Evolution: Education and Outreach
a SpringerOpen Journal

RESEARCH ARTICLE Open Access

Canadian and Pakistani Muslim teachers' perceptions of evolutionary science and evolution education

Anila Asghar

Abstract

Background: This study seeks to explore the intersections among religion, science and education in Muslim teachers' science classrooms in diverse contexts. Specifically, it examines the ways in which the scientific theory of evolution is understood by Muslim high school science teachers in light of their theological beliefs about creation.

Methods: Data were collected from 25 high school science teachers from various schools in Canada and Pakistan. Qualitative interviews and focus group discussions were conducted to probe participants' perceptions of evolution in relation to their religious beliefs and how they address the evolution/creation controversy in teaching.

Results: Canadian and Pakistani Muslim science teachers mostly accepted evolution of living beings except human beings because human evolution contradicts their Islamic beliefs. Canadian and Pakistani science teachers mostly lacked a clear understanding of biological evolution and most were in favor of teaching both the religious and scientific perspectives in their science courses.

Conclusion: This study has implications for teacher development and science education. Better training opportunities are needed for Muslim science teachers to support them to develop sophisticated content and pedagogical knowledge about evolution.

Keywords: Evolution education, Religion and science, Islam and biological evolution, Muslim teachers and evolution education

Background

> *'Evolution means the survival of the fittest; [I have] no problem with it. . . . [I] cannot believe that man came from ape. . . . All the creation is from Allah. . . . [God created] Adam with clay.' (A Canadian Muslim Science Teacher)*

The creationism/evolution social controversy plays out significantly in public schools in North America where creationists are incessantly trying to find ways to include creationism in science teaching along with evolution (Alters 2005; Alters and Alters 2001; Larson 2003; Scott 2004). On the contrary, the scientific and science education communities are in agreement that biological evolution is a central unifying framework of biology teaching and learning (National Academy of Sciences 2008; Inter-Academy Panel 2006) and 'the only explanation for the diversity of life on this planet that is acceptable to the scientific community' (Demers 2006). Nonetheless, the teaching of evolution continues to generate social controversy in many countries, primarily because of its perceived conflict with certain personal religious beliefs (Cobern 2000; Berkman et al. 2008; Branch 2008). While the impact of creationist ideas on K-12 evolution education has been well documented in western societies (Futuyama 1995; Eldredge 2000; Lawson 1999; Alters and Alters 2001; Moore 2001; Alters and Nelson 2002; Scott 2004; Trani 2004; Plutynski 2010; Branch et al 2010), it remains relatively unexplored terrain in Muslim cultures and communities.

Correspondence: anila.asghar@mcgill.ca
Department of Integrated Studies in Education, McGill University 3700 McTavish Street, Education Building Montrea, QC, H3A 2M1 Canada
Full list of author information is available at the end of the article

Research suggests that an individual's religious orientation and convictions may interfere strongly with his/her perceptions, understanding and acceptance of biological evolution, if they conflict with the scientific view of evolution (Cobern 2000; Southerland et al. 2001). At the same time, other studies suggest that understanding of evolution may be a predictor of acceptance of evolution (Rutledge and Warden 2000; Rutledge and Mitchell 2002; Deniz et al. 2008). Further, a growing body of research points to the relationship between an individual's acceptance of evolution and his or her understanding of the nature of science (Asghar and Alters 2011; Hokayem and BouJaoude 2008; Lombrozo et al. 2008;). These findings highlight the significance of a comprehensive understanding of the fundamental characteristics of scientific knowledge and evolutionary concepts for accepting evolution (Kim and Nehm 2011).

In educational settings, teachers' curricular and pedagogic decisions are largely determined by their attitudes and positions about the academic content (Carlesen 1991). Hence, science teachers' acceptance or rejection of evolutionary theory determines how they may present it to their students (Rutledge and Mitchell 2002). Nehm and Schonfeld (2007) argue that science teachers are an important 'missing link' between scientists' views of evolution and the general public's acceptance or rejection of evolution. Teachers who do not understand and accept the science of evolution may not be able to make informed decisions about teaching evolution, thus limiting their ability to develop a comprehensive understanding of evolutionary biology among their students.

Although the contemporary Islamic societies generally follow modern science concepts, it appears that very little is known about how evolution is construed and taught at different levels in Islamic communities. This study explores how the evolution and creation controversy plays out in Muslim science teachers' classrooms in Canadian and Pakistani communities. Currently, Muslims comprise 23.4% of the world population (1.6 billion) and the Muslim population is estimated to increase at about twice the rate of the non-Muslim population over the next 20 years (Pew Research Center 2011). Further, Muslims comprise a large segment of immigrants in Canada and in European countries. Indeed, Muslims form the second largest religious denominational group in most Western countries, including Canada, UK, and US (Cristillo 2008; Niyozov and Pluim 2009). It is important to explore what perspectives they bring to the global and local discourses on modern science, religion, and education (Asghar et al. 2007a; Mansour 2008; Niyozov and Pluim 2009).

While Pakistani teachers are a part of a predominantly Muslim society where religion significantly shapes the culture and is entwined with every aspect of life, Canadian teachers live and work in a secular context. This study offers a comparative view of how Muslim teachers make sense of evolutionary theory in relation to their religious beliefs in these very different contexts. It also looks at how their perspectives on evolution shape their professional practice in their classrooms. Literature on North American teachers' views of teaching evolution (e.g., Alberts and Labov 2004; Moore 2004; Moore and Kraemer 2005; Long 2012) focuses on secular or Christian perspectives, while few international studies in Muslim-dominated countries exist (Asghar and Alters 2007; Aroua et al. 2009; Hokayem and BouJaoude 2008; Asghar et al. 2012; BouJaoude et al. 2010). The lack of information about Muslim teachers' views on the social controversies surrounding evolution and creationism, and their impact on science education, suggests a need to investigate these perspectives in both secular (i.e., Canada) and religious (i.e., Pakistan) contexts.

Islamic perspectives on biological evolution

The introduction of Darwin's theory into the Muslim world generated a vigorous debate among Muslim scholars and influenced the public mind deeply, particularly when it clashed wit1h people's religious, philosophical, and cultural values about the creation of life (Remtulla 1993). Muslim intellectuals have, and continue to, respond to the theory of evolution in myriad ways in light of their faith. The controversy surrounding evolution in the Muslim world stems from the multiple, and conflicting, interpretations of the religious text on the origin and creation of life by Islamic scholars (Cole 1993; Sayin and Kence 1999; Hameed 2008). Some Islamic theologians vehemently contest the idea of evolution because it contradicts the religious view of creation in their opinion, whereas other scholars view it as compatible with their religious interpretations and endorse the integration of biological evolution with modern science (Quddus 1971; Khan 1979; Bucaille 1982; Ziadet 1986; Remtulla 1993; Zaman 2003). In fact, some early Muslim thinkers proposed ideas not inconsistent with Darwinian evolution. Muslim philosophers, such as Al-Biruni (973 to 1048), Ibn Arabi (1165 to 1240), and Ibn-Khaldun (1332 to 1406) proposed evolutionary arguments to explain the evolution of living beings 'although they did not articulate a fully developed, testable theory of evolution through natural selection' (Cole 1993, p. 18; Sayin and Kence 1999; Shanavas 1999). Ibn- Khaldun and Ibn Arabi placed human beings in the animal kingdom and stated that humans are related to other animals including monkeys (Shanavas 2008). These Islamic scholars' writings suggest that they believed in theistic evolution. Similarly, some recent studies in contemporary Muslim societies reveal that many practicing Muslim scientists/biologists believe in theistic evolution to reconcile evolution and their religious views of creation (Asghar and Alters 2007; Asghar et al. 2009a, Asghar et al. 2010a; BouJaoude et al. 2010). Importantly, the Scientific

Academies of several predominantly Muslim countries (e.g., Egypt, Indonesia, Iran, Pakistan) are signatory to a statement proclaiming that evolution is an 'evidence based fact' which has never been contradicted by scientific evidence (Inter-Academy Panel 2006).

Mansour (2011) explicates the powerful role of Islam in shaping Muslim intellectual and broader publics' response to modern science. According to him, Islam in most contemporary Muslim communities is not just restricted to moral and spiritual beliefs like other religions. Instead, Islam for its adherents is a 'complete and comprehensive way of life' (Mansour 2011, p. 285). Thus, any perceived dissonance between their religious convictions and scientific knowledge may lead to a conflicted relationship with certain aspects of science and technology. In view of the central role of religion in the private and public spheres in Muslim societies, it is essential to understand the ways in which it impacts education in these communities. According to Dagher and BouJaoude (2011), science education in Muslim countries is primarily influenced by two notable sources, the official interpretation of religion and science by the ulema (religious leaders) and popular views about the interactions between science and religion. The official stance, however, is not monolithic as there have been pluralistic religious responses to science even within the same religious sect. Dagher and BouJaoude further argue that popular and personal interpretations are more likely to influence how teachers present the relationship between Islam and science to their students. In general, both official and popular stances tend to endorse compatability between Islam and science. Nonetheless, the tensions between religion and science often surface in the arena of evolutionary science. Some scholars expect this controversy between Islam and evolutionary science to grow with the rise in Islamic creationism in some Muslim countries. For instance, Hameed (2008) argues that creationist discourses in Turkey are influencing the minds of youth in neighboring Muslim countries in the region.

According to Mansour (2008), the complex intersections between teachers' social, cultural, and professional contexts significantly influence their thinking and classroom practices. Equally important are Muslim teachers' religious frameworks that inform many teachers' notions of the purpose of science, curricular content and pedagogical objectives (BouJaoude et al. 2010; Mansour 2008). Studies with Muslim teachers in Islamic schools indicated that preparing Muslim students to succeed in western cultures while holding on to their distinct values was central to these teachers' pedagogical practice (Selby 1992; Zine 2001; Niyozov and Pluim 2009). Exploring Muslim teachers' religious and scientific perspectives on evolution is, thus, very important to develop a better understanding of how they enact the curriculum in their classrooms (Mansour 2011). Some recent studies are beginning to shed light on the ways in which social and religious debates about evolution influence how the science of evolution is taught in predominantly Muslim societies. These studies illuminated complex interactions existing among evolutionary science, Islam, and education across these culturally and politically diverse settings. One such finding was that religion seems to play an important role in many Muslim biology teachers' and professors' understanding of evolution and their positions regarding the teaching of evolution. The Qur'an, the holy book of Muslims, includes many verses about creation of life. Accordingly, Muslim scientists and educators interpret these scriptures in diverse ways, resulting in the full range of complete acceptance of evolution, selective acceptance of certain components of the theory to reconcile it to their religious interpretations, or a complete rejection of evolution. Another significant finding was that Muslim teachers' religious orientations often impact their pedagogical practice regarding evolution (Asghar et al. 2007b, Asghar et al. 2009b; BouJaoude & Dagher 2009; Derayeh and Turgay 2009; BouJaoude et al. 2010).

Clément and colleagues (2008) in their studies with Christian and Muslim teachers from diverse cultures (Europe, Africa, and Middle East) found that a nation's cultural and religious contexts are intimately linked to teachers' conceptions of evolution and their response to the evolution/creation controversy. The findings indicated significant differences between countries, religions, gender, and level of instruction. For example, biology teachers were more accepting of evolution than language or elementary school teachers, atheist and agnostic teachers were more likely to accept evolution than teachers with theistic beliefs, and Christian teachers accepted evolution more than Muslim teachers (Clément et al. 2008). Furthermore, they found that there is widespread rejection of evolution in countries with Muslim majorities. Still, other inquiries with Muslim teachers revealed that their theological frameworks substantially shaped their views about the natural world and controversial socio-scientific issues, such as cloning, abortion, birth control methods, etc. Teaching about these issues might pose problems because of their potential discord with their religious and cultural norms (Haidar 1997; Mansour 2008).

This study builds on this prior work and explores Muslim science teachers' views on evolution in relation to their religious beliefs and their pedagogic decisions about evolution in formal education settings. Muslim high school science teachers from Pakistan and Canada were interviewed for this purpose. The questions guiding this inquiry were: (a) What are Muslim teachers' perceptions of biological evolution in relation to their religious beliefs? (b) How do they negotiate any discords between science and their Islamic beliefs? (c) What do they think

about teaching evolution in their courses? (d) What differences, if any, exist for Muslim educators situated in secular and religious contexts?

Methods

Data collection and analysis

This study was conducted in six different Canadian and Pakistani high schools to illuminate the ways in which personal faith, scientific knowledge, and cultural values influence the minds of science teachers vis-à-vis biological evolution. All schools were contacted through local professional contacts that were trusted and respected by the school communities. Given the potentially sensitive nature of this topic for Muslims, it was important to create a safe environment where teachers could talk about their religious beliefs comfortably during the interviews. Therefore, the participating teachers and their school administrators were informed that their identities, institutional affiliations, and any other identifying information would not be disclosed in any published work. Twenty-five high school science teachers from the two countries participated in this study.

The concept of evolution is typically introduced in high schools; thus, this research seeks to explore how high school teachers approach evolution with their students. Muslim science teachers were selected from two Islamic schools located in a large Canadian province. These Islamic schools follow the provincial science curriculum. The theory of evolution and various evolutionary concepts, for example, natural selection, speciation, mimicry, and adaptation, are discussed in the biology curriculum for grades 11 and 12. Seven Canadian Muslim teachers (six men and one woman) agreed to participate in the interviews; three teach biology, one biology and anthropology, one chemistry, one anthropology, and one health science and Arabic. Canadian Muslim teachers were mostly first generation immigrants from the Middle East and South Asia.

Eighteen Pakistani Muslim teachers (three men and fifteen women) from four schools - two public and two private schools - located in two urban centers voluntarily participated in this study including ten biology, one chemistry, one biology and chemistry, one physics and four general science teachers. Pakistan is an Islamic Republic where Muslims constitute around 95% of the population. Islam permeates every aspect of the cultural, social, and educational systems. The national science curriculum used in all K to 12 government schools follows modern science education, although the Islamic faith is the cornerstone underpinning the Pakistani national curriculum. The goal of the national biology curriculum for grades 9 to 12 is to 'enable the students to appreciate that Allah (S.W.T[a]) is the Creator and Sustainer of the universe,' followed by other goals such as 'develop an understanding for Biological facts, concepts and principles and an appreciation of their significance' (Ministry of Education, Government of Pakistan 2000, p. 1). A review of the official biology textbooks being used in public schools all over Pakistan revealed that the topic of evolution is included in the high school biology curriculum and textbooks for grades ten and twelve; various examples of the evidence supporting evolution, for example, the fossil record, comparative embryology and biochemistry, are also presented. Natural selection is discussed in detail in the 12th grade biology textbook. The textbooks also include the religious text that draws on the relevant Quranic verses on the origin and creation of life. The interpretations seem to reconcile the scientific and religious perspectives about the common origin and relatedness of all living beings. For instance, the idea of common origin of 'all living things' including humans is discussed in the ninth grade textbooks and supported in light of certain Quranic verses, such as 'We made everything from water' (The Quran, 21:30) (Asghar et al. 2010b).

Data were mainly collected through individual interviews with seven Canadian and twelve Pakistani teachers (35 to 60 minutes) and a focus group discussion with six additional science teachers (60 minutes) in Pakistan. Interviews with Canadian teachers were conducted in English. All interviews and focus group discussions with Pakistani teachers were conducted in Urdu – the national language of Pakistan. Urdu transcripts and field notes were translated into English later for data analysis. The semi-structured interview conversations were meant to probe teachers' perceptions of the relationship between religion and evolutionary science, knowledge of evolutionary concepts, and how they address the evolution/creation controversy in their teaching. Interview transcripts were analyzed through line-by-line coding to identify the salient concepts that were important to the participants (Strauss and Corbin 1998). Individual profiles were created using data reduction strategies to identify and collapse codes into larger categories and themes. A recursive coding process helped in re-examining and refining the prevalent themes. The constant comparative method using open and axial coding was used to examine the relationship between important concepts and themes related to the research questions (Glaser and Strauss 1967; Lincoln and Guba 1985; Strauss and Corbin 1990). A comparison of the salient themes across all the interviews by creating cross-case matrices and concept maps revealed several notable patterns in the data (Maxwell 2005; Seidman 1998a, 1998b). In this qualitative study, the findings are generalized to the participants only. This study was conducted after obtaining the ethics approval from the Research Ethics Board at McGill University.

Results and discussion

The main categories and themes emerging from the data uncovered several important and interesting trends in the ways participants understood and described evolution in relation to their core religious beliefs about the origin and creation of life. This section illustrates the key themes arising from the conversations with Canadian and Pakistani teachers about the different ways in which they understand and describe evolution in relation to their core religious beliefs; how their religious affiliations relate to their positions about evolutionary theory; and their instructional practice with regard to evolution.

Canadian teachers' perceptions of evolution

Although no Canadian teacher accepted human evolution, three of the Canadian teachers selectively accepted certain components of evolution that were compatible with their religious beliefs. They were in favor of evolution of living beings, excluding humans. One science teacher said that 'complex animals and plants evolved from simple organisms.' He also believed that 'life started in water' and evolved subsequently, but the creation of human beings was not a part of this evolution process. Similarly, two secondary biology teachers cited the 'fossil evidence' supporting the evolution of living beings and indicated that it 'made sense to them'. Nonetheless, they did not accept human evolution. Some believed in the existence of other life forms and their evolution before Adam, the first human being, was created and sent to the Earth. As one participant noted:

> Millions of years old fossils [provide an] impressive record. . . . We can't deny factual record through science, it's very impressive. . . .Adam was thrown on the ground [from the heaven], but doesn't mean that life didn't exist before that; trees, birds, fossils, existed.

As noted, human evolution emerged as a contentious issue among Canadian Muslim teachers. Nearly all teachers emphatically rejected the evolution of human beings as they deemed it incompatible with their religious belief of the special creation of human beings. As most of them further illustrated, they did not want to believe that human beings are biologically related to apes and monkeys. As one male science teacher noted, 'I cannot believe that man came from ape. Humans were created in one shot by God.' Another male science teacher echoed this view against human evolution. He believed that Adam and Eve came into existence as humans and they were not related to apes or other animals.

> [Evolution] is 'non-sense. . . . [My] iman [faith] is that 'human beings were created by Allah in one-shot. . . . [I am] pretty sure that facts don't support evolution. . . Adam and Eve were created in the human form, not as apes.'

Two participants believed in the special creation of all species. As one science teacher said, 'God has made every type; apes and reptiles. It doesn't mean that reptiles or birds evolved' from other animals. He also believed that humans were created before the other animals like gorillas and chimpanzees. As he explained:

> Scientists couldn't trace real evolution despite the development of science. . . . I don't believe that humans evolved from gorillas and chimpanzees. I believe that human beings came first on earth. Adam and Eve, and then gorillas and chimpanzees appeared on the earth.

Echoing these views, another teacher said that all living beings were created by God in their present form; they did not evolve gradually and 'existed simultaneously.'

> Evolution is a man made theory. God doesn't need any chain of events or sequential development of things from simple to complex, doesn't need anything to happen gradually and sequentially. . . . all living beings existed simultaneously, same form and shape.

He brought up deficient examples to support his argument against evolution. For example, he said that he watched a documentary film claiming that humans lived on the earth prior to the existence of monkeys.

> There are serious flaws in evolution, for example, a documentary showed that a human body was found covered in snow, the body was intact, in the arctic region; carbon dating [showed] that this human existed before monkeys.

When probed further about the name of the documentary or the channel where it was televised, he said that he did not remember the name of the channel or the program. One participant, a female anthropology teacher, however, did not hold any firm ideas against the evolution of plants and animals and held it as a 'possibility,' since in her view, 'the Quranic language is very metaphorical and symbolic. I can neither reject nor accept [evolution] completely' in relation to other living beings, she maintained. She also believed that Islam and science are compatible and, therefore, was not averse to the idea of evolution of living beings except human beings. 'Religion and science don't contradict each other. I am open to it. Other living beings could have evolved from simple to complex forms,' she noted.

A health science teacher shared an interesting perspective on religion and science. He did not seem interested in

scientific questions and investigations of the natural world. Instead of 'wasting time' on thinking or asking questions about the creation of plants or other living beings, he concentrated on living his life in accordance with his religious beliefs and preparing for life after death. In his words:

> Iman [faith] is to believe in the unseen. Don't ask too many questions. Allah won't ask why this tree is purple or why leaves fell. He will ask about what we did in our youth. . . . It never came across to me how Allah created plants. . . . Allah will not ask about it after death. I will ask Allah about it. . . . Why waste your time on such questions [now].

Strikingly, all Canadian teachers clearly stated that they do not see any major conflicts between Islam and science in general. As one teacher and administrator said, 'people, through research and investigation, will find out the secrets of heavens and earth. We haven't explored enough.' Likewise, while reflecting on the relationship between science and Islam, another teacher said that he did not see any 'conflict' between religion and science. 'Nature and *din* (religion) don't conflict. They make sense,' he noted.

Canadian teachers' positions on evolution education

All Canadian teachers said that evolution is taught in biology courses in their schools. Nevertheless, the majority (six out of seven) were in favor of discussing the religious view of creation while teaching the science of evolution. One teacher said that she teaches 'the religious perspective on the origin of life and evolution' in her class. Another teacher was in favor of presenting various religious perspectives on the origin of life and engaging students in arguments over Darwin's theory in his class.

> Different religions have different perspectives on the origin of life – Islam, Buddhism, First Nations, etc. [I] present these perspectives also alongside the scientific idea to students. . . and ask my students, what do you think? Are you pro or anti-Darwin and they give their arguments.

Similarly, another male biology teacher explained that he teaches the views of some Islamic creationists as well as the scientific model of evolution. 'Evolution is taught in grade 12. I teach both sides – the religious and the scientific perspectives. I teach [the biology] textbook as well as Harun Yahya's[b] viewpoint,' he noted. Another teacher also shared similar instructional decisions and explained that in a religious school, teachers have the freedom to include their religious perspectives in science as well as other subjects.

> In public schools, religion is not allowed in [science]. . . . In a religious school, it is different; Islam would be in science classes. There is freedom to include Islam in every subject . . . look at things from the religious point of view.

Another teacher who also served in an administrative position at one of the Islamic schools explained that the topic of evolution is taught at middle and high school levels in his school. According to him, following the required curriculum content, including biological evolution, was important even if some topics did not resonate with their religious beliefs. As he noted: 'Evolution should have an accommodation in teaching. We teach a lot of things, which may not necessarily be our belief.'

Pakistani science teachers' perceptions of evolution

Pakistani Muslim teachers displayed a range of ideas, with creationism and scientific evolution on two poles of the spectrum and a continuum of ideas reflecting the ways in which they try to reconcile biological evolution with their religious beliefs about creation.

Most Pakistani teachers (14 out of 18) either accepted or considered the possibility of the evolution of living organisms, although nearly all Pakistani science teachers rejected human evolution because they believed that 'human beings did not evolve from monkeys.' These teachers recognized and accepted the scientific model and evidence supporting the micro and macro evolution of living beings other than human beings. For example, a female secondary biology teacher accepted the evolution of bacteria, plants, and animals as well as the biochemical origin of life, but she firmly believed in the special creation of human beings. In the same vein, a chemistry teacher who also studied biology did not accept human evolution; however, she explained that the fossil record and 'similarities between organisms across different phyla' convinced her to accept the evolution of plants and animals. Similarly, another biology teacher believed that 'animals and plants evolved from simple forms through the process of evolution through modification.' Further, the idea of the biochemical origin of life did not conflict with her religious beliefs as she explained that 'God made everything from water and science also says that life originated in water.' She further added:

> Inorganic chemicals and minerals turned into organic compounds, and simple life forms originated from these chemicals. Complex eukaryotes evolved from prokaryotes and . . . trees and plants and animals developed through evolution.

Like their Canadian counterparts, nearly all Pakistani teachers said that they were opposed to the scientific idea of human evolution on religious grounds as it conflicts with their Islamic view of creation. They believed in the special creation of human beings in their present form. Several teachers said that 'Adam was created by God suddenly, not gradually.' A biology teacher explained that according to the Islamic view of creation, human beings were made with clay and water by God as they are in their present structure and form.

> The Islamic view of human creation is that humans were made with clay and water by God. Then they developed gradually. . . Humans were created by Allah with water and clay as they are in their present form, physical structure and form.

While elaborating her religious view of human creation, another biology teacher who had a master's degree in zoology noted:

> Human beings didn't evolve from any other species. Allah created Adam from clay and blew His spirit into him. That's why humans decompose into clay after dying.

Four Pakistani science teachers completely rejected evolution because they believed in the special and sudden creation of all living beings. According to a biology teacher, 'all life forms were created as they are [including] reptiles, fishes, and humans.' Another biology teacher made an interesting connection between Lamarck's theory of inheritance of acquired characteristics and her religious view of special creation. In her words:

> Different species did not evolve from each other as Darwinism suggests. . . . Actually Lamarckism is related to Islam. According to Islam, God created living beings in pairs and then they changed through the inheritance of acquired characteristics, and that's what Lamarck said.

Nevertheless, all agreed that there is 'no contradiction between science and Islam' in general. Several teachers (ten) emphasized that Muslims need to 'explore the world' to understand it scientifically. As one female biology teacher noted, 'God gave us aqal [reason] to think and understand the world.'

Pakistani teachers' positions on evolution education

Nearly all the Pakistani science teachers (17/18) were in favor of using religious based explanations about the creation of life in their science courses. Although these teachers said that they teach the scientific concept of evolution, the majority said that they also discuss the Islamic point of view about the origin of life. It is not surprising given the fact that the Quranic verses about the origin of life are a part of the official high school biology textbooks. Moreover, many teachers said that they 'tell the students that it's wrong' because their interpretation of the Islamic perspective on creation disconfirms evolution, particularly human evolution, through common descent. A biology teacher, who also teaches chemistry, noted that she teaches biological evolution because it is a part of the required science curriculum and examination. 'We have to cover this topic because students want good grades on their exam,' she noted. Nevertheless, she also felt that it was important to present the religious perspective to students as 'children's Islamic knowledge is limited.' Hence, 'while teaching biology to my students, I tell them that as Muslims we believe that we are created by Allah and our father is Adam,' she further added.

Alternatively, a Pakistani biology teacher said that she does not wish to create a conflict in her students' minds about Islam and science. Although she echoed other teachers' thoughts in regard to the perceived conflict between scientific evolution and the Islamic perspective on creation, she believed in keeping science and religion separate. She said that one of her university professors, who taught biological evolution, had influenced her ideas about science and religion. Her discussions with her professor helped her to reach the conclusion that science and religion are 'separate' enterprises and science should not be 'mixed up' with religion. While she believed in the special creation of Adam and Eve due to her religious convictions, she did not intend to influence her students' minds against evolution because she felt that contradicting evolution on religious grounds would negatively impact students' engagement with this topic as well as their understanding and acceptance of evolution. Therefore, she said that she does 'not tell her students that [evolution] is against Islam' to keep them interested in the topic. As she noted:

> Teachers have a great impact on their students' thinking as my own teachers influenced my thinking profoundly about science and religion. . . .Students' minds shouldn't contradict science and religion. If we say that our religion doesn't accept [evolution], if a controversy arises in students' minds, they won't accept, won't understand, wouldn't want to learn it, they would think that evolution is against Islam.

Several teachers also mentioned that some of their students tend to bring up their religious ideas about creation in their courses if they are 'doubtful' about

evolution. Further, most students with creationist beliefs do not tend to accept evolution. A few teachers said that they explain to their students that evolution 'is your subject, it is science and they should study it to gain knowledge.' As one biology teacher said, 'I tell the students that your religion is right and you have to accept your religion, but we study [evolution] as a subject.'

Conclusions

This work illuminates the powerful impact of Muslim teachers' religious and cultural notions on their understanding of science as well as their pedagogical practice. Importantly, it illuminates the dynamic interactions between their religious, cultural, and scientific spheres in which learning takes place. As the findings illustrate, a clash between these spheres may inhibit teachers' engagement with evolutionary concepts. The interpretive framework developed by Dagher and BouJaoude (1997) was employed to examine participants' positions regarding evolution and the relationship between these positions and their religious beliefs. This framework served as a useful tool to capture the various ways in which participants conceptualized the relationship between religion and evolution. The following categories based on this framework were employed to analyze the main themes from the interview findings:

a. Individuals who accepted evolutionary ideas using arguments from an evolutionary or reconciliatory perspective.
b. Individuals who did not accept evolutionary ideas presenting arguments from a creation or antievolutionary perspective.
c. Individuals who selectively accepted only certain aspects of evolutionary theory arguing from a compromised perspective.
d. Individuals who were neutral espousing either a noncommitted or a confused perspective.
e. Objections to evolution: conceptual difficulties, alternative interpretations.

The analysis of findings using this interpretive framework suggests that Muslim teachers negotiated their relationship with evolutionary science in different ways. Approximately three-fourths of the Muslim teachers tended to selectively accept only certain aspects of evolutionary theory presenting arguments from a compromised perspective. As discussed earlier, the majority had issues with the idea of human evolution on religious grounds, although they recognized the evolutionary relationships among other organisms and accepted their common ancestry. Many teachers said that shared ancestry with apes is unacceptable because human beings are superior. Some teachers presented religious arguments in favor of the special creation of all living beings, thus vehemently rejecting evolution completely. A few displayed a confused perspective because they were not interested in delving into any contentious issues regarding evolution and religion. Studies in other societies with Muslim populations including teachers found that they either did not want to commit to any position regarding evolution or accepted evolution selectively to harmonize it with their religious beliefs about creation (Derayeh and Turgay 2009; BouJaoude et al. 2010). Other inquiries revealed that Muslim teachers and students tend to use a combination of theological and biological explanations when making sense of evolution and other biology concepts because scientific and theological domains are often intertwined or diffused in their minds (Haidar 1999, 2002; Aroua et al. 2009; Asghar et al. 2009a). The tensions that arise between the secular values that come with modern science and teachers' theological frameworks may lead to outright rejection or modification of certain scientific ideas to seek harmony between Islam and science (Mansour 2008, 2011). Notably, scientific evidence did not seem to influence the thinking of those who rejected or selectively accepted evolution. Both Canadian and Pakistani Muslim teachers viewed their theological interpretations as 'true knowledge' and judged scientific claims against their beliefs. Several teachers drew on their personal religious views to make sense of the theory of evolution, while some teachers said that the views of Islamic scholars on this subject influenced their thinking. In general, the teachers in this study reinforce the view that evolution can be an extremely controversial and difficult subject for Muslim teachers, particularly as it relates to human evolution.

Although the purpose of this study was to elucidate teachers' perceptions of evolution in relation to their Islamic beliefs and classroom practice, the presence of misconceptions and knowledge gaps about evolution in the study population is worth articulating. Alarmingly, the majority of teachers lacked a comprehensive understanding of evolutionary theory and demonstrated grave misconceptions about key evolutionary concepts. Several Pakistani teachers did not clearly understand the difference between Lamarck's idea of the inheritance of acquired characters and Darwin's theory of evolution. Indeed, some Pakistani teachers were in favor of Lamarck's theory and used it as an explanation for evolution of living beings. Canadian teachers, on the other hand, did not seem to endorse Lamarck's theory. However, both Canadian and Pakistan teachers had gaps in their knowledge about the mechanisms involving micro and macro evolution. Several teachers did not have a deep understanding of the geological timeline, fossil record, and radiometric dating. Many teachers could not explain the concept of natural selection as well as other evolutionary mechanisms, i.e., genetic drift, migration (gene flow). Another glaring misconception among many teachers was that humans directly

descended from monkeys. Notably, the majority did not know the various stages in the process of human evolution and the evidence supporting it.

A significant majority of science teachers in this study also lacked a clear understanding of the epistemology of science. For example, some objections to evolution indicated that many participants held misconceptions regarding the nature of science, such as attempts to suspect biological evolution by suggesting that it was 'just a theory and thus cannot be correct.' Several teachers seemed unaware of the vast physical evidence supporting evolution and the methodological tools employed by scientists to gather various types of evidence. Studies with Arab Muslim teachers found that they had inadequate understandings of the nature of science because in their professional programs they were not exposed to the scientific principles, approaches, and methods that are used to generate and test scientific claims (Haidar 1997, 1999, 2002). As expounded above, several studies suggest that conceptual comprehension of evolution may influence an individual's acceptance of evolution. In other words, individuals who understand the concept of evolution are more likely to accept its validity (Rutledge and Warden 2000; Rutledge and Mitchell 2002). Importantly, a comprehensive and sophisticated understanding of the nature of science is required to learn and appreciate the scientific status of evolutionary theory, the evidence and arguments that support it, the methods that support its central claims, it's explanatory and predictive power, its importance in history, and its ability to provide a unifying and coherent framework for biology (AAAS 1993; NSTA 2000; NAS 2008). Indeed, research suggests that students' and teachers' views of science and the nature of science (NOS) may influence their understanding and acceptance of evolution (Dagher and BouJaoude 1997, 2005). Further, some studies suggest a positive correlation between understanding the nature of science and acceptance of evolution (Scharmann and Harris 1992; Trani 2004; Rutledge and Warden 2000; Lombrozo et al. 2008). Strikingly, studies with Muslim biologists' revealed that a deeper knowledge and appreciation of the various types of physical evidence supporting evolution led them to accept the scientific model of evolution (_____2011).

Research suggests that teachers' attitudes and views about the content impact their curricular and pedagogic decisions (Carlesen 1991; Deniz et al. 2008). Hence, science teachers' acceptance or rejection of evolutionary theory may determine how they will present it to their students (Aguillard 1999; Shankar and Skoog 1993; Rutledge and Mitchell 2002). Further, scholars contend that teachers who do not accept the science of evolution may not be able to make informed decisions about teaching evolution, thus limiting their students' ability to develop a comprehensive understanding of evolutionary biology (Rutledge and Mitchell 2002; Sanders 2010). A striking association between teachers' religious understandings of evolution and their positions on evolution instruction was observed in this study. A large number of participants in this research advocated the teaching of religious explanations along with evolutionary content. Canadian teachers said that evolution is taught in biology courses in their schools because they follow the provincial science curriculum. Nevertheless, the majority were in favor of discussing creationist ideas including Intelligent Design while teaching the science of evolution. They also said that they explain to their students that they have to cover the required textbook content, even though evolution is not acceptable in Islam. Similarly, most Pakistani teachers were in favor of teaching their religious perspectives about the creation of life in their science courses. This is not surprising in the Pakistani science education context given the fact that religious text related to the origin and creation of life is embedded in the national science curriculum and biology textbooks. It is important to note that the religious text is generally interpreted to be in support of evolutionary theory. Nonetheless, the curriculum enacted by the Pakistani teachers was, in many ways, at odds with the goals of the national science curriculum. Although the biology teachers said that they teach the scientific concept of evolution, many said that they share their creationist beliefs during evolution instruction. For example, they tell the students that evolution is 'only a theory' and 'human evolution is wrong.'

The similarities between Canadian and Pakistani teachers' pedagogical decisions regarding evolution highlight the influential role of theological frameworks in shaping teachers' instructional practice. Muslim teachers in both contexts acted as gatekeepers of knowledge while enacting their science curricula. Their narratives bring out the tension that exists between what they are supposed to teach and what in their view constitutes legitimate knowledge. While they try to cover the curricular content that their students will be tested on in the science exams, they also feel that it is their responsibility to pass on the 'true religious knowledge' to their students. Since many teachers explicitly question the validity of evolutionary theory in their instruction and most have several misconceptions about evolution, it is plausible that students in their classes are not receiving adequate instruction about evolution. If teachers are against evolution, they are likely to employ less effective strategies for teaching evolution (Sanders 2010). Additionally, scholars argue that teachers' beliefs may impact their students' knowledge and worldviews (Diekhoff 1983; Rutledge and Mitchell 2002).

A wide range of sensitivities and concerns can potentially create conflict in relation to evolution instruction. These include internal factors, such as teachers' religious orientations; comprehension and acceptance of

evolution; understanding of the process of knowledge construction in science; teachers' beliefs about how the content knowledge should be presented to students; and knowledge of prevalent misconceptions about evolution. Additionally, several external barriers can pose challenges for the teaching of evolution, for example, school policies related to evolution education, religious values of the school community, students' and parents' views about creationism and evolution, pressure from school authorities and community members; and opposition from religious leaders (Tatina 1989; Moore and Kraemer 2005; Sanders and Ngxola 2009). A careful consideration of these factors in preparation programs may help teacher educators and teachers to address the creationism/evolution controversy and develop effective approaches for teaching the science of evolution.

This study has implications for professional development of Muslim teachers in science education. As a number of studies suggest, providing better learning and professional development opportunities in teacher preparation and continuing education programs would enable them to develop a deeper and sophisticated understanding of biological evolution. Exposing science teachers to the potential challenges they might face while teaching evolution and effective pedagogical strategies to address them would also enable them to create better learning opportunities for their students. In a study with science teachers who had different religious affiliations, Sanders (2010) found that teachers' concerns about teaching evolution significantly subsided as their understanding of the subject matter and pedagogical skills improve. Dagher and BouJaoude (2011) advocate a deliberate engagement with socio-scientific issues and religious perspectives on them in predominantly Muslim cultures. They argue that moderate religious leaders, science educators, and scientists need to engage the academic and broader publics in discussions around the 'nature of scientific knowledge and its relationship to religious knowledge' from various standpoints. Exposure to pluralistic interpretations of religion in relation to science in Islamic societies would inform curriculum developers and science educators' efforts to improve science teaching and learning (Poole 1996; Dagher and BouJaoude 2011, p. 84).

This work also informs science teachers in Western societies about how Muslim students might think about the evolutionary science being taught. Educating students from different ethnic backgrounds requires an understanding of the religious and cultural perspectives that they bring to the classroom to identify cognitive and emotional barriers to learning about evolution (Donnelly et al. 2000; Niyozov and Pluim 2009). As noted earlier, Islam is not a monolithic religion. Muslim philosophers and intellectuals have been actively contributing to vibrant discourses around science and Islam for many centuries and across cultures. Similarly, popular views on science and Islam also vary considerably within and across various Muslim traditions and communities. Therefore, future studies need to explore these multiple perspectives in relation to Islam and science, and to evolutionary science in particular.

Endnotes

[a]SWT is an abbreviation for Subhanahu Wa Ta'ala that Muslims use for the sublime name of Almighty Allah and it means Glory be to Allah, The Exalted. http://islam.about.com/od/glossary/g/swt.htm.

[b]Harun Yahya is the pseudonym of Adnan Oktar, one of the leaders in Turkish creationism (explicit anti-evolution), and very popular in some Islamic countries.

Acknowledgements
This study was supported by a grant from the Social Sciences and Humanities Research Council (SSHRC), Canada.

Received: 30 January 2013 Accepted: 30 January 2013
Published: 26 March 2013

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doi:10.1186/1936-6434-6-10
Cite this article as: Asghar: **Canadian and Pakistani Muslim teachers' perceptions of evolutionary science and evolution education.** *Evolution: Education and Outreach* 2013**6:**10.