

## TWO SIDES OF THE SAME COIN: STUDENT JUSTIFICATIONS FOR OR AGAINST EVOLUTIONARY THEORY

Pratchayapong Yasri<sup>1\*</sup> and Thanakorn Maleesut<sup>2</sup>

<sup>1</sup>Institute for Innovative Learning, Mahidol University, Nakhon Pathom, Thailand

<sup>2</sup>International Demonstration School, Mahidol University, Nakhon Pathom,  
 Thailand

\*corresponding e-mail: pratchayapong.yas@mahidol.ac.th

### ABSTRACT

*Students accepting evolution are likely to rely on science as cognitive authority (i.e. science textbooks and science teachers). In contrast, those not accepting are likely to rely on religion as cognitive authority (i.e. religious texts and religious leaders). A thematic analysis based on existing quantitative and qualitative studies has been carried out in order to propose a theoretical framework for a range of reasons contributing to students' acceptance and rejection of evolutionary theory. This article urges that instruction of evolution is more than the matter of delivering scientific contents. It also deals with personal worldviews influenced by different forms of cognitive authority. It is therefore important to put more emphasis on developing students' learning skills to critically evaluate which source of information is scientifically appropriate, with full respect to religious belief of individuals.*

**Keywords:** acceptance, evolution, cognitive authority, religion

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### INTRODUCTION

Evolutionary theory is stated to be the unifying theme which underlies biological concepts (Dobzhansky, 1973). Therefore, student acceptance of it is fundamental to understanding of other biological sciences. In addition, understanding and acceptance of evolutionary biology are found to be closely related to understanding of the nature of science in regard to what science is and how it works (Lombrozo, Thanukos, & Weisberg, 2008). Previous empirical studies in science education research demonstrate that there are various factors which influence different levels of student acceptance of the theory of evolution including understanding evolutionary evidence (Clores & Limjap, 2006; Downie & Barron, 2000), religious perspectives (Clores & Limjap, 2006; Downie & Barron, 2000; Francis & Greer, 1999; Francis, Gibson, & Fulljames, 1990; Fulljames, Gibson, & Francis, 1991; Yasri & Mancy, 2014), and the status of evolutionary theory within the scientific community i.e. the degree to which scientists and science teachers accept it (Rutledge & Sadler, 2007).

However, knowing only whether students accept evolutionary theory may not provide much further information for its impact on student learning of biology. It is therefore important to understand perceived justifications that students hold to express their view on the acceptance of evolutionary biology. Thus, this article is set to elaborate these in greater detail. It reviews empirical findings from quantitative studies which adopt a survey approach using pre-defined justifications for accepting or rejecting evolution in questionnaires, as well as findings from qualitative studies using in-depth interviews in which justifications for perceiving evolution are attributed by students themselves. It then draws out that student justifications for expressing different responses to evolutionary biology are related to two forms of cognitive authority. One is associated with the scientific enterprise, and the other with religious perspectives. It urges that although it is practically impossible that students are able to acquire scientific understanding about evolutionary theory based solely on first-hand experiences (i.e. they cannot gain access to evolutionary evidence and run experiments

directly by themselves), allowing them to rely on other forms of second-hand knowledge according to the framework of cognitive authority (i.e. they acquire knowledge about evolution through books, online articles, teachers and other experts) has to be observed carefully by biology teachers. Lack of careful observation may lead students to hold some misunderstandings of evolutionary biology which may, in turn, lead to rejection of it. It is therefore important to cultivate students' critical thinking skill in order for them to be able to evaluate which forms of cognitive authority are worth leaning towards. However, this shall be done with full respect to personal adherence to any particular religious beliefs.

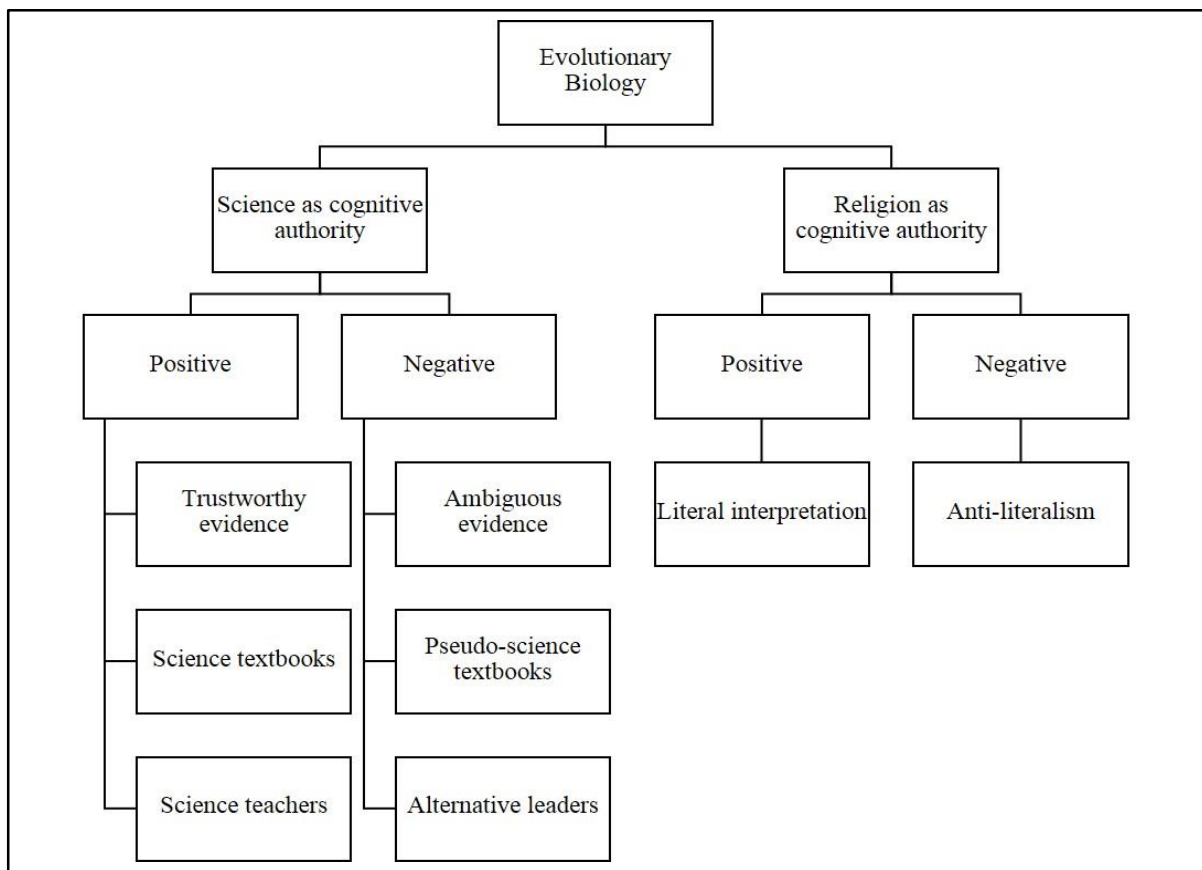
**METHOD**

In order to gain profound understanding of different forms of cognitive authority that

influence students' acceptance and rejection of evolutionary theory, a thematic analysis based on existing literature is carried out inductively. Both quantitative and qualitative studies are used as secondary sources. Reasons for and against evolutionary theory expressed by students are emphasised which are then synthesised into a single framework with sub-thematic levels. The underlying framework for this categorisation is cognitive authority. Consensus between the authors is adopted as a triangulating approach.

**RESULTS AND DISCUSSION**

This review based on existing literature in evolution education shows that students rely on different forms of cognitive authority when justifying the acceptance of evolution. Two broad forms of cognitive authority are influential in student justification: scientific and religious enterprises (see Figure 1).



**Figure 1.** Student justifications on the acceptance of evolutionary theory based on cognitive authority

**Student Justification for or Against Evolutionary Theory Based on Quantitative Studies**

On the basis of student selection of pre-defined items for or against evolution provided

in a questionnaire, Downie and Barron (2000) propose three justifications which contribute to student acceptance of evolution in a period of 12 years of study among university students in Scotland. The three justifications are related to

scientific evidence for evolution, science teachers and the perceived unavailability of alternative explanations. More specifically, first, 78% of the student participants who accepted evolutionary theory (N=1019) agreed that they accepted it because “there are not any good alternatives to evolution that explain well the origin and distribution of species” (p.142). Second, 36% of them accepted evolutionary theory on the ground of scientific evidence as they agreed with the reason that “the evidence for evolution is clear and unambiguous” (p.142). Thirdly, 11% of those accepting evolutionary theory agreed with the choice stating that “I tend to accept what my teachers say: they know the evidence much better than I do”. Note that the summation of the percentages is not 100 because the students were asked to tick all the reasons that applied to them.

In contrast, by providing negative interpretations of those three justifications, Downie and Barron (2000) report that 33% of those rejecting evolutionary theory over the period of 12 years (N=191) viewed that evolutionary evidence is “full of conflicts and contradictions” (p.141). In addition, 19% of those rejecting evolutionary theory agreed that there are good alternatives to evolution that explain the origin and distribution of species. Although these good alternatives are not detailed in Downie and Barron (2000), Southcott and Downie (2012) further explored with another batch of student participants that these alternatives are related to creationist and Intelligent Design perspectives (discussed below). Turning to the present result, interestingly, 71% of those rejecting evolutionary theory rejected it on the basis of religious beliefs by selecting the choice which states that “I accept the literal truth of a religious creation account that excludes evolution”.

Using Downie and Barron (2000)’s questionnaire with some minor modifications, Özay Köse (2010) reports that among Turkish secondary students, there were 183 out of the total number of 250 student participants who rejected evolutionary biology, of which 72.1% rejected it on the basis of the literal interpretation of creationist account on divine creation. In addition, 40.4% perceived that the evidence for evolution is “full of conflicts and contradictions” (p.192). Unlike the Scottish sample, only 56.7% of those accepting evolutionary theory (N=67) viewed that there are no good alternatives to evolutionary theory; 52.2% accepted

evolutionary theory because of its “clear and unambiguous” evidence (p.192); furthermore, 44.7% accepted it because of the influence of science teachers and science textbooks.

As mentioned above, Downie and Barron (2000)’s results were recently updated by Southcott and Downie (2012) whose questionnaire-based survey focused on how first and final year bioscience students attending a Scottish University perceived evolutionary theory. They present that almost half of the first year students who rejected evolution (N=61) viewed that “there are alternative explanations for the diversity of life seen today (e.g. divine creation, Intelligent Design), whereas an average of 24.5% viewed that evolutionary theory is failed to gain support by sufficient evidence and over 20% rejected because they “have insufficient knowledge about evolution” (p.303). In contrast, among 850 students who accepted evolutionary theory, the majority (73.5%) agreed that evolutionary evidence “is convincing and well supported.

Turning to the final year students whom are divided by the researchers into two groups: those having little experience on post-level 1 evolution courses (N=218) and those who have exposed to a range of courses related to evolutionary theory (N=255). The researchers present that only 2.1% of the whole sample rejected the statement for evolutionary theory. However, this figure comes only from the former group; whereas the number of those rejecting evolution was absent among the latter. Like the first year students, most of these final year students (84.5%) accepted the evolutionary theory because they find it “convincing and well supported” (p.304).

Taking these into consideration, rather than being drawn to the different figures presented, I would like to highlight that these studies point out a group of student justifications on which both university and secondary school students rely in order to make their view to support or oppose evolutionary biology. However, these justifications yield bilateral responses. More specifically, there are students who positively perceive that evolutionary evidence is creditable and accept that evolutionary theory is the only existing explanation of the origin of life and biodiversity that is scientifically sound. In contrast, many negatively perceive these aspects by holding the views that evolutionary evidence is not creditable and there are some other convincing explanations to the emergence of

biodiversity such as creationist and Intelligent Design perspectives.

In addition, there are justifications that are not influenced students' own evaluation of scientific evidence or scientific explanations, but by other influential sources of authoritative knowledge such as science teachers and science textbooks (scientific authority) or literal interpretation of religious accounts on divine creation (religious or scriptural authority). In other words, when justifying whether evolutionary biology should be accepted, many students rely on what others may say about it rather than reflect on it by themselves. However, this range of justifications for or against evolutionary theory may not exclusively represent what students actually perceive about evolution as they are fundamentally pre-defined by the quantitative researchers. It is therefore important to review naturalistic accounts given by students themselves based on in-depth interviews. An integrative framework drawn from these two research strands will help us understand student justifications for or against evolutionary theory more clearly.

### **Student Justification for or Against Evolutionary Theory Based on Qualitative Studies**

Hokayem and BouJaoude (2008) carried out in-depth interviews with 11 university students in Lebanon using open-ended questions. Their findings concerning student justifications for forming an opinion whether evolutionary biology should be accepted, deductively appear to be similar to those presented by Downie and Barron (2000) particularly the consideration of evolutionary evidence. More specifically, Hokayem and BouJaoude (2008) point out that all of the participants recognised the importance of concrete evidence in making the justification regarding to the strength of scientific theories. However, they differed in their interpretations of such evidence. Those accepting evolutionary theory perceived that it has been scientifically constructed through concrete evidence. In contrast, those being unsure and those rejecting evolutionary theory found the evidence itself unconvincing and speculative, and thus they decided not to accept evolution without referring to any religious reasons.

A wider range of reasons for forming an opinion on the acceptability of evolutionary theory are reported in the study of Clores and Limjap (2006) whose work adopts a different

research approach (in-depth interviews together with written responses) focusing in a different educational context (university students in the Philippines). Their data analysis adopts an inductive approach. More specifically, among those accepting evolution, about two third perceived that it is sufficiently supported by scientifically valid evidence which has been accumulatively discovered by a number of scientists. In addition, among them, many accepted evolution on the basis of a good understanding about the nature of science and scientific methods. However, the expression of the acceptance of evolution by some students appears to be associated with scientism (e.g. unconditional faith in the work of scientists), as well as misconceptions about evolution (e.g. man linearly evolved from monkeys).

Among those being unsure and those rejecting evolution, in addition to their misconceptions about evolution (e.g. environmental determinism, divine revelation, evolution of plants and lower taxonomical animals only) and misinterpretation of its evidence (e.g. incomplete fossil records, missing links for speciation, pure imagination), they tend to deny evolution for religious reasons. Specifically, two students said that their uncertainty about the correctness of evolutionary theory stems from clashes between the scientific explanations of evolution and their creationist beliefs. Another student understood that his creationist belief does not allow him to consider evolutionary theory as an account for the emergence of organisms. In addition, some of those who rejected evolution explained that evolution is less likely to occur when mathematical probabilities are considered.

Taking these into considerations, reasons for accepting and rejecting evolution presented in these qualitative studies composing of both deductive and inductive approaches involve perceived oppositions between the scientific and religious enterprises. In relation to student perceptions on evolutionary evidence, those accepting evolutionary theory are likely to be convinced by scientifically valid evidence for evolution with either some scientifically sophisticated understandings or the "scientistic" point of view (scientism). However, those rejecting evolutionary theory are likely to either explicitly lean towards the religious enterprise (i.e. literal interpretation of the scriptures and divine revelation) or implicitly rely on some pseudo-scientific concepts or misconceptions

which may arise from religious standpoints. In addition, it appears that the student participants were influenced by some influential sources of knowledge such as science teachers and science textbooks versus religious texts.

### **Two Sides of the Same Coin**

Based on the quantitative and the qualitative studies reviewed above, it is evident that the list of justification defined by the researchers or given by the students themselves are not very different. However, I assume that the cause that makes student justification so diverse is based on different positions on which students stand when they perceive the rationales. A metaphor that I use here is called a two sides of the same coin phenomenon to which I refer as a complexity of reality that viewing the same observation from different perspectives can yield contradictory results. In other words, there are students who view the same aspect of evolutionary theory from different personal points of view, leading to different responses to whether evolutionary theory should be accepted. For example, those studies using Downie and Barron (2000)'s research instrument show that while a group of participants prefer the reasons for evolutionary theory (i.e. clear and ambiguous evidence, science teachers and textbooks say so, and no other good alternative explanations, the other group prefer the opposite statements which are against evolutionary theory (i.e. conflicting and contradicting evidence, scriptural texts do not say so, and there are good alternatives to evolution such as intelligent design).

Similarly, drawing from Clores and Limjap (2006)'s, it can be clearly defined the same phenomena in two different aspects. First, while there are those who accepted evolutionary theory based on scientific beliefs (scientific authority), there were those who rejected it for religious reasons (religious authority). To elaborate this point a little more, these opposite views take priority not to evolutionary theory itself, but personal views in which the individuals adopt to justify whether evolutionary theory should be accepted. Second, similar to the case of Downie and Barron (2000)'s study, while there are those who accepted evolutionary theory because they perceived that it is well supported by evidence, those who rejected evolutionary theory perceived that the evidence is incomplete.

This phenomenon can be unlocked by the constructivist learning perspective which explains that people give different meanings to

the same thing because they hold different belief systems which have been accumulatively nurtured by their previous experiences and other people surrounding them. Therefore, each individual is unlikely to see things as they are but as he/she is. In other words, individuals perceive and interpret situations, events, claims, and/or subjects, according to their beliefs which have been socially constructed by their own set of culture, faith and values. In the context of evolution education, Winslow, Staver and Scharmann (2011) explain that student perceptions of the theory of evolution have been influenced by a set of beliefs which students have been taught in their childhood from parents and/or church communities. When they reach school ages, their perceptions are likely to be influenced by teachers, peers, as well as learning materials (Anderson, 2007; Bishop & Anderson, 1990; Clores & Limjap, 2006; Donnelly, Kazempour, & Amirshokoohi, 2009; Kampourakis & Zogza, 2007; Martin-Hansen, 2008; Taber, Billingsley, Riga, & Newdick, 2011; Winslow et al., 2011; Yasri & Mancy, 2014).

A further explanation can be that even when they grow intellectually older, their perceptions would remain influenced by some other sources of knowledge such as books, thinkers, theorists, preachers, online-documents and so on. It is likely impossible that one can solely acquire knowledge by one's own initial investigations such as running experiments and/or observations to develop some understanding of a particular concept. As conceptual development (both formulation and reformulation) is unlikely to happen without learning from external sources in various forms, it is therefore important to review how scholars explain influences of external sources on individuals' decision making or justification on something. In order to do this, the framework of cognitive authority is selected and will be discussed in the next section. Where possible, the implications of this framework will be drawn to student justifications on evolutionary biology.

### **Cognitive Authority**

In the context of evolution education, student acceptance of evolution is predominantly influenced by a set of beliefs which they have been nurtured since childhood (Winslow et al., 2011). When they reach school age, their perceptions are likely to be influenced by teachers, peers, as well as learning materials

(Anderson, 2007, Clores and Limjap, 2006, Donnelly et al., 2009, Martin-Hansen, 2008, Taber et al., 2011, Winslow et al., 2011, Yasri and Mancy, 2012). These different sources of knowledge that individuals consider sufficiently reliable, trustworthy or compelling to influence their justification for accepting or rejecting evolutionary theory are considered as cognitive authority.

Wilson (1983), one of the key researchers in the area of cognitive authority, explains that people construct knowledge according to two different processes. One is through their personal encounters with entities of interest (direct experience). Knowledge gained through this direct experience or observation is called first-hand knowledge. In contrast, the other process of learning is through learning from others. This is important because a single individual cannot gain direct experience of all concepts; knowledge gained in this way is called second-hand knowledge. Wilson argues that we rely primarily on the latter process as much of our knowledge is gained from others.

While some students might be able to gain first-hand experience of evolution through conducting scientific research alongside scientists, normally school students have to rely on second-hand knowledge. In other words, students usually learn about evolution from science teachers and textbooks. In fact, those who are able to acquire some kind of first-hand experience cannot deny that they have to learn some materials from others as well; thus they also rely on second-hand knowledge. Rasoamampianina (2012) explains that sources of second-hand knowledge can be found in many forms such as individuals (e.g. scientists, teachers, preachers and parents), texts (e.g. books, journal articles, conference proceedings and online materials), as well as institutions (e.g. the scientific community and research centres).

Applying a similar framework to evolution education, Smith (2013) points out two influential cognitive authorities comprised of science and religion. However, he notes that the term authority does not refer to authoritative figures that can enforce decision making (i.e. top-down control) such as political influences of funding agencies on directions of scientific research or the absolute order of the Church to forbid certain explanations (as occurred in the past), that is administrative authority (Rieh and Hilligoss (2008). In contrast, he refers to the idea of cognitive authority as “real authority” (p. 607)

which means any figures or sources that one refers to as the basis of rationales for making one’s own decision or judgement on a particular situation (i.e. according to a bottom-up process).

### Science as a Cognitive Authority

Focusing first on science as cognitive authority, in his review of scientific confidence in evolutionary theory, Wiles (2010) identifies different forms of scientific authority in relation to evolutionary theory. First, he explains scientific authority in the form of scientist experts (individuals). Referring renowned scientists such as Charles Darwin, Theodosius Dobzhansky, Stephen Jay Gould, Robert Carroll, Ernst Mayr and Richard Lewontin, Wiles (2010) firmly argues that their comments on the importance and the factuality of evolutionary theory make evolutionary theory the central and unifying theme in biology and none would doubt about the status of evolutionary theory within the scientific community. In line with the responses from the students in Downie and Barron (2000) and Southcott and Downie (2012) who accepted evolution on the ground that whatever science teachers, whom they perceived as scientists in their contexts, say is trustworthy and scientifically valid. It is possible that a lack of direct access to evolutionary evidence would lead the students to rely heavily on what their teachers say and they may perceive that their teachers have more experience and more knowledgeable. Thus, whatever they say or believe is perceived as “correct”, even though they do not understand much what evolutionary theory is really about.

Moreover, Wiles (2010) further explains scientific authority from institutions by arguing that evolutionary theory is ‘overwhelmingly accepted by the international scientific community’ (p. 21). He provides a list of statements supporting the firm foundation of evolutionary theory among internationally recognised scientific communities such as the National Centre for Science Education (NCSE), the Academy of Science of the Royal Society of Canada (RSC), the American Institute of Biological Sciences (AIBS) and the National Academy of Science (NAS). The agreement from these institutions makes Wiles (2010, p. 22) claim that ‘indeed, virtually every major scientific organisation has issued a statement in support of evolution’. In addition, he notes that this agreement has been found in every part of

the world where scientific information is accessible, not only the Western scientific world. Indeed, this is similar to the responses of the students in Southcott and Downie (2012) and Özey Köse (2010) which showed that the students accepted evolutionary theory because science textbooks, which may represent the international scientific community to them, say so.

Smith (2013, p. 611) explains that “learners stand at the end of chain of evidence – at the end of a justificatory chain of testimony that begins with the researchers who actually made the observations or conducted the experiments that produced the evidence”. This means that those relying on science as a cognitive authority justify their thoughts and beliefs through forms of evidence provided by original researchers who conduct experiments or observations which are generally presented in textual forms such as books, reports research articles and weblogs, as well as verbal presentations such as lectures and seminars. Likewise, according to Wiles (2010), the flow of knowledge about evolution comes from scientists (individuals) who conduct experiments and observations and contribute to a solid body of scientific knowledge within the scientific community (a form of institution), and then this body of knowledge is transferred to learners through science education (instruction).

### **Religion as a Cognitive Authority**

Turning to religion as a cognitive authority, Smith (2013) explains that individuals rely on religion in “four interlocking forms” consisting of perceived doctrines of God, sacred texts, church traditions and church people. He points out that the hearers or readers of the sacred texts (i.e. those relying on religion as a cognitive authority) are influenced by the interpreters (e.g. bible teachers, preachers, and church leaders) who interpret the sacred texts according to the denominational tradition of the church which hold certain doctrines of God.

Yasri and Mancy (2012)’s study shows that students relied on second-hand knowledge associated with religious perspectives as cognitive authority for justifying their rejection of evolutionary theory. Four out of nine student participants in this study explained that they used the Bible as the authoritative source of knowledge and thus any explanations that seem to contradict its accounts have to be rejected. As one of the participants, Nicha explained, when she started learning biological evolution, she did

not realise that she would later need to justify her decision about whether evolution should be accepted because, at that moment, it did not seem to contradict her (religious) beliefs. It is likely that she perceived both science and religion as her cognitive authorities at the beginning of the study.

However, according to her verbal explanations, later on, Nicha explicitly relied only on religion as a cognitive authority, leading to her rejection of evolution when she studied human evolution. She said that this particular content of evolutionary theory was different from what she had been taught from church and read from the Bible. While starting to reject science as a cognitive authority, she leaned towards religion by consulting other religious believers (individuals as cognitive authorities) as well as reading books that support her faith (texts as cognitive authorities). In the end, she said that the advice from others and knowledge from her readings enabled her to reject evolution confidently and hold her religious beliefs firmly. In addition, based on competing forms of cognitive authorities, another participant, Praporn, said that she was not sure whether evolution should be accepted or rejected. She explained that while its explanation is reasonable and its evidence is convincing (science as a cognitive authority), religious belief in God’s creation held her back from accepting it (religion as a cognitive authority). She expressed that a Biology teacher who is also a Christian would help her solve this confusion (an individual as a cognitive authority).

Despite these examples, there is no intention to claim that religion necessarily leads to rejection of evolutionary theory. Although religious beliefs can influence responses to evolution that include conflict and rejection, it is also known that many people, including scientists and theologians, manage to reconcile religious beliefs with acceptance of evolution and their professional role. For example, a random survey of 1000 American scientists towards the end of the twentieth century uncovered that 39.3% believed in a personal God, with highest rates of disbelief in God not among biologists – who might be assumed, on the whole, to accept evolution – but among physicists and astronomers (Larson and Witham, 1998). Indeed, a range of rationalisations is apparent from the official statements of many mainstream Christian groups – including Catholicism and many of the mainstream

Protestant denominations (see the article of Martin (2010) for a review of major US Christian denominations). The ample evidence from these studies point to the diverse outcomes of the influence of religious authority in perceptions of evolution, which can be a result of combined cognitive authorities (both science and religion), or perhaps adopting science as a cognitive authority in the context of evolution while relying on religion in other contexts.

## CONCLUSION

There are those who preferably refer to science as cognitive authority arguing that evolutionary evidence is clear and trustworthy, textually supported by coverage in science textbooks and verbally supported by science teachers. However, there are those who negatively refer to science as cognitive authority. They are likely to claim that evolutionary evidence is speculative, and therefore alternative sources of knowledge (i.e. creationist and Intelligent Design arguments) are considered more convincing. In addition, they prefer to consult religious leaders rather than science teachers regarding which explanation of the origin of life should be taken. Besides these, there are those who refer to religion as cognitive authority when justifying the acceptance of evolutionary theory. Those preferably take religion as cognitive authority claim that literal interpretation of the sacred texts is the absolute truth, therefore any explanations that seem to be contradictory to the religious texts are literally denied. On the other hand, there are those who negatively refer to religion as a cognitive authority by arguing that religion is not a valid source of knowledge, therefore it has no right to claim about the natural world.

It is therefore suggested here that instruction of evolutionary theory is not only the matter of delivering scientific contents, but does it also deal with personal worldviews influenced by different forms of cognitive authority. It is important for science educators and science teachers working on evolutionary theory to put more emphasis on developing students' learning skills to be able to critically evaluate which source of information is scientifically appropriate. However, this should not done in the fashion of rejecting religious beliefs and treating them as enemies of science. In contrast, it should be done with full respect to religious belief of individuals.

We suggest that the aim of the development of instructional approaches should be to focus more on the nature of science. We believe that appropriate understanding of the nature of science would enhance student acceptance of evolution with justified understanding well as helping them to be able to perceive the differences between science and religion and will help them to avoid inappropriately conflating scientific knowledge with religious beliefs.

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