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ORIGINAL ARTICLE

# Lebanese Undergraduate Students' Perceptions of the Tentativeness and Evidence of the Theory of Evolution

**Hayat Hokayem*, Christelle Fayad**

Andrews Institute of Mathematics and Science Education, College of Education, Texas Christian University, Fort Worth, Texas

***Corresponding Author:** h.hokayem@tcu.edu

## ABSTRACT

Research has previously examined the role of the epistemological background of students in accepting or rejecting the theory of evolution. In this study, the participants were 11 undergraduate biology major students in a private university in Beirut, Lebanon. We collected data through semi-structured interviews, and we extracted the patterns regarding how they perceived tentativeness, what constituted acceptable evidence for them to accept the theory of evolution and the role of religion in their lives. Our findings indicated that, unlike their professor, students uncertain about the theory or rejecting it did so due to the tentative nature of science. They also rejected historical evidence as valid evidence in science, struggled to form a cooperative relationship between evolution and religion and refused common descent because they considered humans as superior organisms. We discuss the implications of those results for curriculum and instruction.

**KEY WORDS:** Evidence; evolution; religion; tentativeness

## INTRODUCTION

The theory of evolution is a principal theory in the biological sciences. It was primarily developed by Charles Darwin who proposed that species evolve according to natural selection and that they all share common descent. The scientific community widely acclaims the evolution theory and considers it evidence based (International Academy Panel, 2006). Despite that, Mayr (2000) argued that it is challenging to accept the theory because it contradicts ethics and beliefs especially in its notion of humans evolving from lower species, ethical behavior being favored by natural selection, and natural processes being random rather than predictable. The theory is still highly controversial for many individuals across the world, specifically for those whose religious beliefs are at odds with the scientific theory (Cobern, 2000). This controversy can reach the classrooms because the social and cultural backgrounds of the students highly influence their judgments. Lebanon is an Arab country in the Mediterranean which has a diversity of religious groups who live there. The main groups are different Christian religious sects, and different Muslim religious sects. Even though evolution is found in the national biology high school curriculum in Lebanon, this topic is not required for high stakes Lebanese national exams. Therefore, the majority of the schools do not teach it, and this can be related to the contradiction of the tenets of evolution with the creationism in the religion. This study builds on a previous study where (Hokayem and BouJaoude, 2008) examined undergraduate students' acceptance and rejection of evolution. In this study, we dig deeper to understand the reasons behind the uncertainty or rejection of the theory. Our research questions were:

1. Does the tentativeness of the evolution theory affect student acceptance of it?
2. What evidence associated with evolution theory did students find unconvincing?
3. How do students view the roles of creationism and evolution in human origin?

## LITERATURE REVIEW

Several theoretical frameworks have been adopted to teach the theory of evolution efficiently. One of these frameworks was the conceptual change framework. This attempted to shift students' invalid conceptions into scientifically valid ones. Those who subscribe to this framework believed that students' pre-existing ideas interconnect in a theory web. To modify these ideas, educators need to restructure them to produce a paradigm shift (Kuhn, 1970). Samarapungavan and Wiers (1997) supported Kuhn's framework and, in an empirical study with grade 5 and 7 students, showed that students' answers can be grouped in identical categories such as creationism and spontaneous generation. Another relevant framework is the ontological differentiation in science instruction. Ferrari and Chi (1998) believed that ideas should be categorized ontologically and learned according to their ontological classification. For them, teaching evolution is challenging because its ideas are being ordered within "event" classification instead of the "equilibrium" ontological classification. In other words, instructors teach evolution as a static event when it should be taught as a dynamic process. One of the issues with the conceptual framework is that it considers all ideas as misconceptions which can be problematic in a concept such as evolution.

On the other hand, epistemological beliefs have a major effect on the perception of science in general and the theory of evolution, in particular. Similarly, religious beliefs play a significant role in dictating the individual perception of the theory. "Belief" is a word with multiple meanings and researchers often struggle to classify and unravel the term. Accepting the theory is not just related to just understanding it, but to also thinking how this theory fits within one's beliefs and convictions. This theory contradicts creationist beliefs (Southerland et al., 2001). The relationship between science and religion has gained different identities over time. According to Barbour (2000), this relationship could either be *conflict, independence, dialogue, or integration*. Philosophers also face another dilemma when situating belief, knowledge, and understanding. Cobern (2000) argued that such beliefs should not be separated from science. Instead, educators should incorporate metaphysical questions in science curricula. BouJaoude et al. (2011) found that Lebanese and Egyptian Muslim students have inadequate ideas about evolution and the nature of science which led to them rejecting the theory. Similarly, many qualitative studies examined the relation between religious beliefs and the perception of the theory of evolution. Those studies adopted a sociocultural framework that acknowledged how a person's social and cultural backgrounds influence the construction of knowledge. This framework implies that religious beliefs are not misconceptions; instead, they are part of the individual's identity and require examination and description instead of modification. Those who conform to this framework also subscribe to the worldview theory developed by Kearney (1984).

In addition to religious beliefs, research has shown that understanding the nature of science influences how students deal with scientific concepts. In fact, many studies have shown that NOS understanding affects the acceptance of evolution theory (Cofré et al., 2018; Lombrozo et al., 2008; Nelson et al., 2019). Researchers agree on the tentative nature of science and on the evidence requirement for scientific discoveries (Abd-El-Khalick et al., 1998; Lederman, 2007). In this study, we focus on those two aspects of the nature of science in regard to evolution theory.

Tentativeness reflects the provisionary and epistemically uncertain nature of scientific discoveries (Peters and Dunwoody, 2016). Such discoveries can be falsified and replaced (Popper, 2002). Misconceptions about the tentativeness of scientific discoveries disvalue them and make them less credible, an issue many scientists commonly face when they communicate their findings with the public (Frewer et al., 2003; Zehr, 2000).

Evidence associated with evolution is not purely empirical which is what makes this theory controversial. Philosophers have long debated the expectation of empirical justification of a theory or law. For Elgin (2003), such an empirical requirement suggests a priori deduction of theories and generalization which is unacceptable. On the other hand, Ruse (1988) prioritized the legitimacy of the theory rather than its generalization problem.

Dagher et al. (2004) showed in their study that students identified information as scientific only when accompanied by empirical evidence. In another study, high school students preferred having "physical evidence" to examine in class such as skulls which are a type of observable direct evidence (Donnelly et al., 2009). Wiles (2014) found that the majority of gifted students transitioning from high school to post-secondary education thought of evidence as the major factor contributing to their acceptance of evolution theory. Therefore, educators should take into consideration the type of evidence students approve of. Based on (Samarapungavan and Wiers, 1997), Dagher and Boujaoude (2005) developed a model on the various evidence associated with evolution. For students to construct a full understanding of the evolution theory, they need to be acquainted with the three types of evolution supporting evidence: historical (e.g., fossils), direct (e.g., genetics), and circumstantial (e.g., extinction data). Even though genetics are used to justify the theory (microevolution), fossils constitute major evidence (historical) for macroevolution. As such, recognizing the importance of historical evidence is important to accept the theory of evolution. In this study, we examined how students perceived evidence and the nature of science and related that to their acceptance or rejection of the theory.

# METHODS

## Participants

The participants of this study were eleven junior and senior students (aged 19–22) majoring in Biology and taking an Evolution course at a private University in Beirut, Lebanon. In addition, the professor of the course was a participant. The students had Christian, Muslim, or Druz[1] religious backgrounds. The students and the professor all agreed to voluntarily participate in the interviews and signed informed consent forms.

## Evolution Course

The evolution course was a three-credit elective course offered 3 times a week for the whole semester (15 weeks). The professor relied on a textbook by Strickberger (2000) while lecturing. He occasionally used videos related to animal behavior. The course covered the history of the development of the theory. It also detailed the associated evidence from geology, genetics, and animal behavior. Finally, the course examined different phylogenic trees including the one showing human descents. Importantly, the course only briefly covered any controversies related to evolution and religion. It did not tackle the nature of science except when mentioning Darwin's contribution to the deductive approach. Students were interviewed after taking the course. The interviews ranged from 1 to 1.5 h and had sections that looked into students' views of science and evolution as well as their epistemological beliefs. We audio-taped, then

1 Druz is a special Muslim sect that is a minority in Lebanon.

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later transcribed the interviews "ad verbatim." We compared the texts with the audio to check the accuracy of transcription.

### Interviews and Data Analysis

In our previous reporting, we classified students into three categories: Students who accepted the theory, students who were uncertain, and those who rejected the theory (Hokayem and BouJaoude, 2008). To answer the research questions of this study, the interviews were extensively analyzed to look into themes and patterns in students' responses. We organized the information into three categories: (1) Views on tentativeness of science in general and of evolution theory specifically, (2) thoughts on the evidence associated with the theory, and (3) thoughts on religion and evolution in relation to human life and origin. Accordingly, data reduction for each student's interview allowed identification of response themes. To reduce chances of bias, a biology teacher trained by one of the authors also performed data reduction. The teacher's reduction data were very similar to that of the researchers. In case of disagreement, discussion and referral to transcripts settled any disputation. The reduced data was read multiple times and recurring ideas of the students were grouped into three classes: opinion on tentativeness, opinion on evidence, opinion on the role of creationism and evolution in human origin. Accordingly, Tables 1-3 represent those classes. To reduce the possibility of bias, the biology teacher validated the classification at this stage too. Following this step, we worked on analyzing commonalities and differences in student responses. From the analysis, we created profiles for the professor and the students. We also compared those profiles.

## RESULTS

### Tentativeness

The results showed that all students agreed on the tentativeness of science. The students who were uncertain about or rejecting evolution theory thought its tentative nature affected their acceptance of it. The categories appear in Table 1.

All students acknowledged the tentativeness of science, but the idea of tentativeness of the evolution theory was specifically used to justify their uncertainty or rejection of it.

To give a representative example, S10 (uncertain) said:

**Table 1: Tentativeness of the theory of evolution in relation to the theory's acceptance**

| Student categories | Students accepting the theory | Students uncertain about the theory | Students rejecting the theory |
|---|---|---|---|
| Students | S1-S7 | S8-S10 | S11 |
| Science is tentative | All | All | Yes |
| Tentativeness affected acceptance | Only S5 | All | Yes |

> *They have some hypotheses like example human evolved from monkeys, they found some fossils and they built that tree, they found that the hypothesis was wrong, so they established a new theory that humans and apes, for example, they evolved from a single ancestor.*

This shows that this student thinks that having new evidence prevents him from accepting the scientific theory. Similarly, S11 (a rejected example) said:

> *they find one thing they make up a theory on it, they find something else, they change their theory, they can't work like that, the fact that they found some evidence means they that change their mind, this is not right.*

However, S6 (an accepted example) said:

> *In evolution, things are going to change, truth in science is not a universal true. It is the truth of the moment you can make general statements about today but you can't say that this statement is going to be the same tomorrow, but that doesn't mean that what is happening today is not true.*

S6's statement aligns with that of the professor who claimed:

> *you continue to believe in something as long the evidence supports it and when the evidence doesn't support it then that's it, its' been like this for centuries, otherwise if I different attitude to this it means I have faith in this theory and that's wrong, that's not science, there's no faith.*

It is worth mentioning that S7 (uncertain) was more comfortable with the determinism offered by religion than the uncertainty (tentativeness) of evolution theory unlike the professor:

> *There is always the one thing that's constant, everything goes back to one source, so as long as I have that, and this is something that is constant, I believe it, I have very strong faith in it and a theory such the evolution one, it is such a weak theory that could ever make me clash with that idea.*

On the other hand, the professor criticized the determinism of religion:

> *Whatever idea of God that religion propagates, that I don't accept. I don't actually put the question whether God exits or not. To pray to God, you're trying to make God change his mind about something and God doesn't change and you're trying to make God out of this world, out of the material things, unchanging, everlasting, at the same time you're doing things in religion that really contradicting this.*

### Evidence

The course provided various evidence related to the evolution theory (fossils, chemical evolution, genetics, comparative anatomy, and geographical barriers). Table 2 shows what evidence students found convincing.

The professor considered the historical evidence of fossils convincing, *In the same way we relate living species you might also find logical to relate species that are found in fossils at*

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**Table 2: Students perceptions of the evidence associated with the evolution theory**

| Evidence | Professor | Students accepting the theory (S1-S7) | Students uncertain about the theory (S8-S10) | Students rejecting the theory (S11) |
|---|---|---|---|---|
| Fossils | Found it convincing | S1, S2, S3, S4 and S7 found it convincing S5 found it speculative | S8 found it convincing While S9 and S10 think it has gaps | S11 rejected all the evidence |
| Chemical evolution | | S2 found it convincing | | |
| Genetic mutation | | S1 and S4 found it convincing | S8, S9, S10 found it convincing | |
| Comparative anatomy | | | S8 thinks it's a coincidence | |
| Geographical barriers | | | S8 considered it weak evidence | |

**Table 3: Students' perceptions on religion and evolution**

| Perception | Professor | Students accepting the theory (S1-S7) | Students uncertain about the theory (S8-S10) | Students rejecting the theory (S11) |
|---|---|---|---|---|
| Acknowledged the moral aspect of religion | yes | All | All | yes |
| Explained religion from evolutionary perceptive | yes | S2-S3-S5 | | |
| Believed in conflict between religion and evolution based on human descent | | | All | yes |
| Refused common descent because humans are superior | | | All | yes |
| Believed in creationism | Not sure | S1-S2- S3-S5-S7 | All | yes |
| Incorporated creationism and evolution in human origin explanation | | S1-S3-S5 | S8 | |

*about the same time same place*. Out of the students accepting the theory, only S5 found fossils speculative evidence. Uncertain and rejecting students found fossils as historical evidence that *has gaps*. S9 explained:

> *They do have laboratory experiments and they do have historical evidence but factual, I don't believe that the theories they come up with from historical evidence is factual, like a fossil is a stone, it doesn't even have cells so you can't say this is a snail, maybe it's a stone.*

Many of the students found the historical evidence in fossils "speculative" which, according to the professor, is part of the how science works fundamentally not just for this particular theory, *there are speculations but all of those speculation are found in all sorts of sciences, astronomy, etc.… but these models will remain till someone comes to shake them.* Only S8 who was uncertain about the theory found fossils to be convincing evidence *fossil record is the most relevant argument of evolution*. As for chemical evolution, S2 found this evidence to be convincing *the molecular evolution I had no idea about it so it was totally new to me and I think that that was the missing link*. Genetic evidence was the most acclaimed amongst the students, as noted by S8 *genetics is very convincing, and as they find the genetic map this will give very strong argument to evolution*. S8 was, however, not convinced by comparative anatomy and geographical barriers *comparative anatomy could just be a coincidence*. Then went on *but just weak, it's not observable, we can't make a test, we can't experience it, we can't design an experiment to see if there's a geographical barrier how will their behavior change*. It is worth mentioning that S11, who rejected the theory, rejected all associated evidence:

> *you can't say that all organisms originated from the same thing, from microorganisms from millions of years just because they have some similar amino acids or some similar genes*.

## Role of Religion in Students' Lives

We examined what students think about the role of God in human life and origin as opposed to evolution (Table 3).

All students acknowledged the moral aspect of religion, as examples S1 *the role of religion is the morals and deciding good from bad* and S8 *religion has a role in my life, moral guidelines, don't steel*. Compellingly, only students uncertain about evolution or rejecting it found that the theory of evolution contradicts with religion specifically with the concept of human descent for example S11 *there's nothing called human evolution* and S10 *my problem is more or less with human evolution*. On the other hand, only students who accepted evolution explained religion from an evolutionary perspective like S2 *even religion evolved*, S3 *maybe sometime through evolution and through our perception of life we'll reach to use all the cells, brain cells, and maybe become God*, and S5 *having an afterlife evolved with the evolution of humans*. The professor also explained religion from an evolutionary perspective:

> *There's a rational basis for a lot of ethical things that we do, from an evolutionary perspective, we that in what we call kin selection or group selection, groups are able to cooperate better, and sometimes sacrifices of the individual within the group might lead to the benefit of the group and then it might lead to benefit of the individual Even linked ethics and our evolution as better groups in society.*

The professor also explained:

> *Natural selection says that if, as individuals, do well*

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*then fine, you'll get through and have offspring, group selection says if you as a group do well then fine you could get through. If this gene that makes people behave in a certain way that will reflect eventually well on society and on individuals, then it's more likely to be passed.*

It is worth mentioning that S11, the student that rejected evolution theory, thought that religion cannot be explained from an evolutionary perspective. However, he mentioned the role of religion to organize life so that people do not hate each other which is similar to the professor's idea of surviving as a group. S11 noted *religion has nothing to do with evolution, because religion is not explained from an evolutionary perspective*. S11 then went on *religion came to organize our lives, so that we don't hate each other and live in peace on this earth*. Another compelling finding was that only students who were uncertain about evolution or those who rejected it refused the common descent idea of evolution theory because humans are considered superior organisms such as S10 *maybe humans didn't evolve from apelike beings* and S8 *divine intervention changed humans intellectually or consciously … there has been an upgrade by divine force*. Although most students believed in creationism (except S4 and S6), only S1, S3, S5, and S8 incorporated both creationism and evolution in their explanations of human origins, for example, S3 *I think that God is responsible for evolution* and S8 *maybe we have an ancestor but there has been an upgrade by divine intervention*. Note that all those students accepted the theory except S8 who was uncertain about it.

### Summary of the Findings

Our findings indicate that students accepting evolution theory accepted its tentative nature and its associated evidence. They also formed a cooperative relationship between evolution and religion when explaining human origin. On the other hand, students uncertain or rejecting the theory struggled to accept the tentative nature of evolution theory and its historical evidence. They also found conflict between religion and evolution when explaining human descent. Those results are present in Table 4.

## DISCUSSION

Our data indicated that one of students' major reasons for being uncertain about the theory or rejecting it was its tentative nature. This contradicts other studies, like Cavallo and McCall (2008) who found that students who acknowledged the tentative nature of science were more likely to accept the theory of evolution than their peers who considered science as static. Previous researchers demonstrated that, when faced with a new scientific concept, people can recognize its tentativeness especially when they approach it pessimistically or with a negative approach (Flemming et al., 2015). That could have been the case with students who heard about the controversy evolution poses for religious people. Students should apprehend the value and consequences of the tentativeness of science for them to properly evaluate evolution theory (Khishfe et al., 2017; Sinatra et al., 2014).

In our study, four students struggled to accept the fossil evidence. Students uncertain about evolution (S8, S9, and S10) valued the genetic evidence associated with evolution. Importantly, genetics is considered a type of experimental and testable evidence. Our findings are consistent with the previous research that showed how students consider experimental evidence fundamental to reach correct knowledge and how historical and circumstantial evidence cannot be tested (Dagher and Boujaoude, 2005).

Although research has previously suggested that religiosity is the major predictor of students' acceptance of evolution theory (Hill, 2014; Glaze et al., 2014; Rissler et al., 2014), our study demonstrates that religious Biology undergraduates can still accept evolution. S1, S2, S3, S5, and S7 believed in creationism but were still able to incorporate both creationism and evolution in their explanation of human origin. In fact, most of the participants in our study believed in creationism. According to Reiss (2009), creationism should not be considered a misconception. Instead, it is part of the student worldviews. Following this stance, Reiss (2009) claimed that belief in creationism cannot be modified into belief in evolution. Our findings contradict with such a claim because many of the students who believed in creationism were able to accept the theory of evolution and keep their beliefs. It is possible that they separate their religious beliefs from scientific beliefs which allows them to accept evolution as a science, but then believe.

In our previous findings, we found that the professor was agnostic in comparison to the religious students. One can argue that such stance does not help with the conflict students are having with evolution. It was compelling to find out that students struggled with the idea of common descent because they considered human species superior organisms. Similarly, Downie and Barron (2000) found that Scottish 1st-year Biology students accepted the idea of species evolving and improving within their environment but refused common descent and species changing from one to another.

**Table 4: Summary of students' views on tentativeness, evidence and the relationship between religion and evolution**

| Overall perception | Students accepting the theory (S1-S7) | Students uncertain about the theory (S8-S10)<br>Students rejecting the theory (S11) |
|---|---|---|
| Tentativeness | Accepted | Rejected |
| Evidence | Accepted | Rejected fossil evidence |
| Religion and evolution | Cooperative relationship | Conflicting relationship |

To conclude, our findings showed that even religious students can accept the evolution theory and incorporate it in their explanation of human origin. Many of the participants struggled to accept the tentativeness of the evolution theory along with its associated historical evidence. One might argue that students' inability to accept those two tenets of the theory could have influenced how students accommodate evolution theory with their religious beliefs. Another possible explanation for our findings could be that those students prefer to base their rejection of the theory on its tentative nature and type of evidence when in reality the theory contradicts with their religious beliefs, especially those related to human origin.

Our study implies many instructional and curricular modifications. First, educators should explicitly and meticulously design instruction about the nature of science and its tenets such as the tentativeness of science (Rudolph, 2000). Including refutation texts in evolution instruction can alleviate the refusal of the theory based on its tentative nature (Flemming et al., 2015). Moreover, instructors should discuss with their students how evolution harbors both empirical and historical evidence because it relies on both an empirical and historical approach (Gray, 2014). To reinforce the evidence of evolution, instructors could teach the theory with a historical approach through which students can compare their conflicts with the theory within a large societal scale enhancing their acceptance of it (Solomon et al., 1992). Moreover, resource writers must include more varied and up-to-date evidence in textbooks. This evidence can be obtained from museum collections and scientific publications (Williams, 2009). Finally, we recommend including historical religious figures who accepted the scientific evolution without them giving up their faith. For instance, Teilhard de Chardin (1960) was a renowned Jesuit who was fascinated by the theory of evolution. Chardin incorporated both a scientific and a religious view in his book *The Phenomenon of Man* where he wrote:

> *Our generation and the two that preceded it have heard little but talk of conflict between science and faith; indeed, it seemed at one moment a foregone conclusion that the former was destined to take place of the latter. But in as much as the tension is prolonged, the conflict visibly seems to need to be resolved in terms of an entirely different form of equilibrium, not in elimination, nor in duality, but in synthesis. After close of two centuries of passionate struggles, neither science nor faith has succeeded in discrediting its adversary. On the contrary, it becomes obvious that neither can develop normally without the other. And the reason is simple: the same life animates both.* (pp. 283-284)

Students trying to overcome the conflict between scientific concepts and their personal beliefs can benefit from this man's view.

## CONCLUSION

Our findings indicate that students doubting or rejecting the theory of evolution struggled with both the tentative nature and historical evidence associated with the theory. They also could not accommodate the theory within their beliefs of creationism and human superiority. Thus, the epistemology of students and their perceptions about science need to be considered when teaching the theory of evolution.

### Ethical Statement

This study is based on secondary analysis of data collected in 2006. The American University of Beirut granted ethical approval at that time.

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