CHAPTER 1

Al-BĪRŪNĪ'S VIEW OF THE RELATIONSHIP BETWEEN NATURE, SCIENCE AND RELIGION

1.1 Introduction

Abū Rayḥān Muḥammad ibn Aḥmad al-Bīrūnī[1] was born on Thursday, 3rd of Dhū al-Hijjah, 362 A.H. (4th September 973 A.D.) at "Madīnah Khwārizm".[2] His exact birth place is still a matter of dispute. It is suggested that he was born in the outskirts (bīrūn) of Kāth[3], at al-Jūrjāniyah[4], Khwārizm[5] or at a place called Bīrūn[6], as implied

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[1]"The spellings Al-Bīrūnī and Al-Bērūnī are both legitimate". See Percival Spear, ed. The Oxford History of India, (Oxford: Clarendon Press, 1961) p.209, footnote 1. Also the forms Albērūnī and Albīrūnī, without the hyphen that is, are equally acceptable from the usage there and elsewhere. In this dissertation, I adopt the form al-Bīrūnī because it is more conventional.

[2]See Taḥdīd Nihāyat Al-Amākin, (Ankara, 1962), p.5. Hereafter cited as Taḥdīd

[3]See S.H. Barani, "Al-Bīrūnī and his Magnum Opus Al-Qānūn 'al-Mas'ūdi" in Al-Qānūn Al-Mas'ūdi , (Hyderabad: Deccan, 1956), p. v.

[4]S. J.H. Kramers, "Al-Bīrūnī's Determination of Geographical Longitude by Measuring the Distances", Commemorative Volume, p. 189. Krenkow, for example, maintains that the birth place was the ouskirts rather than in al-Jūrjāniyah. See his "Beruni and the MS. Sultan Fatih No. 3386", Commemorative Volume, p.196.

[5]See Ghadanfar's Risālah al-Mushshatah li-Risālah al-Fihrist which is reproduced in E.C. Sachau's introduction to al-Bīrūnī's Al-Āthār Al-Bāqiya, (Leipzig, 1923), p. xvi. See also A.S. Nadwi, "Albērūnī", Commemorative Vol., p. 255 and H.M. Elliot, The History

by his nickname al-Bīrūnī. The only clue given by al-Bīrūnī was that he was born in a city in Khwārizm.[7] The name Abū Rayhān was given to him due to his love for sweet fragrance.[8] Al-Bīrūnī died on 443 H (1051 A.D.)[9]

Al-Bīrūnī was a devout Muslim yet there is no conclusive evidence of him adhering to any particular madhhab throughout his life.[10] His native language was the Khwārizmian dialect. He knew

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of India as Told by its Own Historians, (London, 1869), vol. II, p.1.

[6]For example, see S.H. Barani, op. cit.,p.34; Al-Āthār al-Bāqiyah, p.LIII; and Ibn bi Usaibi'ah, ʿUyūn al-Anbā' fi Tabaqāt al-atibbā', (Beirut, 1957), pp. 29-30.

[7]See F.A. Shamsi, "Abū Al-Raihān Muhammad Ibn Aḥmād Al-Bayrūni 362/973- CA. 443/1051", Al-Bīrūnī Commemorative Vol., pp.263- 265.

[8]See S. Harmaneh, "Evaluation of Al-Bīrūnī's Book On Precious Stones And Minerals (al-Jamāhir fi maʿrīfat al-Jawāhir)", Hamdard Medicus, xxxi (2)(1988); p. 12.

[9]Rizvi's argument that al-Bīrūnī died on the night of 3 Rajab 441H (30 November, 1049 A.D.) is not likely because al-Bīrūnī completed his Kitāb al-Saydanah in 442 H. See S.S.H. Rizvi, "A Newly Discovered Book of Al-Bīrūnī: 'Ghurrat-uz Zijāt', and al-Bīrūnī's Measurements of Earth's Dimensions", Al-Bīrūnī Comm. Vol., p. 610. cf. F.A. Shamsi, "Abū al-Raihan Muḥammad ibn Aḥmad al-Bayrūnī", op. cit., pp.273-274. The other date of his death which is on Friday, 2nd Rajab 440 A.H. (11 th Sept. 1048 A.D.) is likewise not acceptable because of his Kitāb al-Saydanah which was completed when he was nearly eighty years old. See S.H. Barani, "Al-Bīrūnī's Scientific Achievements", Indo-Iranica, (5&4)(1952/1953): p. 39. See also al-Bīrūnī, Kitāb al-Saydanah fi al-tibb, (transl. and ed. by H.M. Said et al), (Pakistan, 1973), p. 9.

[10]See, for example, E.S. Kennedy, "Al-Bīrūnī, Abū Rayhān Muḥammad ibn Aḥmad" in G.C. Gillispie, ed. Dictionary of Scientific Biography, Vol. II, p.156; that he was a Sunni in S.H. Barani, "Ibn Sīna and Al-Bērūnī" Avicenna Commemoration Volume, Iran Society, (Calcutta,1956), p.7; that he was attracted to Shi'i in his early years but adopted a Sunni tendency towards the end in S.H. Nasr. An Introduction to Islamic Cosmological Doctrine, op. cit., p.114 and that he was a Zaidite but later became a 'tafḍīlī' Sunni in H. Said

Persian but preferred Arabic, because to him the latter is more suitable for academic pursuit. Most of his numerous books and compendia were written in Arabic.[11] He received some of his early education under the tutelage of the astro-mathematician Abū Naṣr Manṣūr b. ʿAlī b. ʿIrāq al-Jīlānī (d. ca. 427 H)[12] and ʿAbd. al-Ṣamad b. ʿAbdal Ṣamad from Khwārizm[13]. This is in addition to his formal elementary religious education at the madrasah.[14] When he was twenty years old, the prince of Jurjāniyah displaced the ruler of Khwārizm, Abū ʿAbd Allāh Muḥammad ʿAlī-ʿIrāq al-Shahid. Al-Bīrūnī probably fled to Rayy, one of the centers of astronomy.[15]

Al-Bīrūnī's first patron was the Sāmānid Sulṭān Abū Ṣalih Manṣūr II who reigned in Bukhara until the city was invaded by the

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& A. Zahid. Al-Bīrūnī: His Times, Life and Works, (Hamdard, 1981), p.198.

[11]See Hakim Mohammed Said (ed.), Al-Bīrūnī's Book on Pharmacy and Materia Medica, v.1, pp.5-16, v.2, pp.17-57.

[12]For an insight into one of Abū Naṣr's works, see Claus Jensen, "Abū Naṣr Mansūr's Approach to Spherical Astronomy as Developed in His Treatise 'The Table of Minutes'", Centaurus, (16) (1971) pp.1-19.

[13]See, for example, G. Sarton, Introduction to the History of Science, vol.1, Robert Kreger (ed.), (New York, 1975), pp. 693-709.

[14]Education and instruction in 'awa'il' sciences such as astronomy, geography and geometry were usually given by individual scholars. See Aydin Sayili, The Observatory in Islam, (Ankara, 1960) pp. 416-417. Until the end of the Umayyad Caliphate, subjects taught as part of a normal curriculum include Quranology, Tradition, Arabic language, poetry and mathematics. For a further discussion on education during this period, see M. Abdul Mu'id Khan, "The Muslim Theories of Education During The Middle Ages", The Islamic Quarterly, (3/3)(1956), pp.420-428.

[15]See H. Said and A.Zahid, Al-Bērūnī- His Life, Times and Works, op. cit., p. 65. Other centers of astronomy were Baghdad and Khwarizm.

Ghaznavid Sulṭān Maḥmūd in 389/999 A.D. Later al-Bīrūnī went to Jurjan to the court of Abū'l Ḥassan Qābūs b. Washmjīr Shams al-Ma'ālī (reigned 998-1012), under whose patronage he wrote al-Āthār al-Bāqiyah 'an al-Qurūn al-Khāliyah which was completed in 390/1000 A.D.[16] Al-Bīrūnī found the Sulṭān indiscriminate and harsh. His next sojourn was in Khwārizm and Jūrjāniyah, in the service of the Sāmānid Prince Abū'l 'Abbās al-Ma'mūn b. Muḥammad II. Under his patronage, al-Bīrūnī received great respect. It was during this period that al-Bīrūnī met the physician Abū Ṣahl 'Isā b. Yaḥayā al-Jūrjāni. His Taḥdīd Nihāyah al-Amākin Li Taṣḥiḥ Masāfah al-Masākin was completed in 1025 A.D.

His Kitāb fī taḥqīq mā li'l-Hind..., was finally published in 421/1030 A.D. The Ghaznavid Sulṭān Maḥmūd invaded and conquered the city in 407/1017. Al-Bīrūnī's other book, Kitāb al-Tafhīm li-awā'il sinā'at al-tanjīm which was dedicated to Rayḥānah, daughter of al-Ḥassan, was written in Ghaznah, 1029 A.D. Al-Bīrūnī's magnum opus, al-Qānūn al-Mas'ūdī fī al-Hay'ah Wa'l-Tanjīm, an astronomical encyclopedia comprising eleven treatises divided into 143 chapters was completed at a later date, in 427/1035 A.D., and was dedicated to the son of Maḥmūd, Mas'ūd. Apart from emphasizing the importance of astronomy, he gives accurate latitudes and longitudes and also geodetic measurements.[17] His Kitāb al-Jamāhir fī Ma'rifat al-

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[16]See the preface in Sacchau, (transl.) Vestiges of the Past (Chronology of Ancient Nations, (Leipzig, 1879), hereafter cited as Chronology.

[17]See for example E.S. Kennedy et al., "The Hindu Calendar as described in al-Bīrūnī's Mas'udic Canon", Journal of Near Eastern Studies, 4:1965, pp.274-84.

Jawāhir was completed less than a decade later (about 435/1043) and was dedicated to the Ghaznavid Prince Sulṭān Shihāb al-Dīn Abu'l Fatḥ Mawdūd b. Masʿūd, Sulṭān Maḥmūd's grandson.[18] His Kitāb al-Saydanah was written towards the very end of his life.[19]

Al-Bīrūnī lived during a period of intense scientific activity. Among his contemporaries were al-Haytham (965-1039 A.D.) and Abū ʿAlī al-Husayn bin ʿAbd Allāh Ibn Sīnā (370/980 A.D.-428/1027 A.D). Others include Abū Naṣr Manṣūr Ibn ʿAlī Ibn ʿIrāq who was one of al-Bīrūnī's patrons; Abū al-Ḥassan ʿAlī Ibn Saʿīd ʿAbd al-Raḥmān ibn Aḥmad ibn Yunus who was an astronomer of distinction (d. 1009 A.D) and last but not least, Abū Ṣahl ʿIsā Ibn Yaḥyā al-Masīhi al-Jūrjānī (d. 1000 A.D.) who was a close associate of al-Bīrūnī and wrote twelve books under his name.[20]

Al-Bīrūnī was a philosopher-scientist, but in him 'science prevailed over philosophy'[21] and he appeared not to have identified himself with any school of philosophy. It was reported that he started doing astronomical observation as early as 18 years old.[22]

Before delving into his philosophy of mathematics, particularly

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[18]See M. Nazim, Sulṭān Maḥmūd Ghaznawi, (Cambridge, 1931) and F.C. Auluck, (ed.), Al-Bīrūnī, (New Delhi, 1971), pp.1-16.

[19]See Hakim M. Said (ed.), Al-Bīrūnī's Book on Pharmacy and Materia Medica, (Karachi, 1973) and the Introduction in vol. II.

[20]See H. Said, A.Zahid, Al-Bīrūnī: His Times, Life and Works, op. cit., pp.98-114.

[21]See S.H.Nasr, Three Muslim Sages, (New York, 1976), p.10. cf. S.H. Barani, "Ibn Sīnā and AlBērūnī; A Study in Similarities and Contrasts" in Avicenna Commemoration Volume, op cit., p.6.

[22]See S.H. Barani, "Ibn Sīnā and al-Bērūnī: A Study in Similarities and Contrasts", ibid., p.3.

his theory of the mathematization of nature, it is imperative to first outline his conception of nature which is, by and large, an offshoot of his philosophy of nature as established by Professor Nasr.[23] Also we may add that in the absence of any philosophical work by al-Bīrūnī singularly devoted either to his philosophy of mathematics or his conception of nature related to it, we need to extract the elements of his philosophy of mathematics and his conception of nature from his various writings on astronomy, history, geography, astrology, geology, history and minerals.

In addition to his Kitāb al-Tafhīm and his Kitāb fī ifrād al-Maqāl fī amr al-ẓilāl, we can also find notable remarks which reflect his conception of nature in his other works. As an example, the introduction to his Kitāb Al-Jamāhir Fī Maʿrifah Al-Jawāhir consists of fifteen tarwīḥah which gives his view on the attitude of man towards nature. It is more than a book on pearls and precious stones.

In Kitāb fī taḥqīq mā li'l-Hind..., or simply the 'India', the book which ʿAbd al-Mu'min ibn ʿAlī Nuh al-Ṭiflisi encouraged him to write,[24] al-Bīrūnī gives his own view on Indian doctrines after describing them. Besides, al-Bīrūnī offers some comments on the teaching expounded by Ḥusayn b. Manṣūr al-Hallāj in his Kitāb al-

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[23]See the Chapter entitled 'al-Bīrūnī' in S.H.Nasr, An Introduction to Islamic Cosmological Doctrine, (Cambridge, 1964).

[24]See India, vol. 1, pp. 5-7

āthār al-Bāqiyah 'an al-Qurūn al-Khāliyah.[25] In what follows, we will examine his conception of nature, his view of scientific problems and the manner they are related to religion.

1.2. Conception of Nature

According to al-Biruni, nature is created by God from 'nothing' (creatio ex-nihilo). Nature is not eternal. If it is eternal, he argues, then it is problematic to believe that nature is created by God because the quality of being new (ḥadīth) necessarily implied the createdness of nature. To reject nature as having a beginning in time would falsify the idea of nature as a creation.[26]

Concerning his views on the relationship between man and nature, it is of interest to note that in his introduction to Taḥdīd Nihāyat al-Amākin, al-Bīrūnī explicitly refers to the Quranic verse:

> "And contemplate the wonders of the creation in the Heavens and the Earth", "Our Lord: Not for naught hast Thou created (all) this" (Sūrah 3:191)

Moreover, al-Bīrūnī contends that "This noble verse contains the totality of what I have explained....".[27] In other words, this

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[25]See E.C. Sachau, ed. Kitāb al āthār al-bāqiyah'an al-qurūn al-Khāliyah, trans. The Chronology of Ancient Nations, op. cit., pp. 194-195. Hereafter referred to as The Chronology.

[26]See al-Bīrūnī, The Determination of the Coordinates of Cities, trans. by J. Ali, (Beirut, 1967), pp. 14-15. cf. S.H. Nasr. An Introduction to Islamic Cosmological Doctrine (Cambridge, 1964), pp.116-118. See also A.Z. Validi Togan, "Bīrūnī's Picture of the World", op. cit., pp. 53-54. On al-Bīrūnī's belief that time is not eternal, see his Chronology, p. 116.

[27]See J. Ali, trans. The determination of the coordinates of position ....(Beirut, 1967) p.3. Al-Bīrūnī completed writing this book (Taḥdīd Nihāyat al-Amākin Li Tashīh Masāfah al-Masākin) on 27th Rajab 416 A.H. (1025 A.D.) at Ghaznah, when he was at the peak

particular ayāt, out of all the other Qurānic verses, is of paramount importance to his scholarly life. The task now is to investigate al-Bīrūnī's understanding of this ayāt, by studying his works and scholarly life in order to unfold his view of nature.

The Quranic verse quoted by al-Bīrūnī points to the affinity between nature and man besides between religion and science. According to al-Bīrūnī, man is God's vicegerent (Khalīfat Allāh) on earth who is better than animals because man possess ʿaql.[28] In other words, man is blessed with the innate capability to contemplate.

Man can contemplate nature because man occupies a particular place in this world. He is at the center of the Universe, the vicegerent of God. He is but the guardian of nature because man is a reflection of God, a theomorphic image, whose purpose of existence in this world is to become an 'integrated, complete man' (al-insān al-kāmil). As a matter of fact, philosophy to al-Bīrūnī can be defined as "the striving to become as much as possible similar to God."[29] And al-insān al-kāmil reflects all the Divine

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of his scholarly life. I believe that his comment on the Quranic verse strongly indicates the main source of his motivation in his quest for knowledge.

[28]See al-Bīrūnī, Kitāb al-Jamāhir Fī Maʿrifah Al-Jawāhir, op. cit., p.4.

[29]See India, Vol. I, pp. 29-30. cf. S.H. Nasr, An Introduction to Islamic Cosmological Doctrine, op. cit., p.114.

Names and Qualities,[30] the highest station a man can be, after the fall from the Edenic state (al-insān al-qadīm).

Al-Bīrūnī's act of starting his research in Tahdīd by quoting the Quranic verse shows the importance of 'contemplation' to him. Contemplation in Islam from the Quranic point of view is a kind of 'knowledge that relates the knower to higher modes of being'[31]. The Muslim who contemplates reminds himself of his origin and when he reaches the station of 'iḥsān', he acts for the sake of God 'without acting' for eventhough he does not see God, he is convinced that God 'sees' him. He is always conscious of the existence of his Creator, irrespective of time and place. He is convinced that every single aspect of his life, in the final analysis, is motivated and moved by God,[32] (Al-Anfal: 17).

The act of contemplation is interwined with action, (ʿamal). Contemplation should precede action because only 'truthful' contemplation can produce knowledge (maʿrifah), which is the mother of righteous action. In this light, there is definitely a close affinity between contemplative knowledge and action. Says al-

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[30]See for example, the discussion in T. Burckhardt, An Introduction to Sufi Doctrine (translated by D.M. Matheson), (Lahore, 1959).

[31]For an excellent discussion on this topic, the reader can consult S.H. Nasr, Islam and the Plight of Modern Man, (Kuala Lumpur, 1975), pp.68-77.

[32]The cosmos is created by God through His contemplation. It is the fruit of God's contemplation of Himself. The Universe is created in order for God to contemplate His own Beauty. God says in a Hadith Qudsiy: "I was a Hidden Treasure, and I desired to be known, so I created Creation that I might be known". For further discussion on this issue, see S.H. Nasr, Science and Civilisation in Islam, (Selangor, 1984), Chapt.13.

Bīrūnī:

> One's deed depend on one's intentions. God does not allow such actions as have altruistic motives to go to waste. He knows what is in our hearts and compensates us accordingly.[33]

Meditating on nature involves contemplating the intricacies of nature and their divine prototypes. It means making nature an object to study, in such a manner that nature becomes a witness (shahādah) of the Divine Presence. When al-Bīrūnī quotes the Quranic verse concerning 'contemplating nature', the 'contemplated nature' is objectivised. Nature is considered as an 'object' to be studied, in order to achieve a unitive knowledge that can aid man to act upon nature, himself notwithstanding, and to climb the ladder of perfection by using his ʿaql. (The term ʿaql imply etymologically to something which restrict the Absolute towards creation and which ties man to the Truth, to God himself.ʿAql is the nous, ratio (reason), and intellectus).[34] It is ʿaql that helps man to be on the straight path (ṣirāṭ al-mustaqīm)[35] in seeking knowledge. A unitive knowledge thus gained "integrates man with his own prototype as well as the prototype of Nature...".[36]

The element of transcendence is evident in al-Bīrūnī's outlook

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[33]See al-Bīrūnī, Kitāb al-Ṣaydanah, (transl.& ed. by H.Said et. al), Kitāb al-Ṣaydanah fī al-Ṭibb, (Karachi, 1973), p.10

[34]Some scholars, like Rumi, differentiate between purely human reason (ʿaql-i-juzʾī) and intellect (ʿaql-i-kullī). See S.H. Nasr, Living Sufism, op. cit., p.43.

[35]ibid., p. 42

[36] S.H. Nasr, Islam and the Plight of Modern Man. (Kuala Lumpur, 1975), p. 75.

of nature. One of the major postulates subscribed to by al-Bīrūnī is that God creates nature; that al-Bīrūnī envisages from the very beginning the affinity between natural phenomena and their metaphysical cause. God creates nature through the Quranic injunction of 'kun fayakūn' (al-Baqarah: 117,163). Nature and its phenomena is nothing but the manifestation of God's initial creative act that is verbal. But God creative act is also continuous. God always intervenes. It is a far cry from the Cartesian world view where God stops to intervene after the initial act of creation.

The concept of transcendence nowhere is better expressed than by the Quran. The Quran mentions at least ninety-nine names for God expressing His sovereignty over the World and His Providence.

God's continuous act of creation, however, does not mean that there is no 'glimpse of permanence' in nature. The terrestrial environment has not 'change' in its general features. The moon still sets and rises the same way as it did since time immemorial. The men of today are physiologically the same as the men of old. The natural forms still reproduce themselves with the same pattern. The repitition of the qualitative changing process of nature brought forth the appearance of eternity. Moreover, the repitition of particular problems in the history and philosophy of science attest to this element of permanency in nature. For example, the relation of One to Many, the Mind/Body problem, the problem of continuity and discontinuity of bodies were discussed during the time of Aristotle and even in the time of al-Bīrūnī.

The encounter of man's mind with nature, more often than not, always focussed on these problems. When men study and contemplate the seemingly permanent features of nature, man can explain and predict. There are universal laws of nature for man to understand for his own well-being. Says al-Bīrūnī:

> I say further that man's instinct for knowledge has constantly urged him to probe the secrets of the unknown, and to explore in advance what his future conditions maybe, so that he can take the necessary precautions to ward off with fortitude the dangers and mishaps that may beset him.[37]

The laws of nature (sunnat Allāh) which in reality are "the laws of God" having different "degree of fundamentality and universality"[38] and which to al-Bīrūnī warrants examination, is possible because of the appearance of permanency in it.

The affinity between nature, the created, and God who is the Creator, points also to the element of sacredness of nature. Accordingly to al-Bīrūnī, the study of nature through contemplation and action ought to be done within the parameters of religion, which to him is Islam because ultimately, "Knowledge is acquired by the grace of God and the determination of man to know by means of the stars and other creations".[39] Knowledge thus produced is "knowledge by participation", to reiterate Paul Tillich's term,

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[37]See Taḥdīd Nihāyat al-Amākin, op. cit., p.5

[38]See O. Bakar, Tawḥīd And Science, op. cit., pp.64-65.

[39]See Taḥdīd Nihāyat al-Amākin, op. cit., p.9.

which is the knowledge of union and salvation.[40] It is not a reductive knowledge that delimits or restricts the object studied. It allows the object of study to expand with no attempt to constraint, so much so that one can know God from the power of the moment. In other words, it is gnosis,[41]or to use Roszak's terminology, "augmentative knowledge".

Therefore there is an esoteric utility to religion in studying nature and al-Bīrūnī believes in this aspect. In Islam, the best Muslim is he who is the most conscious of God (taqwā). All of his activities, therefore, should improve this inner consciousness. Al-Bīrūnī maintains that the same is true in studying nature. Nature should not be studied for the sole purpose of earning a livelihood at the expense of the Hereafter. Thus, in his Kitāb Taḥdīd Nihāyah al-Amākin,, al-Bīrūnī writes:

> We look around and we see that man's efforts are directed only towards earning a living, and for this purpose he endures hardships and fears, though he needs his food only once or twice a day for his life in this world. But he pretends ignorance and neglects what he must not fail to do for his soul in the hereafter, five times in every day and night thinking that his ignorance is a valid excuse, though he has the opportunity and the power to know it (what is good for his

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[40]For a critique on Tillich's view, see I.R. Faruqi, Divine Transcendence And Its Expression, (Kuala Lumpur, 1983), ff. pp.20-23.

[41]For a discussion on the spectrum of gnosis, the reader can consult Roszak, T. "The Monster and the Titan: Science, Knowledge and Gnosis" in E.D. Klemke, R. Hollinger, A.D. Kline. Introductory Readings in the Philosophy of Science, (New York, 1980), pp. 309-317. For the claim that al-Biruni himself was not a gnostic in the traditional sense, see S.H. Nasr, An Introduction to Islamic Cosmological Doctrine, op.cit, p.173.

soul)."[42]

According to al-Bīrūnī, the contemplation on nature involves taking into account the significance of one's place in the Hereafter; that in studying the seen, one should **always** be mindful of the unseen. Believing in the existence of 'al-ākhirah' is one of the pillars of the Islamic faith,[43] without which a person cannot claim that he is a Muslim. It is in the 'ākhirah' that all the worldly activities of a Muslim, which are recorded by the malā'ikat (Raqīb and 'Atīd),[44] are judged by God. It is after the Day of Judgement that Muslims are finally consigned to Heaven or Hell.[45]

In addition to the esoteric utility of studying nature, al-Bīrūnī emphasizes the exoteric aspect too. Again, in Kitāb Taḥdīd Nihāyat al-Amākin al-Biruni continues:

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[42]See al-Bīrūnī The Determination of the Coordinates of Positions for the Correction of Distances between Cities, translated by J. Ali (Beirut, 1967) p.3 and p.175.

[43]The other cardinal Articles of Faith in Sunni Islam are; believing in the oneness of God, the angels, the Books, the Prophets, and the Power of doing Good or Evil.

[44]In the field of angelology, Muslims believe that angels are spiritual creatures of God, neither males nor females, having neither parents nor wives nor progeny, having no specific material bodies and are made of light. Some of the most important angels are the Archangel Gabriel who is the Universal Intellect, Mika'il, Israfil and Izra'il. It was Gabriel who communicated the revelations of God to His Prophets.

[45]Concerning the Day of Resurection, Muslims believe that God will reward those who have led a righteous life and pleased Him by sending them to Heaven. Those who have incurred His displeasure by commiting sins and unworthy actions will be in Hell. Those who have firm belief in the Oneness of God and in His Prophets but die without atoning for and repenting their sins will reside in Hell temporarily until by the Mercy of God, they will be liberated and sent to Heaven.

> The Jews also need a direction, because they turn in their prayers to the Temple in Jerusalem which is of known longitude and latitude... The Christian need the (direction of) true East because their elders, whom they address as fathers, prescribed to them that they should turn to Paradise in their prayers...[46]

Prayer (ṣalāt) is one of the fundamental principles of Islam.[47] It is well-known that Muslims offer their prayers facing the Qiblah. The problem for Muslims all over the world is to ensure that they are facing the 'right' direction in their prayer. This is an example of what we consider as the exoteric aspect which al-Bīrūnī attempted to solve.

Another example is determining the time for prayer. Al-Bīrūnī devoted a whole chapter in his Ifrād al-Maqāl (The Exhaustive Treatise On Shadows) to address this problem.[48] Thus to al-Bīrūnī, studying nature should not be for the sake of studying nature; there must be a greater purpose sanctioned by religion and in this case it is to solve the problem faced by Muslims in offering their prayer.[49]

But is it true that al-Bīrūnī does not include striving for truth as one of the noble aims of studying nature? On the contrary, al-Bīrūnī places truth as one of the noble aims of contemplating

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[46]Op. cit.

[47]The other fundamental principles of Islam are the declaration of faith, zakāt, the observation of fasts in the month of Ramaḍān and pilgrimage to Mecca.

[48]It is interesting to note his sensitivity and understanding about the various madhab in providing the solutions. See al-Bīrūnī, Ifrād al Maqāl, op. cit., pp.160-180, 181-203.

[49]See al-Bīrūnī's Taḥdīd Nihāyat al-Amākin, op. cit., p.10-11.

nature because elsewhere he says:

> I must assay all aspects of this statement, because I do not refuse to accept the truth from **any** source, wherever I can find it.[50]

The Truth (al-Ḥaqq) is one of the at least ninety nine Names of God. What is more noble than a quest for one of the attributes of God since man is a theomorphic image of God? Studying nature to al-Bīrūnī is akin to an investigation to find out the truth. There is a sort of realism in al-Bīrūnī's notion of truth. The external world can provide truth. Thus al-Bīrūnī maintains:

> There is a great difference between an investigator of truth [who studies nature] and a follower of tradition. God says: "Are those equal, those who know and those who do not know ?"[51] [parenthesis mine]

1.3 Scientific Problems as 'Religious' Problems

First and foremost, al-Bīrūnī never uses the word 'science' in the sense that the word is understood today; that knowledge which is 'exact', objective, veritable, deductive and systematic. The closest term that he ever used is the Arabic word ' ʿilm', which also means knowledge. Al-ʿilm in the language of the Qurʾān and Sunnah (traditions of the Prophet) implies knowledge which makes man conscious of God, of His attributes, of the eternals, of the

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[50] ibid., p.79. All quotations underlined is by the author.

[51] See al-Bīrūnī, The determinations of the coordinates, op. cit., p.3.

next world and of the return to Him and Him alone.[52]

Science, to al-Bīrūnī, is a problem solving activity. As trivial as it may sound, we will argue in this section that such is the position of this industrious and dynamic scholar to science. Scientists seek solutions to scientific problems. Solving scientific problems, which to al-Biruni is analogous to "untying knots,"[53] are the main activities of scientists. But what is a scientific problem to al-Bīrūnī? A scientific problem to him is a problem circumscribed by the Holy Qur'ān and Sunnah which is enjoined by God. It is a problem that arises and needs to be solved in order for a Muslim to improve his **'taqwā'**. It is also a problem posed by an Islamic society, arising out of their efforts to practice Islam as correct, and accurate, as possible, in order to please God. A scientific problem, to al-Bīrūnī is not just any problem under the sun.[54] The orientation of the problem[55] determines its 'scientificity'.

A scientist, to al-Bīrūnī, does not solve a scientific problem

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[52]See S.H. Nasr. Living Sufism, op.cit., p.42.

[53]See al-Bīrūnī, The Exhaustive Treatise On Shadows, op. cit., p.2.

[54]It is important to note here that the claim is not that all problems are scientific problems although all problems in a sense, are religious problems. For instance, it is already established that some problems of astrology, for example, are not considered as scientific problems by al-Bīrūnī although these problems are religious problems. Rather the claim is that problems which al-Bīrūnī considered as scientific are also problems sanctioned by religion.

[55]By orientation of a problem, we mean the origin of the problem, method(s) used to solve it and its worthiness.

simply for the sake of solving problem. He does not solve a problem because the problem ought to be solved since it is technologically possible to do so.[56] His motive of solving problems is dominated by his consciousness of seeking God's pleasure, "that which yields Him satisfaction".[57]

That science to al-Bīrūnī is a problem solving activity and a scientific problem is a problem circumscribed by the Holy Qurʾān and Sunnah can be discerned by examining, in particular, the Introductions of his major books. We can see in these cases that his concept of religion is fundamental in shaping his attitude towards science as a problem solving activity. His India, for example, was written "as a help to those who want to discuss religious questions with them, as a repertory of information to those who want to associate with them".[58] One of the honourable tasks of a Muslim is to show the non-Muslim the 'right religion' and definitely this involves exchange of ideas between them. To this end, Muslims should know about Hindus as they actually are. It would not be helpful for Muslims to communicate based on

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[56]Critics of modern science such as Erich Fromm and Orwell argue that one of the major maxims of modern science is that "something ought to be done because it is technologically possible to do so. If it is possible to to build nuclear weapons, they must be built even if they might destroy us all....Once the principle is accepted that something ought to be done because it is technically possible to do so, all other values are dethroned, and technological development becomes the foundation of ethics." See E.D. Klemke, R. Hollinger, A.D. Kline (eds.) Readings in the Philosophy of Science, (New York, 1980), p.298.

[57]See India, Vol.II, p. 246. See also The Exhaustive Treatise On Shadows, op. cit., p.2.

[58]See India, p.9

superficial information. Thus al-Bīrūnī maintains "My book (India) is nothing but a simple historic record of facts. I shall place before the reader the theories of the Hindus as they are".[59] Elsewhere he adds:

> We have given here an account of these things in order that the reader may learn by the comparative treatment of the subject how much superior the institutions of Islam are, and how much more plainly this contrast brings out all customs and usages, differing from those of Islam, in essential fullness.[60]

From another perspective, India was written by al-Bīrūnī primarily because in his opinion, "while Muslims had been able to produce fairly objective works on such religions as Judaism and Christianity, they had been unable to do so with regard to Hinduism".[61] It is for the benefit of Muslims, to solve their ignorance about the Hindus, that the research was undertaken.

The Chronology, which was completed earlier and was dedicated to Shams-al-ma'ālī Qābūs,[62] who "furthers religion and truth, who fights for the altar and the hearth [sic] of the Muslims, and who protects their country against the mischief of the evil doers" as a comprehensive explanation regarding "different eras used by different nations,... causes which led to such difference, and the famous festivals and commemoration days for

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[59]See ibid., p.9.

[60]See ibid., vol. 1, p.10

[61]See Fazlur Rahman, Islam, (New York: Anchor Books, 1968) p.xix.

[62]See Chronology, p.3

certain times and events,[including on the festivals of the Muslims] and regarding whatever else one nation practises differently from another".[63] (parenthesis mine). In other words, al-Bīrūnī's Chronology can further the Sulṭān's understanding of his subjects, for the best interest of Islam.

The Chronology, however, was not written only for the consumption of the Sulṭān. In fact we maintain that the book was written by al-Bīrūnī to propagate Islam among the literate, so that they could compare between Islamic and nonIslamic festivals. To this end, he concludes the book with the Quranic verse (8:44): "Let those who want to perish (as infidels, idolaters) perish, after a clear proof (of the true religion) has been presented to them, and on the strength of it, and let those who want to live (the life of the true religion) live, after a clear proof (of the true religion) has been presented to them, and on the strength of it".

In his other work, Taḥdīd Nihāyah al-Amākin, he clearly states another aspect of a scientific problem. Says al-Bīrūnī, "...geography is very essential for a Muslim for knowing the right direction of qiblah. Allah has also asked us to travel on the earth and see the fate of ancient people".[64] Hence to al-Bīrūnī, finding the direction of the qiblah is an example of a scientific problem which is circumscribed by the Qurʾān and Sunnah.

The interesting thing is that the evaluation of the problems tackled, besides in the Taḥdīd, is not given post hoc or ad hoc.

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[63]See ibid., p.2

[64]See Taḥdīd, op. cit., p.10

It is not the case that al-Bīrūnī solved scientific problems before thinking of its necessity, its worthiness for the ummah, viz., its legitimacy[65] from the Quranic and Sunnah point of view. Concerning geography and astronomy, he states: "...For whoever determines the longitude and latitude of his country with precision will thereby enabled him to find out...the end of evening twilight and of dawn, times which are needed... for fasting".[66] Realising the comprehensiveness of Islam as a complete way of life, he adds;"..the usefulness here exceeds specific religious matters and extends to worldly affairs...is also beneficial in finding the correct direction towards one's destination".[67] Clearly, to al-Bīrūnī, there is a 'sacred' orientation in scientific problems. Scientists qua scientists should solve problems in a manner which bring them closer to God, that can "yield His satisfaction (riḍā)".[68]

In yet another one of his book, The Exhaustive Treatise On

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[65]An example of a problem not circumscribed by the Quran and thus, in my view, not legitimate, is a problem mentioned by Prof. Naguib al-Attas although in so far as I know, he never argues that science is an activity of solving problems. The problem is how to offer ṣalāt at the moon. See his discussions conncerning the nature of questions in Utusan Melayu, (Hari Pelancaran ISTAC). If indeed people were obliged to offer ṣalāt at the moon, than the direction of Qiblah needs to be ascertained. Another problem that I have in mind is on the 'essence' of God. This, from al-Bīrūnī's position, is never a scientific problem. Still another problem is a problem which arised from the assumption that man can escape death.

[66]See Taḥdīd, pp. 323-324. See also A. Sayili, The Observatory in Islam, (Ankara, 1960) pp. 22-23

[67]See Taḥdīd, pp. 323-324.

[68]See al-Bīrūnī's supplication in India, Vol.II., p.246. See also S.H. Nasr, An Introduction..., op. cit., p.174.

Shadows, we can see very clearly the orientation of scientific problems expounded by al-Bīrūnī. In studying shadows, not only did he analyse shadows of this world but also shadows in the Hereafter! He investigates in detail their differences, similarities and nature of existence. He differentiates between shadows in Heaven from shadows in Hell. Concerning the latter, he states:

> However, as for the people worthy of punishment, the shadow they know (in hell) is characterised as smoke (yahmūm) because the utility of shadow is relief from distress of heat and the simum (a hot wind), and if it were other than cool and not present it would increase the painful torment, like the distress present at the strata of the sky which (takes) the breadth (or souls) away and which [chokes].[69]

Thus al-Bīrūnī shows that there is a "revealed perspective" on scientific problems which the scientist should take into account. The scientist should always be mindful of the connection that the problems have to this world and to the Hereafter.

Moreover, from the perspective of the Qur'ān and Sunnah, nature and history (the days of God (ayyām Allāh)), can enlighten man in knowing more about himself and his Creator. Says the Holy Prophet: "He who knoweth his Self knowest his Lord". The Holy Qur'ān views the alternation of night and day, the lengthening of shadows, the variation in human colour and language, the vicissitudes of nations, as signs of God that warrant examination in our quest of knowing Him,[70] so that we will not be "blind to the realities of

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[69]See The Exhaustive Treatise On Shadows, op. cit., pp. 20-21. Al-Bīrūnī also quotes the Holy Qur'ān (7:41).

[70]al-Qur'ān, 25:46, 10:6, 3:131

the life to come".[71] The science of astronomy to al-Bīrūnī, for an example, has its origin from Prophet Idrīs.[72] These are examples of scientific problems enjoined solving in the Holy Qur'ān and Sunnah that from al-Bīrūnī's point of view, merit investigation.

1.4 Problem Solving as an Act of Contemplation.

There is an element of transcendence in seeking scientific solutions. Al-Bīrūnī, more often than not, is always conscious of God while solving problems. He strives to be among those who "...remember Allah, standing, sitting and reclining and consider the creation of the heavens and the earth, (and say): O Lord; Thou created not this in vain".[73] Examples are abundant in his writings where he invokes God's help. In India, he beseeches God so that He will "help him to a proper insight into the nature of that which is false and idle, that he may sift it so as to distinguish the chaff from the wheat". Elsewhere he writes:

> And I pray for God's favour and spacious bounty to make me fit for adopting the right course and help me in perceiving and realising the Truth (al Haqq) and facilitate its pursuit and enlighten its course (sabil) and remove all impediments in achieving noble objects.[74]

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[71] ibid., 17:72

[72] See al-Bīrūnī, The Exhaustive Treatise on Shadows, op. cit., Vol. I, p. 230.

[73] al-Qur'ān, 3:191. See also al-Bīrūnī's introduction in Tahdid.

[74] See Tahdīd, op. cit., p.45.

Generally speaking, within the schema of contemplation, al-Bīrūnī solves problems mathematically. He solves problems 'from the eyes of a mathematician' because al-Bīrūnī considers himself as a mathematician, more than anything else. Says al-Bīrūnī, ".... I belong to a branch of mathematics (riyāḍhī), and since my coming into this world, I have been holding it strongly and have been known by it and my intention never exceeded it..."[75]

There are two complementary aspects of his problem solving; one is the 'external' and the other is the 'internal'.[76] In this section, we will examine the 'external' aspect which involves more of the external senses as opposed to the 'internal' aspect. The 'internal' aspect which heavily involves the processes of mathematical abstraction by the internal senses is investigated in the next chapter.

In the previous section, we have argued that from al-Bīrūnī's point of view, the Holy Qur'ān enjoys a special place in a Muslim scientist's worldview; as a guidance and motivator for him. But the Holy Qur'ān is not a book that has all the nitty-gritty scientific answers sought by scientists. It has only the general principles.

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[75]See al-Bīrūnī's preface to al-Qānūn al-Mas'ūdī. See also Barani, Al-Bīrūnī and his Magnum Opus, al-Qānūn al-Mas'ūdī, p.230.

[76]By the word "external" here I mean the processes that are immediately observable. For example, solat which is the most fundamental act of contemplation likewise bears these two aspects. The 'external' part consists of the directly observable rituals such as taking ablution, standing, prostrating and so on. The 'internal' part which is equally important, is not so much observable. It concerns more the mental processes, interpolation of symbols, internalization of Divine Unity, His Revelations, and so forth.

Al-Bīrūnī states:

> Our World is not eternal, but it is possible to give its age or date of origin. All that is obvious is that events have succeeded within the unknown and unspecified periods of time. We have neither revelation nor records of history to help us in this matter. Even in the Quran the days of the Creation are meant to be thousand or fifty thousand years long.[77]

Man has to conduct research in order to find the answer. Man has to look for information, for evidences, in nature. This is an external aspect of his problem solving. Says al-Bīrūnī, "Human reason needs data and no human being can be an exception from the need of phenomena in which the mind functions".[78] Elsewhere he elaborates the notion of scientific research:

> We have to go upon the records of the rocks and vestiges of the past to infer that all these changes should have taken place in very very long times and under unknown conditions of cold and heat: for even now it takes long time for water and wind to do their work. And changes have been going on and observed and noticed within the historical times.[79]

Al-Bīrūnī's statement urging his readers to observe and collect data about the observables[80] shed some light on his approach to mathematical inquiry: that the process of mathematization, from the external aspect that is, should have

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[77]See Zeki Validi Togan, "Al-Bīrūnī's Picture of the World", op. cit., pp. 54-58.

[78]See Tahdīd, op. cit., p.3. cf. Commemmorative, p. 519

[79]ibid.

[80]I am using the word "observables" here in the traditional sense; atoms are not observables whereas grains of sand are.

empirical import. There are two parts related to his external aspect of his problem-solving (as an act of contemplation) that warrant elaboration here. First is al-Bīrūnī's view on the manner in which one arrives at a theory and second is his perspective on theory-choice.

1.4 (i) Manner of arriving at a theory

Al-Bīrūnī attaches great importance to intense observation and putting exhaustive effort in procuring, comparing, analysing and sythesizing data (which include both oral and written reports).

Al-Bīrūnī maintains that observation is particularly important in arriving at a theory. The external world is out there to be studied in order for us to internalise the greatness of God. Observation is essential to all scientific endeavours, including medicine. Says al-Bīrūnī: "[The medicine man] will not confuse one drug with another and through the frequency of observations he will gain in resource, both intellectual and intuitive".[81]

To begin with, one has to define his object of study. In the case of geology, he needs to focus his observation on 'the rocks and vestiges of the past' apart from referring to what has already been revealed about it in the 'supra rational' Holy Qurʾān, which is the most authoritative 'academic journal' of reference and instruction, so to speak. He should be able to discern the similarities and differences of his object of study. He should have

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[81]See al-Bīrūnī Kitāb al-Ṣaydanah, (transl. & ed. by H. Said), pp. 1-2.

the capacity to detect the changes that have occurred or are occuring within it and note the differences.

Observation involves seeing. Unlike Aristotle who believes that vision was made possible by emission of rays from the eyes, al-Bīrūnī believes that rays are emitted to the eyes by the object themselves. Images are then formed in the eyes.[82] According to al-Bīrūnī, there is no 'objective' observation. Seeing is an experience. It is not a physical state **simpliciter** . A retinal reaction is a photochemical excitation, a physical state. Scientists and not their eyes, see. A layman must learn some astronomy before he can see what the astronomer sees. The infant and the layman can see: they are not blind. The problem is that they cannot see what the astronomer sees, they are blind to what he sees, that is. There are definitely many ways in which a constellation of shapes may be seen. Why it is seen differently perhaps is a question of psychology, but **that** it may be seen differently is important in any examination on the concepts of observation.[83] Al-Bīrūnī admits the possibility of the observation made by his contemporary, the astronomer Abu Sa'īd of Sistan, even though al-Bīrūnī prefers the geocentric theory. Unlike al-Bīrūnī,

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[82]See S.H.Barani, "Al-Bērūnī's Scientific Achievements", op. cit., p.44.

[83]To say that all astronomers make the same observations but utilize them differently trivializes the issue. It is akin to the shallow epistemological doctrine that all normal observers see the same things in x, but interpret them differently. This approach does not explain controversy in research science. See also N.R. Hanson, "Observations", in D. Kline et al., Introductory Readings in the Philosophy of Science, (Prometheus Book, 1980) pp.152-63.

the latter is a proponent of the heliocentric theory. Al-Bīrūnī sees the sun rising but Abū Sa'id sees the horizons of the earth changing in the East at dawn. Regarding this matter al-Bīrūnī writes:

> I have seen the Astrolabe called Az-Zūraqī, invented by Abū Sa'id Sijzī. I liked it very much and praised him a great deal, as it is based on the idea entertained by some to the effect that the motion we see is due to the Earth's movement and not to that of the Sky. By my life, it is a problem difficult of solution and refutation...[84]

As a matter of fact, al-Bīrūnī underscores the importance of observation not only in studying geology but also in mineralogy.[85] One should have keen eyesight, more so than others. Without good eyesight, it would be difficult for them to observe the minute differences and similarities in metals and precious stones, what more at the age where magnifying glasses were not yet invented.

It is through sight that mathematicians can observe nature and contemplate. Unlike the modern positivists,[86] observation which is an integral part of al-Bīrūnī's problem solving is not only for the sake of accumulating information. Observation is done within the schema of contemplation. Just to cite an example, in al-Bīrūnī's

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[84]See Deh-Khudā, Life of Al-Bīrūnī, op. cit., p.12.

[85]See al-Bīrūnī, Kitāb al-Jamāhir fī Ma'rifah al-Jawāhir, p.5.

[86]The word "positivists" is used extensively in this century. The word is used here to denote all those groups which take the rationality of man, that is his ability to know by himself, to the extreme. They also shun metaphysics away from science, such as logical positivists who want to have science that is void of metaphysic and Popperians who relegate metaphysics into the domain of what they called "pseudo-science".

observation of shadows, he quotes the Quranic verse (77:31) and states that:

> "And if one meditates on the verse he will find two of the attributes of the shadow in the masculine form, and the third is attributed to fire in the feminine and if it were permissible to attribut the name shadow to fire from the linguistic point of view, it would be permissible that its portions are the three triangles, or the angles at their bases and the fishbone shape is called fiery".[87]

The place of man as khalīfat Allāh (God's vicegerent) on earth amounts to the necessity of connecting all human endeavour to God, the Omnipresence. Says al-Bīrūnī in one of the 'tarawīḥ' (singular 'tarwīḥah', a pause for devotional, contemplative and meditative prayer) in his Kitāb al-Jamāhir:

> Sight connects what we see to the signs of Divine wisdom in creatures (al ḥikmat fi al makhluqat) and demonstrates the existence of the Creator from his creation.[88]

In other words, according to al-Bīrūnī observations promote realization of God, it points to Divine Presence. The mathematician immerses himself in the higher station of reality by way of observation. Observation which is an important element in al-Bīrūnī's problem solving thus increases one's understanding of His transcendence.

The other sense which to al-Bīrūnī is equally important as sight in helping man to observe is his sense of hearing. Al-Bīrūnī

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[87]See al-Bīrūnī, The Exhaustive Treatise On Shadows, pp. 21-22. This passage is an example of tafsir as a methodology of Islamic Science. See also O. Bakar, Tawhīd And Science, op. cit., pp.29-31. All quotations underlined is by the author.

[88] See al-Bīrūnī, Kitāb al-Jamāhir, p.5. For a discussion on God's wisdom, see O. Bakar, Tawhīd And Science, ibid., pp.62-64.

believes that the main purpose of hearing is "to listen to the word of God"[89] in solving problems. It is an aid for the mathematician to understand the intelligibles. Writes al-Bīrūnī:

> Among sensations of men, God has put both hearing and sight aside, given to him as the two means by which he could raise himself from the sensible to the intelligible.[90]

Just as seeing is not 'objective', so is hearing.[91] Al-Bīrūnī is aware of the limitation of hearing. He is cautious of information that is heard but not seen. Hence his famous maxim "Hearsay does not equal eyewitness".[92]

So to al-Bīrūnī, sight and hearing are two of the most important sense perceptions for gathering data for mathematical inquiry in so far as observation is concerned. Both are integrated "in the heart, which is the seat of intelligence".[93] Data are procured both by means of the ears and the eyes. Evidence that are seen have more empirical import that those that are heard. Clearly from another perspective hearing surpasses seeing because even though we cannot see God, yet it is only through our ears we can hear His words.

Equally important as observation are reports. The mathematician

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[89]See al-Bīrūnī, Kitāb al-Jamāhir, p.5.

[90]Ibid.

[91]For instance, a child or a toymaker hear the ringing of Pavlov's bell as the sound coming from a toy but Pavlov hears it as a sound for conditioning. The point is that they cannot hear what the scientist hears, they are deaf to what he hears.

[92]See India, p.2.

[93]See S.H. Nasr, An Introduction to ...., op. cit., p.150

gathers his data from documented reports. Reports are written in several languages. Al-Bīrūnī's preference for Arabic is not without a strong reason. Through etymological examination of the names of things, the mathematician can be more informed about them. For an example is the word "falak" in his explanation about celestial motion. He writes:

> The celestial sphere is a body like a ball revolving in its own place; it contains within its interior objects whose movements are different from those of the sphere itself, and we are in the center of it. It is called falak on account of its circular movement, like that of a whirl of a spindle...[94]

It is interesting to note that in so far as history of science is concerned, al-Bīrūnī preferred written tradition compared to immediate observation. Says al-Bīrūnī:

> The object of eye-witness can only be actually momentary existence, whilst hearsay comprehends alike the present, the past and the future, so as to apply in a certain sense both to that which is not (that is, which either has ceased to exist or has not yet come into existence). Written tradition is one of the species of hearsay...we might also say the most preferable. How could we know the history of nations but for the everlasting monuments of the pen?[95]

Regarding written reports, al-Bīrūnī maintains that there are those who are satisfied with only superficial information,[96] not withstanding those who are blinded by national pride and parochiality and thus are unreliable because of their bias.[97] Still, there

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[94]See al-Bīrūnī, Elements of Astrology, p.43

[95]See al-Bīrūnī's preface in Chronology.

[96]See India, p.3

[97]See ibid., p.2

are also those who alter and embellish evidences out of an innate, psychological delight.[98]

The error occurring in reports, in a discipline where "the tradition regarding an event which in itself does not contradict either logical or physical laws"[99] can be corrected to a certain degree. Al-Bīrūnī maintains that examination of the reporters background and personality can remove some of the distortion because ultimately, the correctness of the reports depend "upon the character of the reporters..."[100]

Al-Bīrūnī recommended comparing reports. Usually this will reveal their confusion and mistakes.[101] As a matter of fact, al-Biruni laments his predecessors who did not scrutinize their data.[102]

Thus far, we have attempted to show that after focussing on the problem, al-Bīrūnī collects data and this is done by using most

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[98]Ibid., p.7.

[99]See al-Bīrūnī's preface in Chronology.

[100]Ibid.

[101]See al-Bīrūnī, Chronology, p.322. It is interesting to note that al-Bīrūnī's method of verifying reports is very similar to the particular method in 'ʿilm hadīth' known as al-Jarḥ wa al-Taʿdīl (scrutinizing and authenticating), which was laid down by scholars in the second and third Hijrah for accepting and screening the sayings (and interpretations) of the Holy Prophet (s.a.w.) by his successors, successors of the successors, and so on. According to this method, names and circumstances of the authorities were ascertained so as to examine when and where they lived, apart from investigating the manner they are scholarly related. For further discussion on this issue, see Encyclopaedia of Islam, (Leyden, 1921), Vol. II, pp. 190 ff.

[102]See The Exhaustive Treatise On Shadows, Vol. I, p.131.

importantly, his sense of sight and hearing. Data are then compared and analyzed or synthesized, mainly through experiment or verbal verification (questioning the transmitters) or both, depending upon the field of study. What we want to emphasize here is that in al-Bīrūnī's pattern of problem solving, the stage of theorizing comes only after one has exhausted all reasonable efforts in procuring data and in comparing the results of previous or contemporary researches. It is only after he is satisfied with the amount of information relevant to the problem that he goes "from the known to the unknown, from the near distant to the far"[103] to wit, the inductive and deductive process.

Examples are abundant throughout his works which demonstrate his exhaustive effort. In his study of astronomy, after procuring data, he examines solutions offered by others. His study entitled "A Number of Topics Dealing with Shadows" is a case in point. In it he discusses methods for computing the length of daylight at any time of the year used by Brahmagupta, Vijayanandin, and Yaʿqūb ibn Ṭariq besides three other methods of Babylonian and Persian origin.[104]

In the fourth chapter of Al-Qānūn Masūdī, he compared results obtained by Ptolemy and one Yaʿqūb al-Sehri and thereafter made the incisive remark: "Both the methods give results correct to the second order but Ptolemy understood what he did, whilst Yaʿqūb did

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[103]See al-Bīrūnī's preface in Chronology.

[104]See M. Lesley, "Bīrūnī On Rising Times And Daylight Lengths", Centaurus, (5/2) (1957), pp.121-141.

not know what he was doing".[105] In mineralogy, there were extensive etymological considerations in his analysis of minerals. He revised the findings of others. Likewise in his studies of medicine in his Kitāb al-Ṣaydanah.

In his analysis of societies such as in India and Chronology, in sub-topics where experiments could not be conducted, where most of the data is not in the form of direct observation but through oral and written reports, he examines witnesses to remove distortions in addition to comparing reports to ensure that they are as correct and accurate as possible.[106] His emphasis is on the comparative method. In his Chronology, he writes on most, if not all, of the festivals of various creeds and religions found in the regions of the Caliphate. In India he compares the belief and lifestyle of the Hindus with Buddhists, Manicheans and Zoroastrians, to what others wrote about them. Similarly in his study of the circumference of the earth, al-Bīrūnī examines the previous results obtained by astronomers under the patronage of Ma'mūn al-Rashīd (813-833 A.D.), the ʿAbbāsid Caliph.[107] He discovers that they ached different results. Dissatisfied, he conducts experiments in the area of Ghazz Turks and Jurjan.[108]

In light of the above examples, al-Bīrūnī's method of

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[105]See M.A. Kazim, "Al-Bīrūnī And Trigonometry" in Al-Bīrūnī Commemoration Volume, p.164.

[106]See Chronology, p.322.

[107]See Hakim Said, A. Zahid. Al-Bīrūnī- His Times, Life and Works, op. cit., pp.164-172

[108]Ibid.

arriving at a theory certainly involves intense analysis and synthesis, corresponding to the 'rigour' of a mathematician, before he integrates the particulars (the theories discovered) "into the Universal, all divided knowledge into the unitive knowledge, or **ma'rifah**, which contains in principle the science of all things".[109]

1.4 (ii) The Problem of Theory Choice.

In the external aspect of al-Bīrūnī's pattern of problem solving, the problem of theory choice occurs when there are several possible theories (as viable solutions) to a particular problem. In particular, the problem arises when al-Bīrūnī compares possible explanations in order to find a good one. We maintain that al-Bīrūnī does have some criteria which determine his choice and these criteria help him in formulating a good theory. What is more interesting is that these criteria reflect his mathematical acumen and his conception of God (as the 'perfect mathematician').

An important criterion to al-Bīrūnī is accuracy. That accuracy dictates the choice of one theory instead of another is partly because accuracy is less equivocal compared to other characteristics such as simplicity[110] or fruitfulness. Predictive and explana-

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[109]See S.H. Nasr, An Introduction to Islamic Cosmological Doctrine, op. cit., p.173

[110]The objection to simplicity as one of the criteria for theory choice is that there is no objective criterion of simplicity. There is no way to justify that the simpler theory is more likely to provide a truer picture of the world. The geocentric and heliocentric theories are cases in point. If the two theories were compared in terms of actual computational labour to predict a

tory powers of theories depend on their accuracies. Al-Bīrūnī, who was a polymathy, understood this very well. As a mathematician, he knew that accuracy is almost synonymous with exactness which certainly involves measurements. The finer the measurement, the higher the degrees of accuracy obtained. Ultimately, perfect accuracy belongs to God for He is al-Muḥṣi, the One who measures.[111] Al-Bīrūnī's treatment on measurements, on inventing measuring instruments such as the Yamīnī ring,[112] the ustuwānī which he used "to measure the height of heavenly bodies, their apogees, time, depth of wells or rivers and heights of walls, towers and hills..."[113] and his expertise with al-daḥi, sarqalah al-mā', Sirāj al-Khādim and naqshah,[114] and a particular machine that finds the exact prayer times which he constructed for the mosque in Ghaznah[115] points to the importance of accuracy to him. More important than that, the striving for accuracy on the part of

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position of a particular planet at a certain time, they are substantially equivalent.

[111]See for example, al-Qur'ān (7:85) and (34:3).

[112]See Commemoration, p. 184

[113]See Hakim Said and A.Zahid, Al-Bīrūnī-His Life, Times and Works, op. cit., p.148. cf. Commemoration, p.161. See also A. Sayili, The Observatory in Islam, (Ankara, 1960), p.125.

[114]These were instruments used by him to measure densities. See H.Said and A.Zahid, op. cit., p.144-147 and S.M.R. Ansari, "On the Physical Researches of al-Bīrūnī", Indian Journal of History of Science, Vol. 10 (2) (1975) pp.199-207. See also Al-Bīrūnī Commemorative Volume, p.450 and his book, The Exhaustive Treatise On Shadows, p.76.

[115]S.H. Barani, "Al-Bīrūnī's Scientific Achievements", Indo-Iranica, 5/4; 1952/1953, p. 45

the mathematician reflects al-Bīrūnī's understanding that perfect mathematical knowledge belongs to no other but God because it is only He that measures perfectly.

In addition to accuracy, the other criteria is novelty. Al-Bīrūnī believes that a good theory should be able to disclose new relationships of previously unnoted phenomena. A theory should help the mathematician to discover 'new' aspects of God's creation, increasing his awareness of God as 'al-Khāliq',[116] the Creator who creates everything unceasingly. An example to illustrate this is al-Bīrūnī's study of the variation in the length of the year related to the motion of the apogee where he gives the theorem "that the apogee and the perigee are the points at which the apparent velocity reaches its extreme values", a remarkable discovery since it is "the first time that the concept of accelerated motion was made the subject of mathematical analysis".[117]

However the most important criterion is truth. Truth to al-Bīrūnī is more than a regulative principle, it is <u>the</u> regulative principle. The notion of truth is central to his conception of problem solving. We can find that truth permeates at all stages in his pattern of problem solving outlined above. Al-Bīrūnī did not view truth as an illusive notion which, construed as such, is irrelevant to science. After focussing on a particular problem, he

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[116]For example, see al-Qur'ān (2:118).

[117]See Willy Hartner, Matthias Scramm, "Al- Bīrūnī and the Theory of the Solar Apogee: an example of originality in Arabic Science", in A.C. Crombie, ed. <u>Scientific Change</u> (Oxford, 1961) pp. 212-213.

begins his inquiry by asking God to "help [him] perceiving and realising the Truth, and facilitate its pursuit and lighten its courses...".[118] In collecting as much relevant information as possible to the problem, he states "I do not scorn to accept truth from whatever source I can find it".[119] He even reminded himself to "speak the truth, even if it were against yourselves".[120] Truth to al-Biruni, is "enjoined by the holy scriptures on mankind [and] possesses its own intrinsic beauty just like justice...".[121]

More interestingly, al-Bīrūnī's notion of truth is not equivalent to the popular conceptions of truth.[122] It cannot be construed as correspondence theory of truth favoured by realists. Neither can it be categorized under the coherence theory nor the pragmatic theory of truth **per se**. These are the reductive approaches to truth. Truth, to al-Bīrūnī, must be seen from the perspective of Holy Qur'ān and Sunnah. The Qur'ān is revealed as a 'guidance' (huda). [123] Thus in India he states:

> ... I like to confront theories of one nation with those of the other simply on account of their close relationship, not in order to correct them. For that which is not the truth does not admit of any correction, [not that it cannot be corrected]

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[118] Tahdīd, p. 45. See Commemorative, p.594. cf. Chronology, Preface.

[119]See Tahdīd, p.104. See Commemorative, p.594.

[120]See India, p.4. See al-Quran, (4:134).

[121]See al-Bīrūnī's preface in Chronology.

[122]We will treat this subject in greater detail in the third and the seventh chapter.

[123]See al-Qur'ān, (2: 1-5).

> and all heathenism, whether Greek or Indian, is in its path a narrow one and the same belief, because it is a deviation from the truth.[124]

In other words, truth to al-Bīrūnī is always a subset of Islam and never goes beyond it. Truth is underdetermined by Islam. Truth cannot be used to evaluate Islam. It is Islam that evaluate truth.[125]

It is interesting to note that whenever a theory which is a result of his rigorous approach [126] is not consistent with a new discovery of an 'irregularity' of nature, it points not so much to its falsity but more so to Divine Wisdom.[127] Says al-Bīrūnī:

> Frequently, however, you find in the functions (actions) of Nature which it is her office to fulfill some fault (some irregularity) [sic], but this only serves to show that the Creator who had designed something deviating from the general tenor of things is infinitely sublime, beyond everything which

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[124]See India, Vol. I, p.24.

[125]Note that Islam is blessed to only those who are 'guided', not to those who think that truth is with them. This points to the 'sacredness' of truth. We will show in the third chapter that ultimately truth does not reside in arguments but emanates from al-Ḥaqq Truth is guaranteed only to those whom He sanctions.

[126]It is important to underscore the rigor and 'severity' of his approach because elsewhere al-Bīrūnī cautions people against those 'ignoramus' who do not spare much effort but simply "attribute to God's wisdom all they do not know of physical sciences..." See his Chronology, p.253. See also The Exhaustive Treatise On Shadows, p.9.

[127]A modernist like Popper for example would maintain that a discovery of one brown robin points to the falsity of the basic statement "all robins are black" simpliciter. This is, what I call, a philosophy of science void of transcendence. For a discussion on the study of zoology as an example of knowledge about nature connected to God's Wisdom, see O. Bakar, Tawḥīd And Science, op. cit., pp. 62-64.

we poor sinners may conceive and predicate of Him.[128]

Therefore apart from explaining and predicting the sensibles,[129] more importantly a theory 'explains' the Divine Names of God to the mathematician, in such a manner that the mathematician will be conscious of Divine Wisdom and that he will "adhore Allah as though he didst see Him" for even "if thou dost not see Him, he nonetheless seeth thee". A theory should help the mathematician in his ascend to the higher reality. The mathematician is immersed in the Divine 'Muḥṣi', 'Khāliq' and 'Ḥaqq' in the act of problem solving. He forgets the Divine Presence momentarily chiefly because of his sin, his nature of being human. Yet he knows that it is from Him which he issues and to Him which he returns. Accordingly for the mathematician, to be conscious of God is to see Him everywhere and to experience Him as 'al-Muḥṣi', 'al-Khāliq' and 'al-Ḥaqq'. Only then will the mathematician understands the reality of the object of problem solving as āyāt Allah, to the extent that his consciousness is permeated and dominated by the Divine 'Muḥṣi', 'Khāliq' and 'Ḥaqq'; the Divine Qualities of Allah.

No wonder when al-Bīrūnī internalizes the greatness of God who he also describes as "Allāhu al-ḥaqqu al-mahdu" (God is Pure

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[128]See al-Bīrūnī, Chronology, pp. 294-295. See also S.H. Nasr, An Introduction..., op. cit., p.124.

[129]The over emphasis of science to 'explain and predict' are obvious in the writings of western (for lack of a better term) philosophers of science such as R. Carnap, I. Lakatos, I. Hacking, K. Popper and others too numerous to mention here. Suffice it to say that they agree on the predictive and explanatory ability of science.

Truth)[130] and the imperfectness of human knowledge,[131] al-Bīrūnī writes "We ask God to pardon us for every statement of ours which is not true",[132] and reminded himself and others to "take our refuge with God, who renders firm the foot of every one who seeks Him, and who seeks the truth about Him".[133]

In light of the importance of contemplation to al-Bīrūnī, we want to emphasize that although al-Bīrūnī construes science as an activity of problem solving, the mathematician himself is not obsessed with the problems. Rather he is obsessed with the relationship between himself and God. It is God that is central in his problem solving activity. Therefore solving problems is only a consequence of his consciousness, his obsession, and his conception of God.

1.5 Conclusion.

To recapitulate, nature to al-Bīrūnī is the handiwork of God. The activity of deciphering nature, of solving scientific problems, can be an act of ʿibādah, a 'sacred' act which can raise the status of the seeker in the eyes of God. Scientific activity to al-Bīrūnī

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[130]See Bruce B. Lawrence, "Al-Bīrūnī and Islamic Mysticism," in Al-Bīrūnī Commemorative Volume, p.366. It is interesting to note that according to Lawrence, al-Bīrūnī's usage of the name "may exemplify the indirect influence of 'taṣawwuf' on al-Bīrūnī's vocabulary".

[131]On some of al-Bīrūnī's erroneous beliefs, see S.H. Nasr, An Introduction....., op.cit., p.125. cf. Chronology, p.214.

[132]See India, vol. II, p.246.

[133] Ibid., Vol. 1, p.264.

is an activity bounded by the parameter of religion. In his quest to gain understanding of nature, he believes that one should be conscious of Divine Wisdom, which is manifested in nature and all its intricacies. Mathematics is a very powerful tool of studying nature. It is both a theoretical and practical activity of solving problems by using symbols and manipulating them according to certain rules. The mathematician will discover nature and himself by submitting completely to His Sovereignty and Wisdom, thus knowing more about God (His Divine Names) which ultimately is what problem solving activity, to al-Bīrūnī, is all about. Scientific problems are religious problems. In the next chapter, we will examine further the place of mathematics in his conception of science by focussing on his concept of mathematical abstraction.