roth,* (*cercaill*	From the Latin, *sphaera* Lit., 'wheel' From the Lat., *circulus,* but long established in Irish.
orbit	(*cercaill,* (*sibal*	Lat., *circulus,* Irish; lit.; a journey or course.
period (of an orbit or rotation)	*re*	E.g.; *re a cercaill Saduirn;* 'the period of the orbit of Saturn. (Chapter 29) Mod. Ir.; *tréimhse.*
Great Sphere	*speir mhor,* *speir lanmor (lanmhor)* *speir romor* (occasionally)	Latin; *sphaera maxima*
sphere of the Zodiac	*speir na comartad*	Lit.; sphere of the signs
constellation	*airdrinnaidh, airdreannaidh*	Lit.; 'high stars'
star	(*retla, retlann* (*ardreann*	Old Ir.; *rétglu,* Mod.Ir.; *réalta* (high star)
firmament	*firmamint*	Lat.; *firmamentum*
eccentric sphere	*speir sa seantrom ata leth amuith da seantrom na talman*	lit.; 'the sphere whose centre is outside the centre of the earth'.
summer solstice	*solsticium in tsamraidh*	Latin; *solstitium*

It frequently happens that certain Irish words end up having to cater for several distinct concepts with the Tract. The intended meaning is usually clear to any reader familiar with the subject matter, but this has let to potentially misleading and confusing passages in several locations. Power's English translation has, in parts, suffered from this hazard.

A good example of this is the author's use of the word *cercall.* Originally from the Latin, *circulus,* it had entered Irish in earlier centuries, possibly acquiring various shades of meaning. Its simplest astronomical meaning in the Tract refers to the imaginary celestial grid lines that divide the firmament, such as the celestial meridian, *cercall an medon lae* ('circulus meriodonalis'). Geometrically, these are in fact circular in shape.

A second meaning of *cercall* in the Tract corresponds to the English concept 'orbit'. Specifically, it refers to the orbital paths of the planets, the moon and the apparent path of the sun. Geometrically, these are no longer circular in shape as the apparent orbits have to incorporate retrograde motion in varying degrees. This aspect is well described in the Tract and once again, the meaning is usually clear from the context. The author also makes frequent use of the Irish word *sibal,* meaning a course or journey, to signify the concept 'orbit'. In this context, *sibal* and *cercall* are interchangeable when the paths of the planets, sun and moon are being referred to.

Another meaning given to the word *cercall* is that of celestial sphere. For example, in Chapter 14 there is reference to *na deich cercaill (na domain).* The reference is clearly to the ten celestial spheres that constitute the heavens. In this sense, the geometrical implication of the term is a three-dimensional sphere. Again, it does not give rise to any real confusion within the Tract, provided one is *au fait* with a geocentric concept of the universe. In general however, the author relies fairly heavily on the word *speir* which directly equates with 'sphaera' in the Latin text. A less common, but more down to earth Irish word is also used on occasion to relate this concept. It is the word *roth,* literally, 'wheel', signifying in this case a revolving sphere. For example, in Chapter 14 the author informs us that *ta an gluasacht air leth a gac roth do rothaib na firmaminti,* 'each of the spheres of the firmament has a separate motion'.

A rather isolated meaning of the word *cercall* is to be found in Chapter 29 where the author uses the analogy of the potter's wheel to describe the compound circular motion of the planets. The author mistakenly attributes the analogy to Ptolemy. The analogy appears, however, to have been first used by Cleomedes.[1] In this model Cleomedes used the movement of ants in circular grooves on the wheel to represent the movement of the planets on the planetary spheres. The Latin edition of Stabius uses the word *formica*. The Irish author has changed the analogy to that of little balls running along these grooves. The word he uses is *cercall* (*na cercalla beca* – the small 'balls').

The English term 'period' has a fairly specific meaning in the disciplines of physics and astronomy, referring to the duration of periodic rotations and orbits. Within the Tract, the Irish term *re* comes close to this meaning. For example, we have the phrase *re a cercaill Saduirn,* 'the period of the orbit of Saturn'. It is even applied on occasion to the period of the moon, resulting in the potentially confusing phrase, *re re.* The technical term in Modern Irish is *tréimhse.*

Frequently in the Tract, the author has adapted the relevant Latin word. A case in point is the word for equinox, *eccinocsium,* from the Latin word 'aequinoctium'

[1] Cleomedes. *De Contemplatione Orbitum excelsorum Disputatio;* also known under the title of *Circulorum Caelestium Conversione.* (C.f. footnote 1, p39)

(equinoxium). It might be remembered that we have reference to an earlier Irish formula for the autumnal equinox, *deiseabhair na grene*, 'the southing of the sun,' i.e., 'the sun going south of the equinoctial'. It occurs in the 'Life of St Senan' in the Book of Lismore. Presumably there was an equivalent term for the vernal equinox also. Even if the author of the Tract were aware of this indigenous formula, it would have been tempting to borrow a concise foreign word rather than have recourse to the above cumbersome phrase. The autumnal equinox is referred to as the *eccinocium septimpir.*

Similarly, the equinoctial is rendered, *eccinocialis* (*egecinocialis*). Reference is made also to the *line eccinoccialis* ~ the equinoctial line. The word for solstice is also taken directly from the Latin. In Chapter 36 reference is made to the *solsticium in tsamraidh* ~ 'the summer solstice.' The earlier vernacular term *grein-tairsen,* referred to in Chapter 2, has been bypassed.

On other occasions, the author has opted for an Irish phrase. The common astronomical term 'ecliptic' is consistently represented in the Tract by the term *sibal na greine,* meaning, 'the path or trajectory of the sun'. The advantage of such a formula is that it renders the meaning of the concept immediately apparent. The formula, however, has not stood the test of time. The technical advisor under De Bhaldraithe has reverted to the more convenient *éiclipteach*[1] in modern Irish.

A term for eclipse is also derived from the vernacular, *dorchadus* (*na greine*), literally, 'the darkening (of the sun)'. In general however, the term *eclipsis na greine* predominates in the Tract. Likewise the 'lunar eclipse' is usually referred to as *eclipsis an re.* The terms for total and partial eclipses are *eclipsis coitcinn* and *eclipsis rannaighi* respectively. The modern Irish term for an eclipse is *eiclips.*

References to the Zodiac are frequent in the Tract. It is generally indicated by the term *stodiaca,* but on many occasions the author prefers to use the phrase *speir na comartadh,* literally, 'the sphere of the signs'. Modern Irish uses the word *stoidiaca.*

A handful of technical terms are intimately tied to the Ptolemaic geocentric model and are now obsolete: words such as equant, deferent, eccentric, epicycle and the apparent 'retrograde' motion of the planets. None of these terms is borrowed in the Tract. The author has made a considerable effort to explain their meanings by recourse to concrete analogies from everyday life rather than simply confront the reader with concise but obscure Latin borrowings. There are no single words in the Irish that equate with most of these concepts.

A rather long-winded formula corresponding to the Ptolemaic concept of an 'eccentric' is, however, rigidly adhered to. It is the phrase *speiri sa seantrom ata leth amuith da seantrom na talman,* literally, 'the sphere whose centre is outside the centre of the earth'. It occurs repeatedly throughout the Tract. It would have perhaps been easier to adopt the Latin word, but the clarity of meaning would not have been guaranteed.

[1] Tomás De Bhaldraithe (ed.), *English-Irish Dictionary,* Ofig an tSoláthair, Dublin, (1976)

The retrograde motion of the planets, i.e. their apparent backward movement, found a comfortable equivalent in Irish, *caissimpodh,* i.e. a 'turning back'. The author introduces his new term in Chapter 33: 'I shall now tell how they turn backwards, which is called "retrogressio", *.i. caissimpodh .i. an trat impoides an planed tar a ais o Airgheis co Pisis*', ("i.e., a back turning, i.e., when the planet turns back from Aries to Pisces"). From that point on, only the Irish term *cassimpodh* is used. In an earlier Chapter the notion of retrograde motion is expressed by the phrase *sibal tar ais,* - 'backward course', but this formula refers more to the path of the motion rather than the motion itself.

An essential dimension to the geocentric conception of the universe is the assembly of concentric spheres that surround the earth. The Tract refers to ten such spheres. In Classical times, some astronomers postulated more, some less. Ptolemy referred to eight, Messahala to nine. The Irish names for these spheres appear as:

1.	*Speir an Re*	Sphere of the Moon
2.	*Speir Mercuir*	Sphere of Mercury
3.	*Speir Uenir*	Sphere of Venus
4.	*Speir na Greine*	Sphere of the Sun
5.	*Speir Mars*	Sphere of Mars
6.	*Speir Ioip*	Sphere of Jupiter
7.	*Speir Saduirn*	Sphere of Saturn
8.	*Speir na nairdrinnach ndaingin*	Sphere of the fixed stars
9.	*Speir na Comartad*	Sphere of the Signs
10.	*An Speir Mhor*	The Great Sphere

In the case of the last of these spheres, the Great Sphere, it might be noted that a degree of flexibility was involved in its Irish terminology. The terms *speir mhor* and *speir lanmor (*or *lanmhor)* are freely interchanged. The latter term might be roughly translated into English as the 'very great sphere'. On at least one occasion the term *speir romor* is used in close proximity to the above. Perhaps in the use of the more emphatic terms, *s. lanmor* and *s. romor,* the author was trying to stress the overriding influence of this sphere on the movement of all bodies of the heavens.

In all fairness, there seems also to have been similar variations in the Latin terminology of that time. In the Latin of the Stabius edition of Messahala, the Great Sphere is referred to as *Orbis maximus.* In the Latin text from which the Irish author worked, the same sphere appears to have been designated *Sphaera maxima.*

Needless to say, all these terms now belong to the archives of Irish astronomical history. They are long obsolete and have no equivalents in contemporary Irish. In their time however, they would have served their purpose in Irish educational circles admirably.

Two distinct words for the stars are used in the Tract with some degree of flexibility. In general *ardreann* predominates, usually occurring in its plural form. In most cases the plural is more fittingly translated as 'constellation', but not always so. Its literal meaning would appear to be 'high stars', the *ard* referring to their status or dignity rather than altitude. The word *retlann* is used less commonly. It equates with the earlier term in Old Irish, *rétglu.* In Chapter 31, the two terms occur in the one

sentence. It discusses the constellations with respect to the signs of the Zodiac. The term *na hairdrinnaigh* is seen to relate unequivocally to the concept of 'constellation' and *speir na retlann* to the 'sphere of the stars'.

To complicate matters, in Chapter 32 we have a situation in which *retlann* refers to one of the planets: *seantrom na retlainne*, 'the centre of the planet'. Power mistakenly translates the term as 'star', but it is clear from the context that it is the planet Saturn that is being referred to. This, however, is not unusual as the planets had been referred to as stars since Classical times. These 'wandering stars' were known as the *stellae errans* (or *stellae vagae*). In Chapter 34, the planets are actually referred to as such: *na retlannaib seacranacha* (d.pl.) – literally 'wandering stars'. In opposition to this, the Tract often refers to the 'fixed stars': *cercall na nairdrinnac ndaingin* ~ 'the sphere of the fixed stars'[1]. In *Saltair na Rann,* the planets are referred to simply as the *secht rinn(e)* – the 'seven stars'.

Chapter 23 of the Tract, also refers to the planets (Venus and Mercury in particular), as stars (*retlainne*). To complicate matters the terminology reverts to planets (*plained*) as the chapter proceeds.

It is further complicated by the fact that the sun and moon were often grouped with the planets. The so-called 'seven planets' referred to in *Saltair na Rann*; are listed as being: *Saturn, Ioib, Mercuir, Mars, Sol, Uenir* and *Luna*. The Tract presents the same list, referring to them as *na secht plained,* ~ 'the seven planets'. One is forced to accept a degree of inherent flexibility both in the Irish terminology and that of earlier times in general.

A handful of simple Latin terms seem to have entered Irish in earlier times as permanent acquisitions: *plained* appears to be taken from the Latin, *planeta.* I am not sure how long the word *plained* had been in use in Irish but it appears to post-date the compilation of *Saltair na Rann.*[2] The word *firmimint* on the other hand is well established in the *Saltair* as well as figuring prominently throughout the Tract.

The Irish meaning of word *sbas (spas)* would appear at first to equate with that of the English word 'space'. In reality though it does not entail anything of the concept of astronomical space. It appears twice in the Tract. In Chapter 17 it equates with the Latin word *spatia* meaning an interval of time. Reference is made to *sbas se nuaire,* 'a space of six hours'. Later in Chapter 31, the term *spas fada* (great difference) relates to the difference in angle between the axis of the *speir lanmhor* (the very great sphere) and that of the *Stodiaca* (the sphere of the Zodiac). The corresponding word in Stabius' Latin edition of Messahala is *differentiam.* The modern Irish word *spás* is cognate with the earlier term, but it has since acquired its three dimensional astronomical connotations, as has its English cousin which also derives from Latin.

[1] c.f. Chapter 18. In Chapters 33 and 34, the same sphere is referred to as the *speir na nairdrinnach ndaingin.*

[2] c.f. Whitley Stokes, (ed.), *Saltair na Rann,* Anecdotia Oxoniensia; Mediaeval & Modern Series, Vol. I Part III, Oxford (1883)

Members of the Solar System

Until the advent of astronomical telescopes, only five planets of the solar system were known. As noted earlier, these five planets had found their way into Irish writings in previous centuries, notably in the opening verses of *Saltair na Rann*, and the Introduction to the *Senchus Mór.* The point to note is that their names are all taken from the Latin. One might conclude from this that the Irish did not have names for the planets in earlier times. From this we might also infer that they had not taken particular interest in these so-called 'wandering stars' that fascinated the Mediterranean World.

Table 6.2: Visible Members of the Solar System

	Irish	**Comments**
Moon	*re,* (less commonly, *esca*)	Occasionally; *luna* (Lat.) Old Ir.; *re easca* (Mod Ir.; *gealach*)
Mercury	*Mercuir*	Latin; *Stella Mercurii*
Venus	*Uenir, Venir*	Latin; *Venus*
Sun	*Grian, greine*	Occasionally the Latin, *sol,* especially in the diagrams
Mars	*Mars*	Latin; *Mars*
Jupiter	*Ioip, Iubiter*	Latin; *Iuppiter*
Saturn	*Saturnus, Sadurn*	Latin; *Saturni stella*

It is not surprising that the vernacular terms for the sun and moon are used throughout the Tract: *grian* for the sun, and *re* for the moon. Less commonly, *easca* is also used. Both terms are derived from the Old Irish *re easca. Sol* and *luna* are, however, retained on many of the accompanying diagrams.

It would appear that in earlier times, Irish 'astronomy' was confined to the study of the *courses of the sun and moon.*[1] Knowledge and interest in these matters in Ireland seems to date from very early times.[2]

[1] From a Medieval Law Glossary compiled by a certain Duald Mac Fibris. C.f.; Joyce, P. W., *A Social History of Ancient Ireland,* Gill & Sons, Dublin, 1920

[2] Peter Harbison, *Pre-Christian Ireland; From the First Settlers to the Early Celts,* Guild Publishing, London, 1988.pp 94-99.

The Constellations

The other major celestial bodies referred to in the Tract are the constellations. Firstly, there are the twelve constellations of the Zodiac. These crop up repeatedly throughout the Tract. Other constellations are mentioned but only infrequently. In all cases, their names are from the Latin. One would have to conclude from this that the designated constellations of the Mediterranean world had no equivalents in earlier Irish tradition.

Nevertheless, it would appear that the path of the stellar patterns along the ecliptic was known in earlier times. Mention has already been made of the ability to keep track of the night hours by the movement of the stars, as related in the tale *The Intoxication of the Ulaid.* It is tempting to conclude there were vernacular names for various groupings of stars. If that were the case, they have long since slipped from the Gaelic memory.

As with the planets, the names of the Zodiac constellations may be found in Irish writings of earlier centuries. There are minor variations of orthography within the Tract, and also variations when compared with those in *Saltair na Rann*, but these are no more than might be expected during the Middle Ages.

Table 6.3: Constellations of the Zodiac

	Irish	**Comments**
Aries	*airges, airgeis, airgheis, airiete, airigheis*	All are of Latin origin: Mod Ir.; *Airéas* Lat.; *Aries, Arietis,* (g)
Leo	*Leo, leone*	Lat.; *Leo, Leonis,*(g), Mod Ir.; *Leon*
Sagittarius	*saigitairus, sagitairius, saighitair*	Lat.; *Sagittarius*
Taurus	*taurus, tabro*	Lat.; *Taurus*
Virgo	*uirgo, uirgine*	Latin gen. *Virginis*
Capricorn	*capricornus*	Lat.; *Capricornus*
Gemini	*gemin, gemen, geimin*	Lat.; *Gemini*
Libra	*libra, libro*	Lat.; *Libra*
Aquarius	*acarius,*	Lat.; *Aquarius*
Cancer	*cannsir, cangero*	Lat.; *Cancer*
Scorpio	*scoirpio,*	Lat. *Scorpius*
Pisces	*pisis*	Lat.; *Pisces*
Other constellations:		
Drago	*dreagon*	Latin; *Drago,* (the dragon)

Celestial Coordinates

In various places in the Tract reference is made to terms that approximate to our geometric divisions of the globe: the equator, North & South Poles, longitude and latitude. At first sight the terms appear to fit well, but in reality, they generally designate quite distinct concepts in the Tract. All such terms in the Tract must be understood in the context of a geocentric reference frame. Hence the phrase *Arctic Pol* refers to the imaginary axis about which the sphere of the firmament rotates. In the translation in Appendix I, I have generally had recourse to the term *Arctic (Celestial) Pole* to emphasise this distinction.

Similarly, the Irish phrase *line medonach an domain* loosely corresponds to the word 'equator', but again, it is really talking about the imaginary line dissecting the celestial sphere. Within the Tract, *talman* and *doman* correspond to the words 'earth' and 'world' respectively. The distinction is subtle but rigidly adhered to in the Tract. The most fitting translation of *domain* is probably our word 'universe'. The author has conveyed this concept reasonably comfortably in the vernacular.

A more appropriate choice of wording is found in Chapter 36 which discusses the Seven Habitable Zones of the earth. The author uses the term *line eccinoccialis* ~ 'the equinoctial line', where the intended meaning equates with the concept of 'equator'. Later in the same chapter is the term, *line dar lar na talman* ~ 'line through the middle of the earth', a formula which is even closer to the concept. In these latter two cases, reference to the equator in the text is unequivocal.

References to the *lethspeir,* or 'hemisphere', must also be understood in the same way. Clearly the words themselves have changed little over the centuries, but the concepts have altered drastically. Our English word 'hemisphere' is in the same position, retaining the vestiges of its original meaning. Modern Irish, however, has altered the earlier term to reflect the new meaning. Hence, *lethspeir,* meaning half of the celestial sphere, has become *leathchruinne* in contemporary usage, meaning half of the globe.

Chapter 36 of the Tract embarks on a division of the earth's surface into geographically distinct zones. Its use of the terms *fad* and *lethead* equates fairly closely to 'longitude' and 'latitude' provided we remember that longitude was neither fixed nor measurable in those times. The Prime Meridian at Greenwich was not agreed upon until 1884. The Irish terms are from the vernacular and remain in use to the present day: *domhanfhad* and *(domhan-)leithead.*

Chapter 16 of the Tract corresponds roughly with Chapter 10 of the Latin edition of Stabius. It attempts to outline the divisions and reference points of the celestial sphere. Among those discussed are three major circles whose planes are at right angles to each other. These circles intersect at six points on the surface of the sphere. For the most part, the author is content to use the Latin names for these circles, generally appending an Irish translation. The following is typical:

> *As e ainm na cercailli sin .i.* orientalis *&* occidentalis *.i. an cercaill oirrcerac no an cercall iartarach & ainm eli daberar uirre .i. cercall an line diridh, . .*

> That circle is called 'orientalis' and 'occidentalis', *i.e.,* the eastern circle or the western circle, and is also called the orbit of the straight line, . .

The author treats of several other circles in the same way: *Septentrionalis, Australis, Meriodonalis, circulus terminorum, circulus signorum* and so on. With the exception of *cercall na comartadh* (circle of the signs), it is doubtful whether Irish scholars of the time would have used anything other than Latin names for these celestial grid lines. The Irish translations which accompany the Latin names are merely descriptive additions. Like much of the subject matter of the Tract, these divisions of the celestial sphere are largely obsolete, being nowadays chiefly of interest to historians of science.

Table 6.4: Celestial Coordinates

Celestial coordinates:	**Irish**	**Comments**
Meridian (celestial)	*cercall an medon lae*	lit.; *circle of the middle of the day* (Lat. *Meridionalis*). It is midday in any place when the sun passes over the meridian.
c. septentionalis	*cercall tuaiscertac*	lit.; the northern circle
c. australis	*cercall deiscertac*	lit.; the southern circle
c. orientalis	*cercall oircerac*	lit.; eastern circle
c. occidentalis	*cercall iartarach*	lit.; western circle
circulus signorum	*cercall na comartadh*	lit.; circle of the signs (i.e., of the Zodiac)
Arctic Pole	*Pol Airtic*	i.e., Arctic (celestial) pole
Antarctic Pole	*Pol Intairtic, Pol Antairtic, Antartic*	Antarctic (celestial) pole

Geographical Terms

A handful of further geographical terms are also worthy of brief mention. As might be expected, most words relating to the weather are of vernacular origin, particularly those within local experience. A selection of these have been included in the Table 6.7. These terms are generally cognate with those in modern Irish. A small number of geographical terms have been taken directly from the Latin, e.g., *clima,* clime or zone.

Concerning the descriptions of Mounts Etna & Vesuvius, it appears obvious that the Irish writer has never witnessed such phenomena. Even his choice of *cnoc* in the term *cnoc teineadh* ('fiery-hill') strikes one as feeble before the magnitude of the two mountains being described. (*Sliabh* might have added a little respectability!) The terms quoted in the Table 6.5 as equivalents for 'volcanus' in the Tract are merely

descriptions, not the inception of new terms in Irish. It is obvious that there was no existing term in Irish for 'volcano', and neither did the Tract lead to one. The eventual adoption of *bolcán* in later times, can be traced ultimately to the Latin *volcanus*. To his credit, the author was more concerned to convey the meaning of these new concepts rather than simply provide a label for his students.

The phenomena of earthquakes and tidal-waves (tsunamis) are in a similar situation, with the Irish author unlikely to have witnessed any such occurrence. Most of his students would have been even less likely to witness such an event during their lifetime. In Chapter 9, the Latin term *terrae motus* is introduced followed by a literal equivalent in Irish: *crit na talman,* i.e.; 'shaking of the earth'. Our contemporary English word does likewise. The Marsh manuscript differs slightly: *gluasacht na crich,* - 'movement of the shaking'. It is possible that both descriptions are later interpolations. This suspicion is strengthened in the following paragraph where the author continues discussing the effects of earthquakes, but reverts to the Latin term *terrae motus.* Again, it seems he is content to retain the Latin usage, but merely adds an equivalent phrase in Irish to assist the reader's understanding of the concept. It is interesting to note that the contemporary term in Modern Irish is *crith talún,* presumably a distant offspring of the 14th century *crit na talman* in the Tract.

The concept of a tidal-wave, more properly referred to as a tsunami wave, would have been even further removed from Irish experience. It must have seemed more like something out of the legendary tales of the Otherworld. Nevertheless, its relationship to submarine earthquakes is correctly acknowledged. The phenomenon is not given a specific name, but its descriptive phrase is sufficiently graphic: *an fairrgi a fiuchad adbul mhor,* 'sea rage in a terrible manner'. For most readers at the time, this would have been their first acquaintance with the concept. One presumes their understanding of it fell far short of the reality. This passage is likely to be its only mention in the corpus of Irish letters prior to the 20th century. The contemporary Irish word is *muirbhrúcht,* lit. 'bursting forth of the sea'. The English term 'tidal-wave' dates to around 1830, being replaced the following century by the Japanese loan word, *tsunami.*

In Chapter 8 the author goes into considerable detail describing the geological rock cycle: weathering, erosion, transportation, sedimentation, consolidation and finally petrification. One of the proximate sources for this Chapter would have been Avicenna's *Ut Supra,* which in turn relied upon the writings of Herodotus and other Classical writers. In the geological world, a clear exposition of the principles involved in the formation of sedimentary rocks had to wait until the work of an Edinburgh Scot by the name of James Hutton (1726-97). Even so, these views did not gain general acceptance by the scientific community until the publications of Charles Lyell in the early 1830s.[1] The relevant point is that until the early 19th century a generally accepted terminology for these concepts had not yet evolved. The visible groping of the Irish author for adequate terms is not merely a consequence of the language being faced with new concepts; it is more the coming to grips with evolving theories that were yet to fully clarify themselves.

[1] c.f., Gjertsen, Derek, *A Study of Twelve Enduring Scientific Works,* LBP, New York (1984)

Table 6.5: Miscellaneous Geographical Terms

Concept	Irish	Comments
The equator	*line medonach an domain*	lit. 'line of the middle of the world.' Strictly speaking, it relates to the imaginary line dissecting the celestial sphere, rather than that on the surface of the globe. Mod.Ir.; *meánchiorcal, crios na cruinne*
	line eccinoccialis (Cha 36)	Lit.; 'equinoctial line' – used in places as referring to the equator.
	line dar lar na talman (Cha 36)	Lit.; 'line through the middle of the earth'. (used in conjunction with *line eccinoccialis)*
hemisphere	*lethspeir*	lit. 'half-sphere'. Mod.Ir; *leathchruinne* The difference in terms, both translated as 'hemisphere in English, really reflect two distinct concepts. The word *lethspeir* representing a half of the celestial sphere in the Tract, but in today's terminology it would imply half of the globe (of the earth).
latitude	*lethead*	Mod.Ir.; *(domhan-)leithead*
longitude	*fad*	Mod.Ir.; *domhanfhad*
zone or region	*clima*	From Latin; *clima*
volcano	*cnoc ar lasadh atara*[1], *cnoc teineadh*	Lit.; 'hill that is burning', 'fiery hill' Mod. Ir.; *bolcán*
earthquake	*crith na talman* (Stwe B), *gluasacht na crith* (Marsh)	Lit. 'trembling of the earth', Lit. 'motion of the shaking' c.f. Latin *terrae motus* Mod.Ir.; *crith talún*
tsunami (tidal wave)	'*an fairrgi a fiuchad adbul mhor'*	Lit.; 'sea rage in a terrible manner', Mod.Ir.; *muirbhrúcht,* lit. 'bursting forth of the sea.
African (Negro)	*fer gorm*	lit 'blue man'

Nevertheless, the author has managed to cope very well. The concepts of weathering, erosion and transportation in waterways are described in simple language. Sedimentation, solidification and petrification have been a little more difficult to

[1] I suspect there might be minor scribal corruption in this phrase which introduces Chapter 10 in Stowe B II, 1. The sentence is not in the Marsh copy. In any case, the meaning is clear; *cnoc ata ar lasadh,* - 'hill that is burning'.

manage. The word *calcaidid* implies various shades of meaning in the Tract: condenses, becomes hard, concentrated, etc. Its literal meaning is 'becomes calceous'. Perhaps the most common 'calceous' hardening in the experience of rural folk of those times would have been the action of lime mortar used in cottage construction. The use of the word *cruadhaigid,* also meaning 'to harden', seems to do little more than reinforce the notion. The English term 'consolidates' would sit comfortably. The term *dani cloch de,* literally, 'form stone of it', readily equates with our modern term, 'petrify'. The contemporary Irish phrase designating the action of petrification is *déanaim cloch de.*[1] Again, the Tract would have been the first encounter of the language with this process.

Later in Chapter 8 the author addresses the question of fossil remains. Noticeably absent is any term equivalent to the word 'fossil'. The author is content to inform us that 'many shells and small sea fish . . . *ar calcadadh ⁊ ar cruadughad ⁊ ar ndenum cloch dib* (have become hard, firm and petrified)'. The terminology follows that for the formation of sedimentary rocks already described. The modern Irish word for fossil, *iontaise,* is presumably a 20th century acquisition.

A curious term crops up in descriptions of the inhabitants of the various climatic zones. It is the Irish word for an African, *fer gorm*, literally, 'blue man'. It is still used in contemporary Irish and its use may predate the Tract, although this seems to be its earliest appearance in Irish letters. One presumes the author had never seen an African. Close was of the opinion that it is simply another example of Gaelic vagueness in matters of colour. This may well be the case. It is also possible that the seemingly more obvious *fer dubh* may have been avoided as the use of colours such as *dubh, fionn, ruadh* as personal adjectives would generally be taken to refer to hair rather than skin colour. Perhaps also *fer dubh* could be taken as reference to unsavoury character. In any case, the choice of term is now well established in the language.

Remarkably few places are mentioned by name in the Tract. Several of the chapters specifically deal with geographical matters including Chapter 36 which treats of the 'eight habitable regions of the earth', but this has not led to the mention of more than a handful of particular locations. Those that are recorded tend to betray their Mediterranean origin. Chapter 12 on the flooding of the Nile is one such. Chapter 17 (not from Messahala) is clearly derived from an earlier work seemingly written in Alexandria, with Babylon to its east and Africa (i.e. Carthage) to its West. The Irish author proceeded to replace 'Africa' in his example by 'France'; a country closer to home. Later in the Chapter he inadvertently reverts to Africa as his argument draws to its conclusion. The accompanying diagram retains Africa as its Western example.

[1] Tomás De Bhaldraithe (Ed.), *English-Irish Dictionary,* Ofig an tSoláthair, Dublin, (1976)

Table 6.6: Miscellaneous Place Names

Place	**Irish**	**Comments**
Babylon	*Uaibileon, Baibileon*	
Egypt	*Egift, Eghift*	
France	*Frainc, Frainnce*	
Africa	*Afric*	The name is used under its earlier meaning signifying the region of Carthage
River Nile	*Srota Nil*	
Red Sea	*Muir Ruaidh*	
African Sea	*Muir na hAfrici*	The Mediterranean Sea
The Great Ocean	*Fairgi Mor*	The Indian Ocean (?)
The Western Sea	*Fairgi Siar, Fairrgi Thiar*	The Atlantic Ocean
Jerusalem	*Iaruscalem, Iarusalem*	
Rome	*Riomh*	
Spain	*Spainne*	
(Mt) Etna	*Etna*	
Sicily	*Sisaile*	
(Mt) Vesuvius	*Ueranes*	
Apulia	*Apaile*	

In almost all cases, the place names in Irish are derived from their Latin sources with minor alterations. The only exceptions are the references to Red Sea, Western Sea and Great Ocean. The latter two terms are, however, potentially ambiguous and are unlikely to have had any genuine recognition beyond the context of the Tract.

Meteorology

A large number of terms relating to the weather and seasonal patterns are to be found in the Tract. The bulk of these come from Chapters 36, 38 and 39, but they are likely to turn up almost anywhere in the Tract. As might be expected, those that equate with local experience invariably have corresponding vernacular terms which the author has readily drawn upon. This includes most of the meteorological terms and as such their use requires no further comment here.

Table 6.7: Miscellaneous Terms Relating to Meteorology

Concept	**Irish**	**Comments**
lightening	*teinntech*	Mod. Ir.; *tintreach*
thunder	*toirnech*	Mod. Ir.; *toirneach*
thunder-bolt	*teil soidhnein*	Mod.Ir.; *caor thine*
moisture, wetness, etc.	*uisceamlacht* *fliucha, flice, etc.*	Many variations on this theme are to be found in the Tract
frost	*cuisne*	Mod.Ir.; *cuisne* (hoar frost)
hail stones	*clocha sneachta*	Lit.; 'snow stones',
temperate (climate)	*measardha, mesardacht*	

The term for hailstones ~ *clocha snachta*, literally 'snow stones', gives a hint that the hailstorms associated with more temperate climates may have been foreign to the Irish. In any case, the term has long been in use in Irish.[1]

It is not really surprising that there is no one word equating with the notion of 'atmosphere'. The author has had to deal with it in a rather circumspect way, referring to it as the 'region (of air) close to the (surface of) earth', which in its context has been sufficiently clear. Likewise, the relatively modern concept of 'humidity' is not clearly articulated. A great variety of vernacular terms that relate to various degrees of 'wetness' are employed in the Tract. I have included only a few examples in Table 6.7.

[1] E. G. Quin, (ed.), *Dictionary of the Irish Language: Based mainly on Old and Middle Irish Material*, Royal Irish Academy, Dublin (1990)

Table 6.8: Seasonal Winds

Constellation	Irish	Comment
Eurus	*Eurus*	All of these are borrowed from Latin; *Eurus*
Zephyrus	*Zephurus, Xepherus, Stepterus, Stipteris, Sditempirus*	*Zephyrus*
Boreas	*Boreas*	*Boreas*
Auster	*Auster*	*Auster*

The traditional names of a number of seasonal winds are mentioned in the Tract. They are all taken from the Latin, being simply phonetic renditions in Irish. One however seems to have presented the author with more than the usual challenge. The phonetics of the constellation 'Zephyrus' have yielded several attempts at an Irish equivalent, all within the confines of a single chapter: *Zephurus, Xepherus,* and *Stepterus* in ms Stowe B. Those in the Marsh copy are even more aberrant. It is possible that this was the only occasion these geographical terms have entered Irish writing in earlier times. One can detect also in this chapter a hint of apology for the inclusion of these Mediterranean weather patterns that were clearly an ill-fitting suit in an Irish context.

Geological Terms

The names of a mere handful of minerals have found their way into the Tract. Jacinth is mentioned as being a 'gemstone', *cloch uasl,* literally, a 'noble stone'. But the reference is merely a passing one, in a passage dealing with the apparent gradual corruption of all earthly matter. Chapter 15, in which it occurs, is not based on the Messahala text. Its proximate source is not known but derives ultimately from Aristotle's *De Caelo,* Book II, Chapter 6. The mineral Jacinth was one of a dozen or so precious stones well known since Classical times. They figure prominently in the medieval lapidaries and correspond to the twelve gems of the heavenly Jerusalem referred to in the Apocalypse (Cha 21, vv.19-20).[1] The Irish term *iacingetis* is clearly borrowed from the Latin *hyacinthus.*

The reference to lodestone (the mineral magnetite) arises only incidentally, its attraction for iron being cited by the author as analogous to the gravitational pull of the moon on the earth's tidal waters. The Irish term is taken from *adamas*, the medieval Latin word for lodestone. The reference to alum is also a passing one. In former times it was used in the dyeing trade and had some medicinal applications. The term *alum* is taken directly from Latin. Although these two terms are not likely to have been part of common experience in rural Ireland, they would not have been unheard of.

[1] c.f., Joan Evans & Mary Serjeantson, *English Mediaeval Lapidaries,* Oxford Univ Press, London (1933)

Table 6.9 Geological Rocks & Minerals

	Irish	**Comment**
Jacinth (mineral)	*iacingetis*	Lat.; *hyacinthus* Mod. Ir.; *iasaint*
gemstone	*clocaib uaisli (d.pl.)*	Lit.; 'noble stone' Mod Irish: *cloch lómhar*
lodestone (magnetite)	*adhamas*	Mod. Ir.; *adhmaint* c.f., Med.Latin; *adamas*
alum	*ailimi (g.pl.), alum*	Mod. Ir.; *alúm* (Chem)

Chemical Terms

The Tract does not directly concern itself with what we might call chemical matters *per se.* Nevertheless, the names of many chemical elements are to be found in several chapters. It goes without saying that within the context of 14th century knowledge, we would not expect a long list. Most of the metallic elements quoted in the Tract are of long standing in the language and are likely to date from Iron Age times if not earlier. They are, however, recognisably cognate with their Latin equivalents, betraying a common Indo-European origin. They are frequently encountered in the Saga literature of earlier centuries.

> In the centre of the house was Conchobor's own room, guarded by screens of copper, with bars of silver and gold birds on the screens, and precious jewels in the birds' heads for eyes. Over Conchobor's head was a rod of silver with three apples of gold, for keeping order over the throng.[1]

The words for sulfur, alum and glass are presumably acquired from the Mediterranean world in earlier times. The Irish terms for salt (salty, saltiness etc.) and acid (acidic & so forth) are also likely to have long predated the Tract. In the case of the latter, the concept itself has undergone considerable refinement since the Middle Ages. As can be seen in Table 6.10, these terms are, for the most part, still current in Irish.

The word *duil* (element) and its derivatives occur frequently in the Tract. Its meaning corresponds to the Aristotelian notion of four basic elements (*cethardula*), from which all matter is composed. The word itself originally signified a 'created being' or 'creature'. In manuscripts of the early Middle Ages it glosses the Latin word 'elementum'.[2] The term *dúil* has survived in modern Irish but the concept has undergone considerable evolution during the intervening six centuries.

[1] From the Ulster Cycle; 'How Conchobor was Begotten and how he took the Kingship of Ulster'. C.f. Thomas Kinsella, *The Tain,* Oxford Univ. Press, London, 1972, p6.
[2] E. G. Quin, (ed.), Dictionary of the Irish Language: Based mainly on Old and Middle Irish Material, Royal Irish Academy, Dublin (1990) (c.f., Column 435)

Table 6.10: Chemical Terms

	Irish	**Comment**
element	*duil*	Old Ir; *dúil,* (Quin), Mod.Ir.; *dúil*
The four elements	*cetharduil*	Middle Ir; *na ceithre duile* (Quin) This concept is now obsolete.
metal	*mitaill*	Mod. Ir.; *miotal*
iron	*irann, iarann*	Mod. Ir.; *iarann*
gold	*or, (oir)*	Mod. Ir.; *ór*
silver	*airgead*	Mod. Ir.; *airgead*
tin	*sdan*	Lat.; *stannus.* Mod. Ir.; *stán*
copper	*umha*	Mod.Ir.; *copar*
brass	*pras*	Mod. Ir.; *prás*
sulfur	*sulfur*	Mod. Ir.; *sulfar*
acid	*serb*	Mod. Ir.; *searbh,* (& *aigéadaim*)
salt	*salann, (goirt, saillte)*	Mod. Ir.; *salann, goirt, saillte*
alum	*ailimi (g)*	Mod. Ir.; *alúm*
glass	*gloine*	Mod. Ir.; *gloine*
volatile	*seimh*	Mod. Ir.; *soghalaithe*
insoluble	*sooscailte*	The term used in the Tract does not fully equate with 'insoluble' in contemporary Chemistry (Cha 8)

Geometry

It was not the purpose of the Tract to address geometric matters *per se*. Nevertheless, a significant number of geometric terms are encountered. There are thirty-one geometric diagrams that accompany the text. These serve to illustrate details of celestial movements of the sun, moon and planets as well as the movements of Sphere of the Fixed stars, the Sphere of the Signs and the Great Sphere. Further diagrams illustrate the solar and lunar eclipses, the division of the earth into geographical climes, the geometry of the phases of the moon and several others relating to the seasons and the spherical nature of the earth.

For each of these diagrams, the text relates in detail their geometrical construction step by step (often to the point of tedium). As a result, a wide range of geometric terms have found their way into the Tract.

Table 6.11: Geometric Terms

Concept	**Irish**	**Comments**
geometry	*iomitric, geomitrice*	Latin; *geometrica*
degree	*ceim*	Mod. Ir.; *céim*
quadrangular	*ceithreuilinneach*	
circle	*cercall*	Lat.; *circulus*
diameter	*diameiter* *tighi cercailli*	Lit.; 'thickness of the circle'
angle, quadrant	*cuil*	Mod.Ir.; *uillinn*, *cúinne*
straight line	*line direch*	Mod.Ir.; *line dhireach*
sphere	*cercaill cruinn,cercaill,* *speir*	Lit. 'curved circle'. Lat.; *sphaera*
hemisphere	*lethspeir*	Mod.Ir.; *leathchruinne,leathsféar*
spherical	*liathroidi cruinde*	plus various other formulas
round, spherical	*cruinn*	Mod. Ir.; *comhchruinn*
roundness, sphericity	*cruinne*	Mod.Ir.; *comhchruinneas*

Mostly the terms are borrowed directly from the Latin but frequently the vernacular is employed. At times the vernacular and Latin terms are used interchangeably. Reference to the diameter is one such case: *diameiter* and *tighi cercailli.* The treatment of concepts such as sphere, spherical, curvature, roundness, convexity, concavity, tends to use vernacular terminology in a variety of ways. Most of these have corresponding equivalents in Modern Irish. There is a certain flexibility in the use of these terms. For example, although *speir* is regularly used to designate a celestial sphere, the author on occasion simply uses *cercaill,* where reference is made to *na deich cercaill* ~ 'the ten (celestial) spheres'. Mention has already been made of this seemingly inherent disposition towards flexibility in the use of technical terms without loss of clarity.

Frequently the author has recourse to metaphors, e.g., *liathroidi cruinde* ~ 'spherical'*, i.e.,* 'with the roundness of a ball'. The word *sentrom,* taken from the Latin *centrum*, does not seem to have gained common usage in Irish, the vernacular term *lár* and its combinations serving quite well.

One geometric concept that is noticeably absent is that of a conical shape. The tapering shadow from the sun's rays cast by the earth or the moon is generally referred to as circular. Clearly, the author has in mind the circular cross-section of this cone as it might be projected on the surface of the moon for example. It would, however, have been more fittingly described as conical.

In general, one could say that the author has described some fairly complex geometrical constructions avoiding both confusion and ambiguity. The paragraphs in question may not provide the most entertaining reading but, like others of their genre, they serve their purpose adequately.

Table 6.11 (cont.)

Concept	**Irish**	**Comments**
convexity	*atmaireacht*	
convex	*atmar* (+others)	
point	*ponc* (usually) *pinn* (on occasion)	Mod. Ir.; *ponc, pointe,* from the French or English, *point* (?)
centre centre (of a circle)	*sentrom* *ponc* (p68)	Lat.; *centrum* Mod. Ir.; *lárphointe, ceartlár, lár*
fraction	*mir*	Lit.; 'portion', *treis mir uaire* = ⅓ hour.

Physics

Many of the physical terms listed in Table 6.12 belong to the realm of pre-Newtonian kinematics. The relationships between force, speed, velocity, acceleration and so on were not clearly understood, partly because quantitative studies of motion were not realistically possible without accurate time keeping devices. In addition, the concepts of 'impulse' and 'momentum' had proved rather elusive to classical scholars. Motion, for its Aristotelian commentators, was deemed to be either natural or forced.

Within the Tract, the indigenous term *gluastach* comfortably describes the concept of translational motion. Three types of spontaneous or natural motions are described. These are referred to as prime motions, *primgluasachta.* This hybrid Latin/Irish term occurs consistently throughout the Tract. One of these prime motions is described as *gluastacht timcill,* or 'circular motion'. The other two forms are *gluastacht o medhon,* 'motion from the centre' and *gluastacht cu medhon,* 'motion towards the centre (of the earth)'. These terms are in conformity with Aristotelian concepts of motion.

The terms *gluastacht* and *gluastacht timcill* are still used in contemporary Irish, both colloquially and in technical terminology. The other three terms were rendered obsolete in the wake of Newton's *Principia.* It is interesting to note that *gluastan* was

the spontaneous response of the vernacular to the advent of the automobile in the Gaelteacht.

Table 6.12: Physical Terms

Concept	**Irish**	**Comments**
measurement	*tomus*	Old Ir; *tomus* (Quin)
'body', (*as in a movable object*)	*corp*	c.f., Latin*; corpus* Middle Ir.; *corp* (Quin)
motion	*gluasacht*	Mod Ir.; *gluiseacht*
circular motion	*gluastacht timcill*	Cha 14
Prime motions	*primgluasachta*	Latin/Irish.
speed	*luas*	translates *'velocitas',* Old & Mod Ir.; *luas*
slowness	*amluas*	Old Ir; *amlúas* (Quin)
to accelerate	*luathaiges* (pres.ind.rel.)	Cha 6 (Power edn. p20)
to retard	*mallaighes* (pres.ind.rel.)	from *mulluigim,* 'I retard'.
force (power)	*brig*	Lit. 'strength'
force (mechanical)	*ainneonac*	Lit. 'involuntary', i.e., with respect to *forced* 'unnatural' motion
humidity (dampness of air)	*a fliche cumuisgter an taer*	Various other solutions to this are to be found in the Tract
trajectory, path, orbit	*sibal*	E.g.; *sibal na greine*, *sibal an re*

The terms for speed and slowness had natural equivalents in Irish. *Luas* in the Tract translates 'velocitas' in the Latin edition of Stabius. *Amluas* was the obvious term for 'slowness'. Similarly, concepts of acceleration and retardation found convenient vernacular terms *luathaiges* and *mallaiges.*

In common with the norms of medieval physics, the concept of 'force', in its Newtonian sense, is only vaguely grasped in the Tract. Mechanical force required to effect 'unnatural' motions is seldom addressed in the Tract. (The 'natural' motions were not seen to be in need of a cause of movement). Chapter 14 provides one such example:

> Everything that moves naturally with a vertical motion can be moved by force and contrary to nature . . .

Gach uili ni gluises co nadurtha da gluasacht direc, fedtar a gluasacht co hainneonac 7 a nagaid naduir . . .

The operative term for 'force' is *ainneonac* which literally means 'involuntary (movement)'. However, this negative description of the action of a force limps severely in the light of post-Newtonian physics. A similar usage with the word (*n*)*ainneoin* is to be found in Chapter 6.

The word *brig* is often translated by the term 'force' but its meaning is more along the lines of power or strength. It has a rather general notion in the Tract of anything that might cause a physical change. This can include, for example, the heating or cooling of an object. It is also used in places to convey the notion of essence: *brig a teasighachta* ~ the essence of its heat, and *brig a fuardhachta* ~ the essence of its coldness. Alternatively, it could be interpreted as the power to heat or cool.

In the final analysis, there is no Irish term used in the Tract that adequately covers the concept of a mechanical force. The absence of such a term in the Tract merely reflects its position in the historical development of physical science in the West.

Table 6.12 (cont.).

Concept	**Irish**	**Comments**
heat	*teasbach,* *britin* *teasigacht*	Cha 14, (Power edn. p70) Cha 12, p50 Cha 6, p20
freezing	*ar sicc*	Mod. Ir.; *sioc, reo*
vacuum	*inad folam*	Lit. empty place, Mod. Ir.; *folús* (Phy.)
amplitude	*leithne*	Lit.; 'wideness' (Cha 29) cainndigeacht leithe a speiri fein, = *quantitatem amplitudinis orbium suorum*
density	*tromidacht,* *truimeacht,* *troma*	lit. 'heaviness', but the intended meaning is clearly 'density', (Cha 7) ditto (Cha 13)

The trajectory of a moving body equates comfortably with *sibal* (course or journey). In the case of celestial bodies, it is the most commonly used term for an orbit. For example, we read of the *sibal na greine* ~ orbit of the sun, and the *sibal an re* ~ orbit of the moon.

Physicists have long had recourse to the term 'body' when addressing the motion of an object. This tradition seems to have been a common habit of long standing as the author of the Tract frequently uses *corp* for this purpose. It equates with 'corpus' in the Latin texts.

The term *leithne*, meaning literally wideness or extent, is used to translate the concept of amplitude. In Chapter 24, which deals with the ten celestial spheres, we find the phrase *cainndigeacht leithe a speiri fein*. It equates with the Latin of the Stabius edition, 'quantitatem amplitudinis orbium suorum' ~ 'the magnitude of the amplitude of its own orbit'. At first sight, it appears to equate with diameter. Why therefore did the author not use either of the terms *diameiter,* or *tighi cercailli,* as are used elsewhere in the Tract? The answer is that while the diameter of a circle is, by definition, constant, the 'amplitude' of the celestial sphere is not. In the Ptolemaic system, the eccentric and the action of the epicycle means that the distance from the earth to any point on the surface of the sphere is constantly changing. The author of the Tract has recognised the need to separate the concepts of diameter and amplitude by the choice of distinct terminology.

In a discussion of the physical properties of matter[1], the term *tromidacht* is used to address the notion of density. Its literal meaning would be close to 'heaviness', but the context makes it clear that it is density rather than weight that is intended. The technical word for density in modern Irish is *dlús*, although *troimeacht* still has colloquial applications.

A rather intangible concept presented itself to the author of the Tract. It is the concept of a vacuum. His response was the rather concrete term *inad folam,* meaning literally an empty or unoccupied place. The modern term *folús* is no doubt more convenient, but inherently less graphic. It appears to be a derivative of *folamh.*

The notion of humidity and various types of 'wetness' invariably has many solutions in the Tract. Indeed there is much flexibility in the description of water in general, and of matters related to the water cycle: evaporation from the sea, cloud formation, precipitation, condensation and so forth. One curious passage dealing with this cycle actually refers to the rain as 'the sea falling from the clouds' (*an fairrgi tic as an nelaib*)[2]. It would be misleading to append Irish terms for all the relevant physical concepts in this area. There is a genuine fluidity of terminology that is descriptive but not technical. Again, many of these phase transformations were yet to attain clarity in Western scientific thought.

Weights and Measures

Weights and measures are not addressed *per se* in the Tract although they do crop up at regular intervals with reference to other matters. The list of weights in Table 4.13 is extracted mainly from the entries on the cover page of ms Stowe B. This page has the elaborate rotula for astronomical computations and details of the movement of the sun and moon through the Zodiac constellations. These entries, their translation and evaluation are included in Chapter 7. As mentioned earlier, they were added during the working life of the text. One of the weights listed, the *sgrubulus,* clearly equates with the 'scruple', a measure traditionally used in pharmaceutical formulations during the later Middle Ages. One could safely conclude that the list of weights and their

[1] IAT, Chapter 7
[2] IAT, Chapter 8

shorthand symbols is more closely related to the Irish medical tracts of the same period. Nevertheless, some pertinent generalisations can be made.

Firstly, all units together with their names date back to Classical times. They have a universality not confined to national boundaries. Only the term *punt* is not borrowed from an earlier Latin or Greek word. It is in fact interchangeable with *libra* on the manuscript. A reason for this universality is most likely the fact that the units of weight were all at one time or another denominations of coins or used in the measure of precious metals. The oft heard maxim, 'money speaks all languages', probably says it all. Hence, among all these terms used for weights, none can claim a vernacular origin. Most of these are of great antiquity, and most have continued in use to the present day in Irish.

Table 6.13: Weights and Measures

Unit	**Irish**	**Comments**
pound	*punt, libra*	Mod.Ir.; *punt*
dram	*dregma*	Greek (silver coin); *drachma* Mod.Ir; *dram*
scruple	*sgrubulus*	Late Roman; *scripulum* Mod.Ir.;
ounce	*unscia, unsa*	Lat.; *uncia*, Mod.Ir.; *unsa*
mile	*mile, mili*	Mod.Ir.; *míle*
inch	*orlac*	Mod.Ir.; *orlach*
degree (angle)	*ceim*	Mod.Ir. *céim* Old Ir; 'measurement of length or degree' (Quin)

The Irish word *mili* occurs in many places throughout the Tract. It equates with the Roman 'mile' and its modern day descendant. Its standardisation as a precise length however is of relatively recent centuries. Even so, calculation of the Earth's diameter and circumference in the Tract has yielded very respectable figures. The Irish term for inch, *orlac,* is of vernacular origin, as also is the word *ceim,* meaning the degree of an angle. Both words remain almost unchanged in Modern Irish.

Philosophical Terms

Although the Tract principally deals with the physical sciences, there are indications here and there of a scholastic background. The work of Messahala refers to God in places, and these references are retained in the Latin translation of Stabius, although frequently they bear traces of Messahala's Jewish background. Chapter 6 of the Stabius edition refers to the names of God: *Creator, cuius nomina sanctificentur.*

Maxwell Close[1] remarks that the Moslems held there to be ninety-nine names of God, and the Jews seventy-two. The Irish Tract has altered this to simply *tusmigteoir beannaithi,* 'Blessed Creator'. Elsewhere God is referred to as the Eternal First Cause, *an siraidhi bunaid,* literally, 'the everlasting origin'. The change in terminology is subtle but it is certainly in conformity with Thomistic terminology, echoing the second of Thomas Aquinas' proofs for the existence of God[2], as the 'First (uncaused) Cause'.

Table 6.15: Philosophical Terms

Concept	**Irish**	**Comments**
Creator, First Cause	*tusmigteoir*	
The Eternal First Cause	*an siraidhi bunaid*	lit.*; the everlasting origin* (Cha. 7)
substance, essence	*folad*	Old Ir.; *folud, folad,* (Quin)
substance	*sustaint, sustainnte*	Lat.; *substantia*
accident	*aicid*	Cha 10; *gabaid na huisceadha aicid on inadh a ticid* – the waters receive (their) accident (i.e.; heat) from the place whence they came'. The word *aicid* is used in its strict Aristotelian sense.
nature (essence)	*naduir*	Lat.; *natura* Mid.Ir.; *nádúir* – a late Middle Irish loan word from Latin (Quin)
nature (instinct)	*dutchas (duchas)*	Old Ir.; *dúthchas* (Quin)
nature (quality)	*cailidecht*	Lat.; *qualitas*
without sense knowledge	*neimeadfadach*	Translates *insensibilis* (Lat.)
vegetable life (soul)	*ainim fastach*	Lat.; *vegitatis anima*

The introduction to the Tract also has a scholastic feel about it, particularly its assertion in the preface that God is known to us by his creation, i.e., *the worker would be known from the works, and the creator from the deeds.*

Throughout the Tract, one finds terms which, although not confined to, are clearly compatible with scholastic philosophy: *substance, accident, essence, nature* etc. On

[1] Maxwell Close, *Irish Astronomical Tract; Introduction, Comments and Appendices.* (handwritten), ms 854 3A9, Royal Irish Academy Library (1901), p11b.
[2] Thomas Aquinas, *Summa Theologica,* Part I, Question II, Article 3. Dominican Edition, Burns, Oats & Washbourne, London (1976)

occasion, the Irish word is taken directly from the Latin: *naduir,* (natura), *sustaint*, (substantia). On other occasions a more fitting Irish word has been used. Table 6.15 gives some indication.

In Chapter 14 while discussing the different types of motion a body may possess, the text makes the distinction between the essential and accidental properties of a being. We are told that *mar as aicideach gac ni aindeonac & mar as sustaint gac ni deonac nadurtha* . . . – 'as every non-essential thing is accidental, and every essential natural thing is a substance . . .' The reasoning goes on to contend that the relationship between accidental modes of being and substantial being is analogous to that between non-essential motion and natural motion. This treatment of motion has long been obsolete, but it does illustrate the author's familiarity with Aristotelian/Thomistic philosophy that had permeated scientific thought in scholastic circles.

Chapter 40, which derives ultimately from Aristotle's *De Plantis,* refers to a vital force called *ainim fastac.* Power translates this term as 'vegetable life'. A translation more sympathetic to Aristotelian philosophy would be 'vegetative soul'. The Irish word *ainim* clearly equates with the scholastic use of *anima* in Latin[1], from which it is no doubt borrowed.

These hints of a scholastic background would be compatible with the earlier suggestion of a Dominican context for the translation and dissemination of the subject matter in the Tract.

Instruments

The corpus of technical instruments mentioned in the Tract is small. It must be remembered, however, that it predates the advent of both the telescope and microscope. Even as late as Brahe, the elevation and azimuth of celestial bodies were measured with the unaided eye. The development of compound lenses by Flemish lens makers, leading to the telescope, did not take place until the sixteenth century. It was not until Galileo that the telescope was directed towards the heavens. This element, and its pre-Colombian geographical context, place the Irish Tract firmly in the Middle Ages, albeit in its penultimate times. While the Tract is very much part of the developments taking place in the field of scientific knowledge, it was destined to be rendered quite obsolete within a century or two of its compilation.

The use of the Latin term for 'astrolabe' should not surprise, nor should its retention in modern Irish. Concerning this instrument, a closely related term deserves mention. The technical term 'elevation' has a fairly specialised meaning in the fields of trigonometry and astronomy. It designates the angular displacement of an object above the horizon. Within Chapter 35 of the Tract, this concept is used several times in relation to this instrument. In each case, the phrase in Irish is along the lines of (* *ceim*) *ar airdi os cinn na talman,* meaning, '(angular) height above the earth's

[1] c.f., Aristotle, *De Anima,* Bk II, Cha IV.
Aristotle's De Anima with the Commentary of St Thomas Aquinas, ed., Forster, K. & Humphries, S., Routledge & Kegan Paul, London, 1959

horizon'. This formula is used consistently throughout the Chapter and equates well with the concept of 'elevation'. This formula is still use in Modern Irish.[1]

The use of an astrolabe is dealt with principally in Chapter 35. During the fourteenth and fifteenth centuries, any astrolabes such as might have been available in Ireland are all likely to have been brought by scholars from the continent.[2]

Spechlai is another term whose borrowing should not surprise. It is interesting to note that the author has mentioned spectacles in passing, it being assumed that the audience, or pupils, would have been familiar with the phenomenon of light refracting through glass. While their use is unlikely to have been widely spread, it seems they had penetrated at least certain sectors of society, in this case, presumably clerics.

The only other 'instrument' of an astronomical nature, the sun-dial, is not mentioned in the Tract. The terms *solam,* and *soiler,* from earlier Irish sources both appear to be derived from the Latin, *solarium.* Their use in the Irish Middle Ages is briefly addressed in Chapter 3 of this thesis.

Table 6.16: Technical Instruments

	Irish	**Comments**
glass spectacles	*spechlai glaine, spechlai*	Mod. Ir.; *spéaclai*
lodestone	*adhamas*	Mod. Ir.; *adhmaint*
astrolabe	*astrolaib*	Mod.Ir.; *astraláib*
(angular) elevation	(* *ceim*) *ar airdi os cinn na talman*	Lit.; 'angular height above the horizon'.

Biological Terms

The list of terms that relate to the biological sciences is not unexpectedly short. Those relating to human biology follow a predictable pattern. Terms for the external parts of human anatomy are all drawn from the vernacular and require no further comment here. The occasional detail of internal anatomy equates with then contemporary knowledge in the West. In Chapter 9 we find the term for 'bile', *lionn ruadh,* literally, 'red humour'. The same term occurs in one of the medical tracts associated with the Stowe B manuscript. It is there discussed as one of the four 'humours' of the body, the others being *fuil derg* (red), *lionn fionn* (white), and *lionn dub* (black humour). Needless to say, such classifications are long obsolete in the field of biological sciences. It was in former times thought that all diseases arose from some change to the body humours.

[1] e.g., *Airde os cinn na farraige* – 'elevation above sea-level'. (De Bhaldraithe)
[2] c.f., Robert William T. Gunther, *The Astrolabes of the World,* 2 Vol., London: Holland Press, 1972 (3rd Edn.)

Concerning the limited number of names of plant species that have unexpectedly found their way into a cosmographical work, we find a predictable pattern. The names of indigenous species such as the apple, in this case a wild apple, are of vernacular origin. The names of Mediterranean imports such as parsley and cucumber are of Latin derivation.

This modest cohort of biological terms could be more fittingly added to the multitude of terms that would result from a similar study of the various Irish medical tracts.

Table 4.17: Miscellaneous Botanical Terms

	Irish	**Comments**
plant	*planda*	Latin
vegetable life (soul)	*ainim fastach*	
Plant species:		
parsley	*apium, opium*	Latin; *apium.* Mod.Ir.; *peirsil*
cucumber	*cucumer*	Latin; *cucumis.* Mod.Ir.; *cúcamar*
gourd	*cucurbita*	Latin; *cucurbita*
crab apple	*uball fiadain*	Lit. 'wild apple'
aloes	*aloes, aloe, alues*	Mod. Ir.; *aló* (from the Latin)

Table 4.18: Terms relating to Human Anatomy & Ailments

	Irish	**Comments**
brain	*inchinn*	Mod. Ir.; *inchinn*
bile	*lionn ruad*	Lit.; 'red humour'.
blood	*fuil*	Old & Mod. Ir.; *fuil* (Quin)
'bad' blood (i.e., diseased)	*droca fola*	Cha. 11. The term & concept are long obsolete.
head	*ceann*	Mod. Ir.; *ceann*
pupil (of the eye)	*mac imrisan*	Mod. Ir.; *mac im reasoan*
neck	*muinel*	Mod. Ir.; *muineál*
hands	*lama*	Mod Ir.; *lámha*

shoulder blades	*slinnein*	Mod. Ir.; *slinneán*
navel	*lican*	Mod. Ir.; *imleacán*
loins, small of the back	*fordronn*	Mod.Ir.; *fordhronn* Lit.; 'extreme of the back'
bone	*cnaim (cnam)*	Mod Ir; *cnámh*
marrow	*smir*	Old Ir.; *smiur* (Quin)
thighs	*sliasta*	M.Ir.; *sliasta* (more commonly *ceathrú*)
knees	*gluine*	Mod. Ir.; *glúin*
ulcer, boil	*neascoid* *neasc* (Marsh ms)	Mod. Ir.; *neascóid*

Writing Style

Pertinent to this chapter would be at least a brief comment on the author's style of writing. As noted earlier, Power relates that it is "simple and straight forward, sometimes even bald in description; it bears no trace of affectation, becoming almost colloquial in places, so that one is tempted to put it down as a sample of spoken Irish of the fourteenth or fifteenth centuries."[1]

From my experience over the years as a Physics teacher, the text gives the impression of having been written by one whose scientific knowledge exceeded his skills in the liberal arts. Such tends to be the norm rather than the exception among technical people. The resultant lack of 'polish' can be seen in several characteristic elements of style.

One is the excessive use of the conjunction 'and' to yield seemingly endless sentences. Frequently, the conjunction in its abbreviated form *is* (⁊) can be found a dozen or more times in the space of a single sentence, encompassing an entire paragraph. The resulting text is tiresome to read at the best of times.

In addition, the author has the habit of starting sentences with the conjunction *ocus* (or *agus*). Often the Latin *et* is used.[2] I have not bothered to keep tally of these matters, but to illustrate the point, in the main paragraph of the opening chapter of the Tract, this conjunction recurs 25 times. There are seven sentences in the paragraph. This ratio is greatly exceeded in many places throughout the 40 chapters of the Tract. The more extreme cases involve long tedious descriptions relating the construction of accompanying astronomical diagrams, point by point, line by line. In fairness to the

[1] M Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914). See Introduction, p x.

[2] The manuscripts use a shorthand scribal abbreviation ⁊, equivalent to our keyboard symbol '&' for the beginning of the sentences. This can be equally taken to mean 'et' or 'agus'. Power tends to restore it as *et* and O'Farrelly as *agus*.

author, there are passages in Ptolemy's *Almagest,* (among others) that are of similar ilk. Furthermore, such habits are commonly found in all kinds of clerical writing.

If as it seems, the Tract served as lecture notes, one gets the distinct impression that the lecturer scarcely stopped to draw breath. One can imagine the written text being the next best thing to having had a tape recorder preserving his delivery *verbatim.*

There are certain turns of phrase that the author uses with great frequency, becoming almost his 'trademark'. He has the habit of beginning each new idea with an acknowledgement to an earlier authority. The main variations on this theme are:

Agus mar aderaid na feallsamain . .	And as the philosophers say . .
Agus mar adeir an feallsam sin . .	And as that philosopher says . .
Agus mar sin aderaid . .	And as they say . .

Occasionally the author is more specific;

Agus mar adeir Partholomeus & na fallsamain ele . .	And as Ptolemy and the other philosophers say . .

This form of discourse is rather typical of scholarly writings during the Middle Ages and is not out of place in the Tract. Dicuil's *Liber de Mensura Orbis Terrae,* referred to in Chapter 3, can be reduced to an almost endless sequence of quotes from earlier authors, interspersed by the occasional gem from Dicuil himself. Likewise, the author of the Irish Tract occasionally reveals his own views:

As mar sin aderim . .	And thus I say . .
Agus aderim aris . .	And I say again . .
As mar adubramar . .	And as I mentioned . .

Some at least of these turns of phrase derive from the Latin source texts; e.g., *Sicut dixit Ptolemaeus . . . ,* and *dicunt philosophi . . .* To a large extent, however, they seem to be distinctive element of the author's style. All in all, the resulting text is probably a typical example of its genre. These peculiarities of style do not detract from the quality of the Tract. It is important to remember that it is essentially 'functional prose' and not a literary work. Its paramount aim was to render the technical and scientific concepts readily accessible to students and fellow lecturers; an aim which is arguably fulfilled.

* * *

Chapter 7: Data Entries on MS Stowe B II (RIA)

I. Relating to the passage of the Sun through the Zodiac

A mi ianair sol in acarius insin .9.	Sun in Aquarius on the 9th of January[1]
A mi feabra sol in pisis is in - - - -	Sun in Pises on the - - - of February
[A mi marta] sol in airiete insin 10. la	Sun in Aries on the 10th day (of March)
A mi aipril sol in tabro is in 11.	Sun in Taurus on the 11th of April
A mi mai sol in geimin is in 9 la.	Sun in Gemini on the 9th day of May
A mi iuin sol in cangero isin 10	Sun in Cancer on 10th of June
[A mi iul sol] in leone is in 11	Sun in Leo on 11th of (July)
A mi aghuist sol in uirgine is in 19.	Sun in Virgo on the 19th of August
A mi Septimpir sol in libro is in IX.	Sun in Libra on the 9th of September
A mi octimpir sol in scoirpio isin 6.	Sun in Scorpio on the 6th (?) of October
A mi [nouimbir sol in sagi]tairius is in -.	Sun in Sagitarius on the 12th of (November)
A mi disimbir sol in capricornus isin 10. la co leith	Sun in Capricorn on the 10th (and a half) day of December

The above data relating to the sun's movement through the Zodiac are reminiscent of similar data included in the opening poem of *Saltair na Rann.* By way of interest, it may be noted that the respective dates (on the Julian calendar) for each sign of the Zodiac would have drifted on average four or five days during the interval separating the composition of these two works. This list, together with that relating to the lunar movements, fits comfortably with the exhortation in the concluding two verses of the poem.

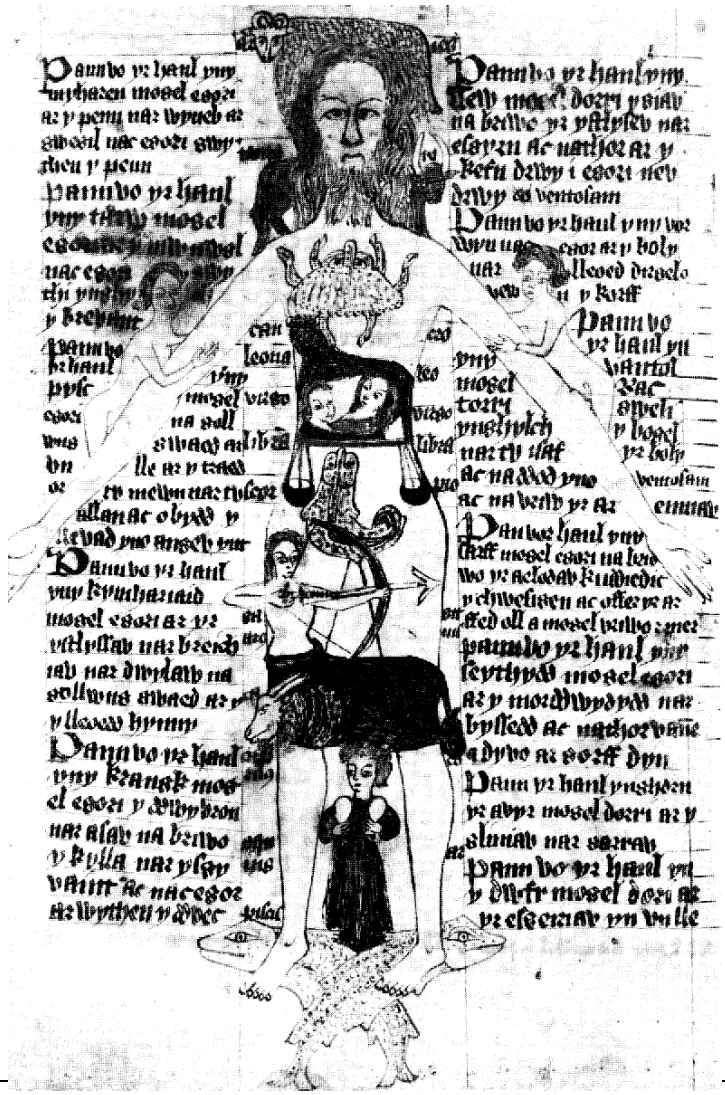
A coic cach lae d'fiss cenbrath *Dlegair docachintliuchtach,* *Docachoen, cengláma gné,* *Bis fograda ecailse.*	For each day five items of knowledge Are required of every intelligent person, From every one, without appearance of boasting, Who is in ecclesiastical orders.
Laa mis grene, ésca aes, *Rith mara cen immarbáes,* *Laa sechtmaine, feili noeb n-uag,* *Iarcertglaine con-imluad.*[1]	The day of the solar month, the age of the moon, The sea-tide, without error, The day of the week, the feasts of the perfect saints, After just clearness, with their variations.[2]

[1] This entry is rather worn. O'Farrelly read this to be the 10th of January. I suspect the original read the 19th. He was also able to decipher (with some uncertainty) the entries for February, June, July, October and November. It would seem that legibility of the parchment had deteriorated in the 20 year period that had elapsed by the time of Power's work. I have confined the computer evaluations to those identified by Power. With the exceptions of those for January and April (O'Farrelly took 11 to mean 2nd rather than 11th), her dates agree with those of O'Farrelly.

II. Relating to the Anatomical Associations of the Zodiac Signs

Airigheis an ceann,	Aries, the head,
Tabrus an muinel,	Taurus, the neck,
o geimin na lama ⁊ na slinnein,	From Gemini, the hands & the shoulder blades,
C-------, le--------	Cancer -------, Leo, the stomach,
----------	Virgo, to the navel,
libra on lican co fordronn	Libra from the navel to the loins,
scoirp o fhordronn co cnaim,	Scorpio from the loins to the haunch bone,
saighitair na sliasta,	Sagitarius, the thighs,
caipricornus na gl[uine] ---------.	Capricorn, the knees.

This association of the signs of the Zodiac with various parts of the human anatomy is to be found illustrated in a near contemporary Welsh manuscript, Mostyn 88.[3]



[1] Whitley Stokes, (ed.), *Saltair na Rann,* Anecdotia Oxoniensia; Mediaeval & Modern Series, Vol. I Part III, Oxford (1883)

[2] Eleanor Hull, *The Poem-Book of the Gael,* Chatto & Windus (1913)

[3] Mostyn 88, p26. C.f., Morfydd E. Owen, *Functional Prose: Religion, Science, Grammar, Law,* Chapter XI of *A Guide to Welsh Literature, Volume I,* ed., A O H Jarmen & Gwilym Rees Hughes, Christopher Davies, Swansea (1976).

III The times of the Moonrise at the start of each month & length of night & day

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---------- *uair.*	*Nox horum [XVI, dies VIII].*
---------- *easca feabra*	*Nox horum XIIII, dies X*
A nderigh (?) aichi tic easca marta.	*Nox horum XII, dies XII.*
A medhon (?) aithi tic esca aipril	*Nox horum X, dies XIIII*
---------- *tic esca mai.*	*Nox horum VIII, dies XVI.*
A medhon lae tic esca iuin.	*Nox horum VI, [dies XVIII].*
Im noin tig esca iuil.	*Nox horum VIII, dies XVI.*
Idir medon(?)⁊ easpartain tic esca agustus.	*Nox horum X, dies XII.*
Annsan easbartain tic esca septimbir	*Nox horum XII, dies XII.*
A tosac aiti tic esca octimbir.	*Nox horum XIIII, dies uero X.*
An VI uair daitchi tic esca noimpir.	*Nox horum XVI, dies VIII.*
A trian na haithi tic esca disimpir.	*Nox horum XVIII, dies VI.*

English

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----------hour-------.	Night hours, 16, daylight (hours), 8.
----------moon (in) February	Night hours, 14, daylight (hours), 10.
Moon(rise), end of the night, agrees March	Night hours, 12, daylight (hours), 12.
Moon, middle of the night, agrees April	Night hours, 10, daylight (hours), 14.
Moon ----------agrees May	Night hours, 8, daylight (hours), 16.
Moon, middle of the day, agrees June	Night hours, 6, daylight (hours), 18.
Moon, at Nones, agrees July	Night hours, 8, daylight (hours), 16.
Moon, btwn midday & evening, agrees Aug.	Night hours, 10, daylight (hours), 14.
Moon, in evening agrees September	Night hours, 12, daylight (hours), 12.
Moon, beginning of the night, agrees Oct.	Night hours, 14, daylight (hours), truly 10.
Moon, the 6th hour of the night, agrees Nov.	Night hours, 16, daylight (hours), 8.
Moon, the 3rd (hr) of the night, agrees Dec.	Night hours, 18, daylight (hours), 6.

Concerning the terminology used in the these entries, a few generalisations can be made. It appears the author of these is not the original author of the Tract. The word used for 'moon' in the Tract is usually *re* throughout the text. On occasions *esca* is employed, although the Latin *luna* is frequently retained in the diagrams. The additions to the Stowe B copy, however, only use the Irish word *esca.* Both words derive from the Old Irish term '*re esca*'.

A similar variation occurs with the term for the sun: *sol* in the appended data, and *grian* in the main body of the text. The diagrams accompanying the Tract have, however, usually retained the Latin *sol.*

The handwriting of these entries is clearly inferior to the calligraphy of Aedh Buidhe Ó Leighin, the scribe of Stowe B II.

Minor variations of spelling for the names of the constellations of the Zodiac are common, but not unexpected; the additional entries being less prone to simply adopt Latin spelling.

One further word in these entries is worthy of mention. For the month of July we are told that *Im noin tig esca iuil,* i.e., '(the) moon, at Nones agrees July.' Nones is of course, the ninth hour of the Church's liturgical prayer, corresponding to 3.00pm. It is possible that the term may have had limited circulation in secular usage, but it would have been predominantly at home within a monastic context. Use of this term adds a little weight to the suggestion that the Tract was compiled, transmitted and disseminated within monastic institutions.

* * *

In an attempt to ascertain their date of entry, the details relating to the passage of the sun through the Zodiac and the rising of the moon each month were compared with computer generated skycharts for the relevant times, dates and global co-ordinates. The computer program[1] employed is able to reproduce details of the visible sky from any location on the earth's surface at any point in time over the last six thousand years.

Of the entries in the Tract relating to the sun, seven months of the year retain a legible date for its entry into the next Zodiac constellation of the ecliptic. These dates were used with the computer program to generate skycharts around the turn of the 15th century. The precise location used was Cork, latitude 51°54'north and longitude 8°28' west. Cork was chosen for this exercise principally because the author of ms Stowe B, Aedh Buidhe Ó Leighin, is known to have worked in and around the Fermoy district of County Cork. Cork was also the site of an established Dominican monastery. In reality, however, the choice of another location in Ireland would involve only minimal changes to the skychart.

The accompanying table of results relates to the year 1400AD. Again, the precise year is not critical for these readings as there are only minimal changes in the sun's location on the ecliptic for the twenty or so years either side of this year. Allowance has been made for the fact that the dates on the manuscript are in the Julian calendar. This involved taking into account ten days that disappeared at the inception of the Gregorian calendar on the 5th of October 1582, and the inclusion of leap years in 1400 and 1500 under the Julian system.

[1] *EZ-Cosmos*, *3.0*

A few preliminary points need to be made concerning these correlations. Firstly, there are no discrete boundaries separating constellations of the Zodiac. Unlike stars, their locations do not have precise coordinates. Hence, there is a certain subjectivity in assigning a point in time at which a planet is said to have passed from one constellation to the next. Secondly, it must be understood that a discrepancy of several days is relatively small in the context of a cycle of a little over 365 days.

Table 5.1

Manuscript date (Julian calendar)	**ms Sign**	**Computer location of Sun**	**Correlation**
9th January	Aquarius	Approx. 10 days short of Aquarius	Fair
10th March	Aries	Entering Aries	Very good
11th April	Taurus	Entering Taurus	Very good
9th May	Gemini	Approx. 12 days short of Gemini	Fair
19th August	Virgo	Entering Virgo	Very good
9th September	Libra	Approx. 12 days short of Libra	Fair
10th December	Capricorn	2 or 3 days short of entering Capricorn	Good

Also relevant to these correlations is the current state of legibility of the first page of Stowe B. Many individual words and numerals have been lost during the earlier years of wear and tear in the working life of the text. For the entry concerning the month of January, Maura Power deciphered the script to read "*in acarius insin .9.*". I was at first intrigued by the presence of a full stop before the numeral. It is not customary within the manuscript to preface a numeral by a point. If it transpires that this mark is the last remnant of the numeral '1', then we get perfect computer correlation from the 19th of January. O'Farrelly took the same number to read 10. My inspection of the negative photographic prints of this page at the RIA Library was unable to clarify the matter. A closer inspection of the original parchment might prove fruitful although it appears to have deteriorated slightly since the time of O'Farrelly's work.

It is also possible that the entries for May and September may have suffered the same fate, but again, a closer inspection of the original would need to be undertaken. On the whole however, the close agreement of four of the remaining entries is impressive.

* * *

The analysis of data relating to the moon is considerably more problematic than that for the sun. The entries in the text are concisely phrased, giving the impression they were personal notes of the *magister,* not intended for any wider audience. For each month, a time of the day is given for the moon. One would assume the time relates to the moonrise. It must also be assumed that the day in question is the start of the month. Neither of these assumptions is unreasonable. Indeed, there doesn't seem to be any other reasonable interpretation.

There are several other factors that render the lunar analysis more hazardous that of the sun. Firstly, the sun changes its daily position on the ecliptic very slightly each year. Even the day to day progression is slow. By contrast, the elevation of the moon is very sensitive to changes of date and time.

The matter is further complicated by the vagueness of the times given. Qualitative descriptions such as 'between midday and evening', 'beginning of the night', 'evening', and 'end of the night' are highly frustrating to a physicist. Even seemingly more quantitative descriptions such as '6th hour of the night' and '3rd hour of the night' are in the end just as elusive. Likewise, the term *a medhon lae,* 'the middle of the day', does not necessarily equate with what we take to be 12:00pm. No doubt, the author of these entries knew exactly what he meant by these terms. Presumably, the terms were also more meaningful in their colloquial context at the time.

One of the times does, however, seem to provide a fixed reference point, *im noin tig esca iuil,* 'at Nones, the moon agrees July'. Nones, the ninth hour of the day, was marked in monastic circles by the recitation of liturgy of the 'Hours' at 3:00pm.

The entry for July, therefore, was selected for computer analysis. The rising times for the moon over Cork were surveyed for the years 1395 to 1440AD. This range is likely to cover the working life of Ó Leighin plus a little later. Three years (on the Julian calendar) were found yield a moonrise close to 3:00pm on the 1st of July. These were the years, 1402, 1410 and 1421.

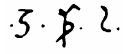
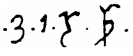
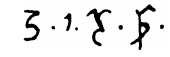
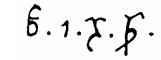
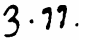
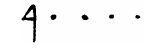
Each of these years was then assessed for the other months of the year to see if agreement could be found. The years 1410 and 1421 yielded no further linkages. For the year 1402, an approximate correlation was found although I would hesitate to say it was conclusive. For example, 'in evening September' was comfortable with 6:00pm, but 'beginning of the night' for October had to equate with 5.20pm. Others were even further out.

The entries themselves would seem to support the suggestion of imprecision regarding the lunar times listed in ms Stowe B. In the case of June, we are confronted with the phrase 'middle of the day'. It is possible that a full moon can be located on the horizon at 12.00pm, but it would need to be in the vicinity of the summer solstice and at a latitude close to that of Iceland. The month of June satisfies the need for proximity to the summer solstice. One is therefore left with the choice of either a wandering Irish scholar accompanied by his parchments or a time that probably relates to early afternoon, say 2.00 or 3.00pm, depending upon the precise latitude. In the context of a lengthy June day, one could easily imagine this time being described as 'middle of the day'. Given this degree of flexibility in the recorded times, it is quite possible that 'nones' for July could have been up to an hour or so off 3.00pm (presumably later).

In the final analysis, I would suggest, with caution, the year 1402 as a tentative date for the compilation of these addenda on Stowe B.[1]

[1] This corresponds to the Julian Day, 2233328.1533

IV Weights & Measures

sgrubulus	*dregma*	*unscia*	*punt*	*libra*
				
	lethdregma	*lethunsa*	*lethpunt*	
				
	dragma co leth	*unsa co leth*	*punt co leth*	
				
da scrubulus	*da dregma*	*da unsa*	*da punt*	
				
			ceatrime puint	
				

As mentioned earlier, the inclusion of the *scrubulus* among this list of weights seems to imply an apothecary connection for these entries. One might conclude that pharmaceutical formulations at that time made use of symbols for the *scrubulus, dregma, unscia, punt* and *libra.* Shorthand symbols were also employed for simple multiples of these: half, *leth,* one and a half, *ceann co leth,* two, *da,* and a fourfold, *ceatrime.* Although this latter entry is mostly illegible, it appears the symbol would have been that for 'four pounds'. The only weight symbol that appears remotely recognisable is that for the *punt* or *libra*, which seems to bear a distant resemblance to our contemporary symbol for the monetary pound, £.

It would be of interest to compare these symbols and units with any that may have found their way into the various Irish medical tracts of that time.

* * *

Chapter 8

Concluding Remarks

In many ways, a study of the Irish Astronomical Tract throws considerable light on hitherto hidden aspects of Ireland during the later Middle Ages and its transition into the Renaissance era. The 'Age of Saints & Scholars' during the 6th to the 8th centuries has been traditionally recognised for its contribution to and participation in the intellectual life of Western Europe. The so-called 'Gaelic Revival' of the 13th and 14th centuries has also been recognised, but to a large extent it would appear to have been overshadowed by political developments in the lead-up to the upheavals and turmoil of the centuries that were to follow.

The Irish Astronomical Tract throws into high relief an aspect of the intellectual and educational growth taking place within the Gaelic world at that time. The surviving copies of the Tract bear witness to its significant use for educational purposes in a broad sweep of what we might call the secular sciences. As might be expected, astronomical matters make up more than half of its subject matter. Added to this we have sizeable input from the fields of physical geography and meteorology. Also touched upon are elements of physics, chemistry, geology, physiology, botany and human geography. Admittedly, much of the subject matter was on the verge of being overcome by the scientific developments that followed in the wake of the technological advances of early modern times. The advent of the telescope and microscope, for example, provided undreamed of opportunities for the observation of natural world. Nevertheless, the level of scientific understanding displayed in the Tract was pretty much on par with that circulating in the West at that time.

It is tempting, from our viewpoint at the beginning of the 21st century, to judge the scientific content of the Tract rather harshly. It should be remembered, however, that within the context of pre-Newtonian physics and a pre-Copernican astronomy, the Tract stands up to scrutiny quite well. The geocentric view of the universe according to the model of Ptolemy is fairly accurately described. The complicated systems of deferents, epicycles and eccentrics are explained in reasonably simple language with clear and concise terminology.

Data, such as the radius and circumference of the earth, and the periods of the visible planets and the moon, are respectable when compared with the known values. In a few places, the Tract is a little ahead of its time. The treatment of the gravitational influence of the moon on the earth's ocean tides anticipates, in some respects, the work of Kepler and Newton by nearly two centuries. The mention of the possibility of an annular eclipse goes beyond the work of Ptolemy and the earlier astronomers. The figure given for the rate of precision of the equinoctial points is also an improvement on that given by Ptolemy. The Irish author has, in this matter, been able to draw upon the advances of the Arabic and Persian astronomers of the Middle Ages.

In regard to the use of technical terminology in the Tract, some pertinent conclusions may be made. Although many terms are borrowed directly from the Latin, a surprising number have been taken from simple everyday speech. Many of these terms have continued in use down to the present day, and find their place in the technical vocabulary of Modern Irish. Often we find the equivalent English term is

simply borrowed directly from Latin, while Irish has furnished its own. The word for 'element', *dul,* is a typical example.

Other concepts have been addressed by the use of a short phrase in a somewhat cumbersome way. Hence, we have the rather longwinded term for an 'eccentric sphere', *speir sa seantrom ata leth amuith da seantrom na talman,* - 'sphere whose centre is outside the centre of the earth'. As might be expected, its continued use has not passed the test of time.

Much of the astronomical vocabulary of the Tract has been rendered obsolete with the demise of the geocentric framework. These extinct relics of an earlier age now belong to the archives of late Middle Irish technical vocabulary.

Several terms used throughout the Tract display a distinct looseness of precision. The term *cercall,* for example, can have several quite different meanings. The meaning in each case is usually fairly obvious from the context, but one would have to admit of the possibility of misunderstanding. In several places in the ITS English edition, the word is inappropriately translated.

One also finds a looseness of precision in the use of terms relating to force and movement. The notion of 'force' is expressed inadequately in a variety of ways. The reason for this, however, is not due to limitations on the part of the language, but rather to a lack of clarity in the scientific understanding of these concepts at that point in time. In this regard, the Tract closely parallels the historical development of these concepts in the West. A more precise understanding had to await the advent of Newtonian physics.

I have no doubt the Tract was a useful repository for many words that found their way into the dictionaries that helped standardise Modern Irish early in the 20th century. Both Power and O'Farrelly are acknowledged as contributors to Dineen's ITS Irish Dictionary.

Overall, there is little in the Tract that would separate it from mainstream scientific thought in the West. There are, however, occasional gems which provide a brief window into rural Ireland of those times. The author's description of the qualities of the inhabitants of the various latitudes has its own charm. We can identify the fifth zone, on the basis of stated lengths of daylight hours, as corresponding to Irish latitudes. We are told that its inhabitants are of 'neutral complexion' and have 'medium-sized bodies'. We are further told that 'their wisdom is less and their life shorter than those of the preceding zone' (i.e., Mediterranean Europe). On the other hand, 'their trees are more numerous and the fruit of their fields more excellent'.

The analogy of a quern (*bró*) is occasionally used in the Stabius edition of Mesahallah, but it is used with great frequency in the Irish Tract. It was presumably an example which found a resonant chord with students from a largely rural community. Likewise, we have the numerous references to cartwheels and so forth.

The treatment of the Four Winds in one of the meteorological chapters is another occasion where the local imprint of the Irish author can be detected. He is noticeably

apologetic about the ill-fit of these Mediterranean weather patterns to the local experience.

The data entries on the cover of ms Stowe B are not, strictly speaking, part of the Tract. They pertain moreover, to the working life of the Tract, presumably as a teaching document at one of the early fifteenth-century centres of learning. With some caution, the year 1402 is offered as a possible date for these entries, based upon computer analysis of celestial movements over a sixty-year period. This date does not seem to be in conflict with any internal evidence within the Tract or with the attribution of the Cork scribe Aedh Buidhe Ó Leighin, to ms Stowe B.

The mention in the Tract of the regression of the planet Saturn from Aries to Pisces, and the fact that this passage is known to have taken place in the year 1350, may possibly point to the date of initial compilation of the Tract, but not necessarily so.

The likely institutional context of the Text has been discussed in some detail. Circumstantial evidence would tend to suggest a Dominican background for the compilation of the Irish version as well as a no longer extant Latin prototype. The dissemination of this work and its use for educational purposes is also likely to have been via Dominican houses of learning. Further exploration of these possibilities has been deemed a little beyond the scope of this work, but it remains an interesting avenue for future research.

Two further areas of research present themselves. Firstly, there is the difficulty that earlier editors faced when confronted with the final chapter of the Tract dealing with plants. Water damage of the final folio of both Stowe B and the Marsh ms meant that scarcely more than the opening paragraph in each manuscript was discernable. It is possible that scanning under ultraviolet light (or perhaps X-Ray scanning), together with digital enhancement of the image could restore the text.[1] The retrieved content would be unlikely to add much more than that contained in Aristotle's *De Plantis*, but it would be pleasing to have the Irish Tract in a form close to its medieval integrity. For some of the medieval botanical terminology in Irish, the Tract would be their only vehicle of preservation for contemporary scholars.

Secondly, there remains Maura Power's conviction that comparison of the Tract "with some of the numerous medical tracts . . . would doubtless supply much interesting material with respect to the resources of our language in treating of purely scientific and technical subjects."[2] In many respects the extension of this work to fully include the medical texts is a potentially more arduous and daunting task.

Since the publication of Maura Power's translation of the Tract by the Irish Texts Society in 1914, it would be true to say that it has received very little attention in the academic world, or even mention in more general studies of Irish history. Given the specialised nature of its subject matter, this is perhaps not unexpected. Nevertheless, the Tract would seem to be worthy of greater recognition as its surviving manuscript

[1] One is reminded of the case of Codex Ephraemi, the fifth century parchment copy of the Greek New Testament currently housed in the Bibliothèque National in Paris. It had been erased and reused during the Middle Ages. By means of chemicals the entire New Testament copy and fragments of the Old Testament were recovered.

[2] M Power, *An Irish Astronomical Tract,* Irish Texts Society, Vol. 14, London, (1914), p i.

copies bear eloquent testimony to the solid participation of Irish learning in the formative years leading up to the Renaissance in the West.

* * *

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