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Studying Abu Rayhan's Viewpoint toward the Nature of Science

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Abstract: This paper aimed at studying Abu Rayhan viewpoints toward the nature of science based on today's definitions. Since he is one of the Muslim scholars who has some innovations in different sciences, his position toward the "first order" science will be studied and then, his position toward the second order science will be under study. The methodology used in this paper is based on the definition of nature of science provided by National Council Science Technology Education in the project 2061. The data needed for this paper was collected by library note-taking and was analyzed in a descriptive-analytic way.

Key *words*: the Nature of Science, Abu Rayhan Birouni, Muslim Scientists

Introduction

In science, the nature of science is known as Natural of Science, or in short form, NOS, in English. There are some terms for this concept. Studying the literature of nature of science and its components, Soltani et al. (2010:4) introduces 7 components as fundamental aspects of recognizing the nature of science: being temporary, experimental basis, creativity, the role of imagination, the effects of social and cultural issues, and the role of observation, deduction, theories and scientific rules. Mc Comas (2002) defines the nature of science as an intertwined combination of philosophy of science, history of science, sociology of science, and psychology of science by which we may specify the position of science.

Ministry of Education in America (Ministry of Education in America website, 2009) knows teaching physical sciences and understanding the nature of science as well as promoting the exploratory spirit in understanding the phenomena and other scientific phenomena as the

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standards of teaching sciences. And, the Research Council of America confirmed the nature of science as a part of standards in science content. In Project 2061, National Council of Science Technology Education focuses, on the concept of the nature of science, on three main subjects: 1) Scientific worldview, 2) scientific methodologies, and 3) the nature of scientific activities (scientific practices). On the first subject, i.e. scientific worldview, the scientists have some particular main opinions and attitudes in common based on their own viewpoints, which are about universe and what we may learn. First, the scientists' scientific viewpoints suggest that: the universe is understandable, the scientific ideas are subject to change, the scientific knowledge is permanent, and science cannot answer all questions. On the second subject, i.e. the scientific research methodologies, though some differences in the way of dealing with those phenomena, the degree of relying on the historical information or experimental data, and the qualitative or quantitative methods selected by the researchers, they agree on the way of communicating the data, information and concepts as well as standards determining validity. Generally, there are some specific features for a scientific research:

Science needs evidence, science conforms to rational deduction principles, science explains and predicts, the scientist tries to explore, and avoids biases, science is not a dictator. In the Project 2061 the scientific activity includes different individual, social, and organizational dimensions, having the following features (Shahidi, 2001: 19): the scientific activity is a complex social activity, science is organized in content fields, and is managing in different organizations. In managing a scientific activity, there are some accepted moral principles, the scientists participate in social affairs both as a specialist and a citizen.

Scientific advances happened after 800 AD- about the second century in Islamic calendar and for about 5 centuries by Muslim scientists. They could collect the previous works, make them the base of their studies, and create new fields based on them and expand it. The great scientists in the given era were Kharazmi, Farabi, Biruni, Ibne Sina, Omar Khayam, Khaje Nasiroddin Tousi,

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and the latest was Ghiyasoddin Jamshid Kashani. Iranian, in this era, could show their competence, learn new sciences and technology by relying on their past culture and the new tradition, and expand it (Mo'tamedi, 2010). Given the importance of science history in education, this paper aims at studying Abu Rayhan, as one of Muslim academics, attitudes towards the nature of science. As the writers searched, there is no other equivalent work in this subject.

The main question is that what is Abu Rayhan's position about today's definitions on the nature of science? Or that is it possible to see today's definitions of nature of science in such great scientists' attitudes and activities as Abu Rayhan Birouni as a great scientific academics? The data was collected by note-taking of library sources, and then, the questions were analyzed by a descriptive- analytical method. The sources used in this paper are mostly the literatures done about Abu Rayhan in Iran. The basics of this paper are the common classifications of science, definitions and concepts of nature of science in the Project 2061 in America, which are placed on three issues: scientific viewpoints, scientific research methods, and the nature of scientific researches.

1. An Overview of Abu Rayhan's Life

Abu Rayhan Muhammad Ibne Ahmad Birouni Kharazmi was born on Zihajje 3rd 362 AH In Biroun, Kharazm, and died in 442 AH/ 973-1050 AD. His father was Abu Ja'far Ahmad Ibne Ali Andijan, the astrologist in Kharazm Shah Royalty in Gorganj, and his mother, Mehrane, was a nurse. His family name was Birouni, referring to the place he was born (Biroun) (the current name of Kath), the capital city in Kharazmshahian era. This city was one of the ancient land, Kharazm, (now called Aral), which is now located in the autonomous republic of Gharaghalpagh, and is named after this popular scientist as "Birouni". Birouni lived for 25 years in that city, and learned mathematics from the great mathematician in that era, Abu Nasr Mansour Ibne Ali Ibne Iraq, and started searching and writing in his early youth

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(Payervandsabet, 2009: 71, quoted by the Great Soviet Encyclopedia, Vol. 3, p. 345). This scientist was born in a Muslim and Shia family.

Abu Rayhan died in Ghazane, in Rajab 440 AH, aging 77. Abu Hassan Ali Ibne Isa, the popular jurist who was beside him in his last moments of life, wrote that “on his last moments of life when he could breathe so hard, I was on his beside. He asked me: Explain about "Jodat Fasede" (one of the majors in arithmetic), once I asked you. I replied: it is not a good condition to. He said: my friend, which is better, dying after knowing this matter, or dying uninformed? And I explained the matter to him. I was returning when I heard the sound of whimpering from his house (Ariyaei and Momtaz, 2012). Birouni is called, in western countries, as Maitre, Aliboron, and Albiron (Ali, Abdollah Defa’, 2003: 159).

Shajari et al. (2010: 53) studied Abu Rayhan’s position in identifying the Iranians after Islam and concluded, according to the evidence, that: Birouni identified an Islamic identity for himself, against a violation, though having many opinions. He rejected whatever related to Iran and the Iranians, referring to them as prejudice, idiocy, and ignorance. He asserted that the Persian language has no capacity to convey the meaning, to spread it naturally, and that the Iranians have some useless ideas. In contrast, to him, everything attributed to Islam is considered sacred, because he could not or did not want to differentiate among Arabs, Arabic culture and language, and Islam. The Arabic government was sacred to him as it was a symbol for Islam, and the Arabic was respectable for him as it was the language of religion and revelation.

2. Abu Rayhan’s Works

“In the bibliography of Razi’s works, the treatise “in Muhammed Ibne Zakaria Razi’s works list” [Persian translation: The list of Razi’s books and Bipouni’s Books], in which Birouni wrote in

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427 AH included a list of his works written to that time, including 130 completed works and 10 incomplete ones (e.g. Asaroalbagheye[1] and Ghanoon Masudi[2] among others).

According to the Bowall's Ahsa (No. 2, pp. 161-256; No. 3, pp. 391-396), after works by Videman, Suter, and Resher (pp. 55-96), all the works done by Birouni, writings or treatises on particular topics, were over 180 (Islamic Encyclopedia website). The German orientalist, Edward Schaw, (Ali, A. Defa', 2003, p. 16) referred to one of Birouni's writings, Alasarol Bagheye anel Ghorunol Khaliye[3], in the introduction of his book in German as summarized in Table 1:

Table 1:

No.	Subject	No. of works		No.	Subject	No. of works
1	Geometry and Astronomy	18		8	Light	4
2	Arithmetic	18		9	Geography	15
3	Astrolabe	5		10	Other writings and stories in Persian	13
4	Calendar and Seasons	5		11	Religion	6
5	Phoebe Homes	12		12	Personal version, not available	13
6	Protracted Stars	5		13	Incomplete books	10
7	Astronomy	7			Total	113

[1] آثار الباقيات
[2] قانون مسعودی
[3] الآثار الباقيه عن القرون الخاليه

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Some believe that the numbers of the written works by Birouni are 103, 152 or 180 books and treatises. 35 books are available. Some include:

Mallelhand[4] Research: this book is the results of Birouni's travels to Indian subcontinent, and consists of some issues on sciences, religions, and Indians' traditions.

Altafhim le Avayel Asnaate Tanjim[5]: This book was written on arithmetic, geometry, astronomy, both in Persian and Arabic. This book was as a mathematics and arithmetic textbook for several decades.

Tahdid Nahayatol Amaken le Tashih Masabat al Masaken[6]: This book was written in order to measure the distance of the cities.

Ghanun e Masudi[7]: This book is based on Islamic astronomy, consisting of 11 units. There are some units on trigonometry and spherical trigonometry as well as earth and its dimensions, the sun, moon, and the planets.

Aljamahir fi Ma'refatol Javaher[8]: Birouni wrote this book under the name "Abu fath Modo Ibne Masud Ghaznavi[9]". It introduces the materials, particularly different jewelry. This book is the oldest treatise on mineralogy in Arabic.

Almosahere fi Akhbar Kharazm[10]: this book that is originally in Persian is not available, but Abolfazl Beyhaghi noted some parts of this book in his book, Masudi's history.

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[4] تحقیق ماللهند
[5] التفهیم لاوایل اصناعت التنجیم
[6] تحدید نهایات الاماکن لتصحیح مسابات المساکن
[7] قانون مسعودی
[8] الجماهیر فی معرفه الجواهر
[9] ابوالفتح مودوبن مسعود غزنوی

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Sidane[11]: this book is about chemical materials, their properties and preparation. It is translated into Persian.

Asarol Baghiye anel Ghorunel Khaliye[12]: Abu Rayhan studied the epochs and chronometry of different ethnic groups. According to Bagher (1974), Birouni was in Gorgan, in 366 AH (976 AD), 371 AH (981 AD), 389 Ah (998AD), and 403 AH (1012 AD), where started his earliest and greatest work on different issues such as calendar, epochs, mathematics, astronomy, and astrology in Soltan Shamsol Emali Abu Hassan Ghabus Ibne Voshmgir's rayalty, and entitled it as "Asarol Baghiye anel Ghorunol Khaliye". This book was probably awarded to Ghabus Ibne Voshmgir in 390 Ah (1000 AD).

Estekhrajol Outar[13]: this book is about measuring the diagonal of a circle. It is translated into Persian.

Maghalide Elme Elahiye, Tasvirolkavakeb, Tashihol Sovar, fi Sanatol Ostorolab[14]: this book is one of the other books written by Birouni.

4. Classifying science by Abu Rayhan Birouni

Biroun divided his works in 10 categories, implying the classifications of science. According to him, science can be classified into different categories as follows (Azarmi, 1990: 24):

1. Natural sciences such as geography, mineralogy, gemology, and medical sciences.
2. Mathematics such as astronomy, arithmetic and geometry.
3. Humanities such as religious beliefs and beliefs.

[10] المساهره فی اخبار خوارزم
[11] صیدنه
[12] آثار الباقیه عن القرون الخالیه
[13] استخراج الاوتار
[14] مقالید علم الهیه، تصویر الکواکب، تصحیح الصور، فی صنعه الاسطرولاب

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5. Abu Rayhan's activities in the first order science

The analysis of Birouni's works subjects and his practical activities show this Muslim scientist's attention to the first order science. For instance, astronomy and mathematics are common subjects in the first order science in his works "Asarol Baghiye" and "Altafhim le Avayel Asnaat al Tanjim Taghvimha[15]". Moreover, he introduced aerology in his work "Asarol Baghiye". He studied measurements of physics bases in "Tahdid Nahayatol Amaken le Tashih Masafatel Masaken" and "Estekhrajol Outar[16]". Chemistry is the main subject in "Aljamahir fi Ma'refatol Javaher[17]" and "Sidane". Abu Rayhan's practical activities are recorded in astrophysics, geography and science of measurement. He used an hour circle in order to observe the solar altitude of meridian in Kath (the capital city of Kharazmshahian), and drive the latitude of the earth. Birouni observed the lunar eclipse on 30 may 376 AH while it had been arranged that Abu Vafa observes that in Baghdad at the same time. Abu Rayhan lived for a long time in Ghazane. A large number of his recorded observations were there, which started with the sun movements towards the meridian such as Summer solstice in 398 AH, and included the lunar eclipse on 21 Sep. of the same year. He continued observing the Equinox and Solstices, in Ghazane. His latest observation was Midwinter in 400 AH. He determined the direction of Qibla by using scientific measurement. He was the first who introduced the idea of prominent image (Ghalamsiah, 1986: 6). He completed and perfected the Islamic astronomy. He provided some new ideas about natural subjects and astronomy. He measured the diagonal of the earth by using astronomical observations. He wrote "Tahdid Nahayatol Amaken" and showed how one may measure the distances among cities, and he took this job practically (Mo'tamedi, 2010). His book "Maghalid Elmol Heye' ma Yahdeso fi Sathe Basitol Kore[18]" is one of Bitouni's greatest work, and the first complete

[15] التفهيم لاوايل اصناعت التنجيم تقويم ها
[16] استخراج الاوتار
[17] الجماهير فى معرفات جواهر
[18] مقاليد علم اهيئه ما يحدث فى سطح بسيط الكره

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book on spherical trigonometry. Birouni entitles this book after “Abol Abbas Marzban Ibne Rostam Ibne Shervin”, one of the princes in Bavand dynasty, who was the author of “Marzbanname[19]”. The subject is about Moghni and its application in astronomy instead of the form of sectors (the Islamic Encyclopedia Website). This book can be used in astronomy; it was written in Islamic period, and is a masterwork whose scientific value should be introduced to all (Ma’tamedi, 2010). Birouni has done some great researches on physics such as spheroid of the earth, measuring the specific gravity of some bodies, inventing hydrometer, estimating the diagonal of the earth, and the magnetic properties. Furthermore, the science historians confirmed on Biroui's role in the science history. In this context, George Sarton introduces Abu Rayhan as the greatest historian of the sciences history in the present, since he lived in 11th century. Edward Zakhao considers him as the greatest scientific mind who have ever emerged in the world. The American professor, Pop, glorifies him and says that all the great scientist in the world should consider a special status and a high position for Birouni, and undoubtedly, the mathematics history, astronomy, geography, and humanities is not completed without him (Shaegh, 1973).

6. Abu Rayhan and the second order science

The second order science is defined as what is discussed "about science". Based on the given framework of this paper, the nature of science is focused on three categories: scientific worldview, scientific research methodology, and the nature of scientific work.

6.1. Abu Rayhan Birouni's worldview

Considering the roles of worldviews in producing science, the Islamic worldview can undoubtedly produce new and modern sciences by providing unity and harmony of the world and connecting it to GOD; as Whitehead said: it was the belief to the harmony of the nature

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that provided the setting for progress in science. The Islamic scientists like Abu Rayhan Birouni and Khaje Nasiroddin Toosi who founded first Academy of Islamic sciences in Maraghe, found a deep relation between their scientific explorations and Qura'nic worldview, implying that GOD did not produce the universe in vain. In Islam, there are some worldviews that have different effects with what described; for example, Asha'ris' thinking that was against rational science, or Ghazali and Ibne Khaldoon who criticized the natural sciences.

The comparisons among different worldviews show clearly that they are generators or reasons of producing science; in other words, producing science requires a format in which the different worldviews are effective in making the structure of this format and making new passive forms for the human. The worldviews do not make propositions for science, but they form the methods. For instance, philosophy never produces science, but the scientific issues are indebted to the philosophical concepts. In fact, our view towards causality or existence are considered as a container which raises the scientific concepts, and this is the meaning of impacts of worldview on producing science (Ebrahimi, 2005: 796).

It should be noted that Birouni concerned the philosophy of history, and it is inferred by the content of some of his works. He also considered the characteristics of fossils and sedimentary nature of land boulders inside. He believed that there happened some big storms, and left some seas and big lakes on the hard ground. Finding such evidence in the human history, he realized some periods, in the same way as Indian Youghas. He also found that any period of the human life was disconnected till a disaster destroyed civilization, and GOD sent another prophet to start a new age in the history (An analysis of the Islamic scientists' lives and works, 1983: 53).

Shajari et al. (2010: 59) studied Abu Rayhan’s position in Iranian identification after Islam and concluded, according to the evidence, that Birouni knew himself as a Muslim, though having many different ideas. He denied whatever related to Iran and the Iranians and referred

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to them as fanaticism, idiocy, and ignorance. He referred to lack of capacity in Persian language to present the meaning and its lack of natural exposure as well as its absurdity of some of its beliefs. In contrast, to him, whatever attributed to Islam was sacred, since he did not want or could not differentiate among Arabs, Arabic and Islam. The Arabic governments were sacred to him because they were symbols of Islam, and honored the Arabic as it was the language of religion and revelation.

Birouni's criticism of Aristotle on cosmology and physics is considered as peripatetic. Following Islamic theories, Birouni believed the existence of other worlds, and disagreed with Aristotle about availability of only one world (Azarami, 1990: 24).

We may summarize Birouni's worldview: the creation of the universe was from the pre-existing eternal matter or the exportable olla monster, which was also called as "nonexistent". The creator should identify with absolute time in the meaning of eternal "period" or "universe" and "Zarvan[20]"; that is GOD. He considers the fact process as the nature action, whose doer is the olla or the first stimulus; that is the eternal existence or GOD. He named the absolute place as primitive which is nonexistence space or "vacuum" which the negative aspect of the eternal existence; and is identified logically with infinite time (Ozkaei, 2007).

6.2. Abu Rayhan Birouni's scientific research methodology

Knowing different scientific and experimental ways done by many great scientists in different periods and the ways of reasoning as well as the progress of sciences not only opens its formal and normal process, but also provides a proper context for understanding science. In this context, it can prepare people to think correctly and logically.

Birouni's methods in researching social issues and humanities: in fact, Abu Rayhan Birouni is the creator of anthropology. He used a special method to study society, history,

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civilization, and the nations' beliefs, which almost no one used in the past. Some properties are considered for his "comparative" studies:

1. Collecting accurate and correct information and supplying proofs
2. Recognizing historical deviation routes such as love, hatred, benefits and fear
3. Avoiding inductive method in studying history
4. Applying mathematical and cultural methodologies
5. Comparing and contrasting the events in different societies

Realism and impartiality in research, and separating the reality from the researcher's valuation were some of theoretical foundations in Birouni's anthropological researches. He attempted to explain and illustrate the reality as it is. He sees available facts in the social and cultural researches, and the visible objectives. He matched the results of the researches with the realities and objectives; he believed that data and information was valid if it conforms to the results of experiments, experience, and objective observation. He admitted his objectives in the introduction of his book "Mallelhand Research":"I will transfer the Indians' ideas to the readers as they are."

Impartiality, avoiding ethnocentrism, love and hatred, and personal desires in researching are other features of Birouni's methodologies. As he asserts: I accept facts from any source, and throw away whatever is not fact. I purified my mind from whatever I am addicted to such as prejudice, following fantasy and presidential ambitions, which all lead to destruction. We should assess people's ideas to reach this objective (Javanmard, 2001: 141). "Will Durant" introduces Birouni as a universal-mannered, and considers him as a careful researcher, in reviewing narrations and texts such as Bible, who is unbiased and impartial. He is admirable in contrast to "Ibne Sina", as he was skeptic, critical, and liberal (Boloukbashi, Ali, Islamic Encyclopedia Website). Some of the Iranian scholars recognized Aristotle's heuristic method insufficient in

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knowing physics, and doubt and criticized his physics. Zakaria Razi and Aboureyhan Birouni considered the empirical and inductive methods in studying physics (Mo'tamedi, 2010).

Birouni and the research methodologies in natural science: induction and sensory testing were so important to Birouni; he could be convinced by mathematical proof in general scientific issues and in minor issues by "induction and sensory testing". He attained some facts by observing and applying mathematics in studying the nature, which inspired many scientists in researching the natural sciences (Azarm, 1990: 29).

Birouni's scientific activities were based on observation, experiment, measuring the quantities and phenomena. He applied the scientific method and introduced it over six centuries earlier than Francis Baken (1561-1626). It is interesting that when he heard that "python will be blind when it sees emerald" experienced a dangerous action. He kept an python in a cage on a carpet made of emerald for about nine months, even hanged a necklace of emerald around its neck, and hanged a string of emerald in front of its eyes, and finally realized that this ideas is nonsense. He found that emerald has no effect on the python's eyes. It was said that diamond is poisoning and one might die if he ate it, he gave a piece of diamond to a dog to eat and proved that this belief is unfounded (Mo'tamde, 2010).

6.3. The nature of Abu Rayhan Birouni's scientific works

Abu Rayhan Birouni is the first scientist who studied historical background and comparing the earlier scientists' ideas in any subject in his works. His another research feature was this fact that Birouni was a multilingual. He was fluent in Persian, Turkish, Arabic, Hebrew, Syrian, and Sanskrit, and know some Greek. He understood well that using translators or the translated books is not as useful as learning people's language, whose culture is under investigation (Fattahi and Ghanei, 2012).

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About 500 years before the West, one of Abu Rayhan's contemporaries, Abousaeed Sajazi, proved that the earth turns around the sun. Abu Rayhan also relied him and said: "I believes that the earth turns around the sun and I am still astonished whether the earth turns around the sun or the sun turns around the earth. By "astonished" he means that I have the scientific reasons of both theories: according to Ptolemy, the sun turns around the earth. He said: I could not trust any side" (Velayati, 2004: 12).

Abu Rayhan and Ibne Sina had some debates by which we may find the scientific issues at that time. These debates are included in "Asarol Baghiye", consisting of two parts:

1. Some criticisms on Aristotle's book, "Alalam[21]", including 10 questions.
2. Some scientific or philosophical problems to himself had, including 8 questions (Mo'tamedi, 2010).

For instance, Birouni rejects Aristotle's idea about inherent motion and inertia of the celestial bodies, and says that: these bodies may be forced to move. He challenged Aristotle's idea; he believed that there is no vacuum. Birouni asserts that there is no reason to prove that there is no thing as vacuum. The scientific dialogues between Birouni and Abu Ali Sina in different issues are examples of such dialogues in the world history of science, and the highest point in flourishing physics in ancient Iran (Akhavan, 2012: 22). Moreover, Birouni believed in scientific communities in carrying out scientific activities. He, as an example, writes in his book, Tahdid Nahayatol Amaken (Aboureyhan Birouni, p. 235), that when I was in Kharazm and Abu Vafa was in Baghdad, we both observed an eclipse as planned before.

6. Discussion and conclusion

According to Abu Rayhan's books and writings and historians' narrations, Birouni was expert in the first order science in different fields such as physics, astrophysics, geography, chemistry,

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medicine, pharmacology, mathematics, mineralogy, botany, and commenting on the creation time of the universe, on how the earth surface layer was formed, and changing the seas to land. He proposed some new methods, and invented some modern devices. Hence, it can be concluded that Abu Rayhan was one of multidimensional characters in science.

On the second order science, Abu Rayhan's viewpoint generally is consistent with fundamental components of the nature of science, including temporary nature of science, empirical basis, and creativity, the role of imagination in science, the effects of social and cultural issues on science, the role of observation, induction, theory, and scientific rule as fundamental aspects of the nature of science.

Given the role of Abu Rayhan in identification of Iranians, he stabilized his scientific worldview based on the religious (Islamic) principles. He introduced changes in civilization resulted from science in the advent of the prophets. When Birouni asks some main questions and challenges Aristotle's ideas, he focuses on this fact that the scientific ideas are subjects to change. And this is consistent with the scientific worldview of the American Project 2016: universe is understandable, the scientific ideas are subject to change, the scientific knowledge is permanent, and science cannot answer all questions.

Arranging observing the eclipse with Abu Vafa in Baghdad, contributing to providing the theory of optics Abu Ali Sina and Ibne Heysam are some instances of Birouni's belief to the collective identity in the nature of scientific works.

Applying and generalizing the scientific research methods, Birouni could innovate some modern and new ideas in this context due to his beliefs to natural sciences criticisms and rationality, and his logical themes affected the humanities. The applied scientific methods by Birouni in scientific researches show that: "I accept the facts from any source I can find, and if it doesn't change to facts, they will be discarded. When I removed my heart from whatever that is harmful such as prejudice, following the lust, presidential ambitions, which direct people to death and

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prevent them from meeting the truth, then I should evaluate their ideas in proving this goal. These examples are consistent with what is in the Project 2016:

Science needs proof, science is consistent with principles of logical reasoning, science can explain and predicts, the scientist tries to recognize and identifies, and avoids prejudice, and science is not dictator.

According to Abu Rayhan's writings, he constantly studied the relation between the scientific and religious issues, and did not forget to learn in any situation and condition. Therefore, "lifelong learning" is one of the features in Birouni's time of life, which is today introduced as international organizations and institutions' mottos, and modern theories of learning, including connectivism.

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